

**Reengineering the Management Process of Hospital
Consumable Medical Supplies to Reduce Cost and
Improve Quality - An Empirical Study in China**

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Thesis submitted as partial requirement for the conferral of the degree of

Doctor of Management

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November 2015

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Declaration

I declare that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university and that to the best of my knowledge it does not contain any material previously published or written by another person except where due reference is made in the text.

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Abstract

As the society continues developing and people's living standards rise in China, the top priority of its new medical reform has become pushing forward public hospital reform and optimizes the medical service system. At the same time, the medical reform's guiding principles for operating the country's hospital system have changed into maintaining non-profit medical institutions as the main body of the healthcare system, for-profit medical institutions as supplements; public medical institutions playing the leading role, and encouraging the concurrent development of non-public medical institutions. This change in guiding principles has led to intensified competition among hospitals. To survive in the competition, hospitals are emphasizing on reducing cost and improving service quality. Therefore, reducing cost and providing high quality medical services has become an important goal for hospital management.

With continued advancement of medical technologies, the type and the quantity of medical supplies have been continuously increasing. The number of wasted medical supplies has also been increasing rapidly. Medical supplies include three major categories, namely, pharmaceuticals, consumable medical supplies, and medical logistical materials (Fu, 2009). This thesis aims to study the management of consumable medical supplies.

This thesis examines how hospitals can achieve inventory reduction of hospital consumable supplies, improve management quality, and lower cost by reengineering and optimizing the management process of the whole lifecycle of consumable medical supplies, including production, circulation, hospital, units and utilization, and by utilizing information management systems.

The first half of the thesis describes the theoretical bases of reengineering and optimization as well as information systems utilized to achieve improved hospital consumable supply management. The second half uses three groups of data, namely, interviews, a case study and questionnaire surveys, to provide analysis results of successful use of reengineering and optimization as well as information system to improve hospital consumable supply management process in China. The first group of

data includes interviews of several managers from three companies providing hospital consumable medical supplies which offer qualitative analyses regarding the problems in hospital consumable medical supply management process, solutions to resolve those problems, and challenges in solution implementing. The second group of data includes a case study of a large hospital in Shanghai, from the supplier's perspective, of their consumable medical supply management process resulted from the restructured information systems platform. The third group of data includes questionnaire survey responses from leaders of multiple hospitals regarding comparisons of its consumable medical supply management process and results between before and after the implementation of the information systems platform.

Key Words: Consumable Medical Supply Management Process, Total Quality Management, Business Process Reengineering, Information Systems, Medical Supply Interconnection Service Platform

JEL: M00

Resumo

À medida que a sociedade Chinesa se desenvolve e as condições de vida melhoram, a prioridade da reforma médica tem vindo a concentrar-se na reestruturação dos hospitais públicos e na otimização do sistema médico nacional. Ao mesmo tempo, os princípios orientadores do funcionamento do sistema hospitalar nacional mantêm as instituições médicas não orientadas para o lucro como o corpo principal da sistema de saúde, e as instituições orientadas para o lucro como suplementares; em suma, enquanto as instituições médicas públicas desempenham o papel principal no sistema de saúde, o desenvolvimento de instituições privadas é incentivado.

Esta mudança de princípios desencadeou uma concorrência entre hospitais. Para sobreviverem no ambiente cada vez mais concorrencial, os hospitais concentraram-se na redução de custos e na melhoria da qualidade dos seus serviços. Deste modo a redução dos custos e a melhoria dos serviços médicos prestados transformaram-se em objetivos principais, para os gestores hospitalares.

Com a evolução contínua das tecnologias médicas, o tipo e a quantidade de fornecimentos hospitalares tem vindo a aumentar. A quantidade de desperdícios resultantes dos fornecimentos hospitalares tem também aumentado de uma forma muito rápida. Os fornecimentos hospitalares consumíveis incluem três categorias: farmacêutica, consumíveis médicos e materiais de logística (Fu, 2009). Esta tese tem como objetivo principal investigar a gestão dos fornecimentos médicos consumíveis.

Esta tese investiga como os hospitais podem diminuir o inventário dos fornecimentos hospitalares consumíveis, melhorar a qualidade da gestão e baixar o custo através da reengenharia e otimização da gestão de todo o processo de vida dos consumíveis médicos, incluindo a produção, a circulação e utilização, apoiando-se sistemas de informação para a gestão.

A primeira parte desta tese descreve as bases teóricas da reengenharia e otimização, assim como dos sistemas de informação utilizados para conseguir a melhoria da gestão dos fornecimentos. A segunda parte utiliza três tipos de dados, nomeadamente, dados recolhidos através de entrevistas, dados provenientes de um caso, e dados recolhidos

através de um questionário. Estes dados permitem-nos descrever casos de sucesso na melhoria da gestão dos fornecimentos hospitalares na China.

Os dados provenientes das entrevistas a gestores de três empresas fornecedoras de consumíveis médicos permitem-nos, uma visão qualitativa dos problemas e soluções para os resolver. Os dados provenientes do estudo de caso de um grande hospital de Shanghai, na perspetiva dos fornecedores fornecem-nos uma ideia da importância da existência de plataforma de sistemas de informação. O terceiro grupo de dados é proveniente dos questionários administrados a gestores de hospitais onde se questiona sobre a situação da gestão dos consumíveis médicos hospitalares antes e depois da existência de plataformas de informação.

Palavras Chave: Processo de Gestão de Consumíveis Médicos Hospitalares, Gestão Total da Qualidade, Reengenharia de Processos, Sistemas de Informação, Plataformas de Informação.

JEL: M00

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Several years of management practice have made me deeply aware of my lack of theoretical management knowledge. From 2011 to 2015, I had the honor to study in the Doctor of Management in Healthcare Program co-hosted by the China Southern Medical University and the Portugal ISCTE Lisbon University Institute. Four years of study enabled me to continuously improve my capability in theories, practice and ways of thinking in new fields. I have greatly enjoyed the pleasure of learning and the fruits of self-improvement.

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Chapter 1: Introduction

As the economic system transforms, the market mechanism establishes and matures, China's economy and the world economy have become mutually penetrated and intertwined. As a result, the medical industry in China has also undergone profound changes. In this environment, a large number of foreign medical institutions have entered China; the number of private hospitals has been increasing by the day in the past few years; and resource-rich public hospitals have also been growing. Foreign medical institutions, Chinese private hospitals, and Chinese public hospitals emerged to become the three pillars of the Chinese medical industry. As a result, patients are now able to choose from a wider range of hospitals and doctors. Hospitals are no longer public welfare institutions. In order to survive and grow, hospitals need to provide patients with low cost but high quality service, ensure fair compensation and welfare of their medical staff, and at the same time lower cost. Therefore, improving and raising hospital management level, lowering hospital costs, and improving medical service quality have become some of the most important objectives for hospitals.

As medical technologies rapidly advance, the use of consumable medical supplies has soared. Consumable medical supplies have become a top cost element for hospitals, second only to drugs. Cost related to consumable medical supplies is the second largest category of hospital working capital. Furthermore, China announced in 2009 that its overall goal of medical system reform is to establish basic medical and health care system that covers both urban and rural residents, provide the population with safe, effective, convenient and affordable medical and healthcare services (*Gazette of the State Council of the People's Republic of China*, 2009). Resolving problems related to the management of consumable medical supplies has become one of the most important and difficult challenges. As such, reengineering consumable medical supply management process to reduce cost and improve quality has become an inevitable trend.

1.1 Research Background

1.1.1 Dilemmas in the Evolution of Consumable Medical Supplies

Hospital consumable medical supplies refer to consumable equipment and materials used for clinical diagnosis and treatment. They constitute the material foundation for hospitals' smooth daily clinical operations and medical services. All clinical operations and medical techniques are dependent on the use of consumable medical supplies (*Medical Device Classification Catalogue*, 2000).

In recent years, with the continuous improvement of medical service level and advancement of medical technologies, the variety of consumable medical supplies has also increased rapidly. More and more new and high-tech disposable one-time use medical supplies have been used in clinical treatment and care, greatly enriching the range of consumable medical supplies. In addition to variety, the quantity used and purchase price of consumable medical supplies have been rising; the number of manufacturers and suppliers related to hospital consumable medical supplies has multiplied. As a result, the percentage of hospital working capital taken by consumable medical supplies is only second to the top category, drugs. According to statistics, the annual cost of consumable medical supplies is 16% of the total hospital revenues and 22% of the annual clinical income. Furthermore, the annual wastage of consumable medical supplies has been increasing at an alarming rate, between 26.98% and 47.07%. Therefore, how to lower the cost of consumable medical supplies has become a core issue for hospital growth (Liu, 2008).

1.1.2 Observable Problems in Management Process of Consumable Medical Supplies

Three perspectives can be used to examine the main problems in the management process of consumable medical supplies: from the perspective of the suppliers, from the perspective of the management of the process from suppliers to hospitals, and from the perspective of the hospital internal management of consumable medical suppliers.

1. From the perspective of the suppliers

The overall management cost of consumable medical suppliers is very high before

they reach the hospitals. This is a result of poor management starting from the completion of production by manufacturers, such as high error rate, unsatisfactory services, and poor management.

2. From the perspective of the management of the process from suppliers to hospitals

The process from suppliers to hospitals is excessively complex and inefficient, and involves long circulation cycle. A large number of steps are involved in order management, circulation management, logistics management and service management. As a result, consumable medical supplies can hardly be delivered to hospitals with ensured quality in a timely manner.

3. From the perspective of the hospital internal management of consumable medical suppliers.

Hospital logistics personnel depend primarily on personal experiences in managing consumable medical supplies. The cause of the problem is that the deepening medical reform has posed ever-increasing demand on hospital logistics management, including ever-more strict control of the staff quotas of hospital logistics department; causing reduced new hires. As a result, most logistics staff manages consumable medical supplies based on personal experiences.

This research is carried out on the basis of the three above-mentioned perspectives.

1.1.3 Drivers and Opportunities for Addressing Consumable Medical Supply Management Problems: Medical Reform

The current Chinese medical reform emphasizes the development of four major systems. The support system for drugs and medical equipment supply is one of the four systems that should be improved in the new medical and health care system. This system should include the disbursement of regulated/standardized essential drugs and the direct distribution system of community health organizations. Therefore, the government will continue pushing for enhanced pharmaceutical circulation, and regulated distribution. Reducing the number of intermediary steps in the procurement and distribution process will become one of the major measures to lower the cost of pharmaceuticals (medical equipment) (China's Ministry of Health, 2012).

As China's socio-economic development advances and medical reform progresses, in order to gain sustainable growth space, hospitals need to, on one hand, enhance their medical technical competence; and on the other hand, reform their management process

and strive to lower operational cost. Government policies can be used to guide hospital to reforms in reducing hospital operational cost. With the advancement of the new medical reform, a series of new terms have emerged in the medical supply industry, such as “industrial upgrading”, “enhanced concentration”, “structural adjustment”, “supply chain integration”, and “hospital zero inventory management”. These terms reflect systematic, scientific and integrated management of hospital medical supplies, optimization of materials management process, reduction of materials wastage and overstocked materials, and reduction of the costs of materials procurement and management (Wen, 2011).

1.1.4 Feasibility of Addressing Consumable Medical Supply Management Problems

The new material management system for consumable medical supply management can reduce the overall management cost of consumable medical supplies before they enter into hospitals. This means cutting down the number of intermediary steps in the distribution process, and reducing error rate. It would make it possible to provide each of the hospital’s clinical units with supplies at the right time, with the right quality and quantity. A sound logistics system can reduce resources consumption, improve productivity, lower operational cost, and strengthen competitiveness (Meng, 2006).

At present, logistics management, logistics technology, and logistics specialization have reached relatively advanced levels, which support the new business operation model that enables consumer online shopping, online business-to-business transactions, and online payment. The transformation of the way of doing business brought by e-commerce has pushed logistics industry to be more advanced in using information technology and networks (Peng, 2005). The advancement of information technology has enabled the application of electronic data interchange (EDI), enterprise resources planning (ERP), and material requirement planning (MRP) that support logistics information exchange, management, and control. Added value of commodities is realized through utilizing such network technologies as point of sales (POS) and Barcode to collect and transfer information (Deng, 2003). As such, the advancement of information technology has provided favorable conditions for the rapid development of the logistics industry.

Today, medical institutions have been shifting their focus to the core business. They

are also repositioning non-core business in medical procurement and distribution cycle by restructuring the traditional hospital purchasing and supply system. The rapid development of the logistics industry has made it possible for hospitals to adopt new procurement and distribution process. More specifically, hospitals use outsourcing to accomplish logistics and distribution, which have become their non-core business activities. Thus, it has transformed the previous hospital acquisition-storage-disbursement supply chain model into a new hospital logistics supply model characterized by “reengineering and optimization of consumable medical supply management”. In addition, hospitals use information technology methods to implement product coding, bar coding, online ordering, and purchasing data analysis. The benefits of hospitals’ reengineering and optimization of consumable medical supply process include: (1) by implementing new hospital logistic supply model, hospitals can focus on their core business activities; (2) hospitals reduce working capital by mainly reducing the supply chain circulation steps; and (3) hospitals reduce the supply cycle of medical materials, reduce the management cost of consumable medical supplies, and achieve the objectives of process reengineering and optimization.

Based on literature review and case analysis, this thesis studies the challenges involved in the reengineering and optimization of consumable medical supplies management process, the medical equipment interconnection service platform, the impacts of hospital’s application of the platform.

1.2 Significance and Purpose of the Study

Problems exist in both the overall macro traditional management process of consumable medical supplies and hospitals’ internal micro logistics management process of consumable medical supplies. Because of these problems, hospitals’ costs have remained high and couldn’t be easily reduced. However, in today’s competitive environment, hospitals are in urgent need to reduce costs in order to survive. Therefore, hospitals’ reengineering and optimization of their consumable medical supply management process has become an inevitable trend and a significant step in hospitals’

long-term development.

Distribution of consumable medical supplies is one part of the consumable medical supply management. China's medical reform requires hospitals to conduct unified distribution of consumable medical supplies, reduce the number of intermediate steps, reduce the cost of intermediate steps, and as a result, to eliminate the situation where hospitals are paying overly high cost of consumable medical supplies due to the multiple channels and multiple steps involved in the acquisition and distribution process of consumable medical supplies. This provides a fundamental guarantee for the reduction of medical cost. To meet the above mentioned requirements, logistics management techniques and systems methodologies should be introduced into hospitals. Hospitals abroad have widely used logistics management techniques and system technologies to emphasize and improve logistics operation process and to reduce the number of unnecessary activities so as to reduce the overall operational cost (Dong, 2008). Through logistics management techniques and system technologies, just-in-time (JIT) system has been applied in the clinical field of hospital logistics management (Heinbuch, 1995). By emphasizing standardized logistics management processes, hospitals have achieved the goal of reducing no-value-added activities and controlling inventory (Pan, 2007). It can be seen that the optimized consumable medical supply management process, namely, the reengineered consumable medical supply management process, through the introduction of modern logistics management, is significant for the advancement of the medical reform.

Since the Chinese medical reform started, hospitals have gradually changed their operations into the market-based economy. As such, clinical departments have started to introduce and conduct cost accounting, examples include: taking into consideration the revenue and expenditure in the distribution/use of medical supplies; the authorization and purchase of medical supplies have changed from the past personal experience-based approaches to scientific planning-based approaches, which reduced the number of blind applications and overstocks. As a part of the new approaches, procurement of consumable medical supplies is conducted according to the needs of clinical departments. The

traditional “large quantities and small number of batches” management concept has been transformed into the new “zero inventory” management concept. More specifically, under the new zero inventory concepts, the warehousing and distribution of consumable medical supplies to clinical departments have been outsourced. Each clinical department, on the basis of maintaining an appropriate number of consumable medical supplies for daily use, applies as much as possible the principle of “small quantities and large number of batches,” in order to reduce inventory cost. The management of medical consumable supplies by utilizing the relative “zero inventory” approach, based on the assumption of knowing the demand of clinical departments in a timely manner, would enable hospitals to enhance financial liquidity and improve capital utilization rate (Healthcare Financial Management Association, 2002).

1.2.1 Problems in Traditional Consumable Medical Supply Management Process in China

There are four problems in China’s traditional consumable medical supply management process:

1. The traditional circulation process and supply model characterized by decentralization, small scale, and primitive transaction approaches. It remains the main circulation and supply process model for consumable medical supplies. A main characteristic of this process model is that there five to six steps from the manufacturers to the users. Small and medium-sized distribution enterprises account for the majority of market share. However, small and medium-sized distribution enterprises mainly focus on market growth. There is a very low likelihood to introduce modern enterprise management approaches and modern logistics practices. As a result, the majority of those small and medium-sized distribution enterprise logistics systems are isolated, closed and self-contained. Although they have their own distribution departments and warehouses, but their scales are very small. As a result, each of those enterprises accounts for a very small portion of the market share. Besides, every step in the distribution process between the manufacturers and the users incurs capital cost, material cost, labor cost and other uncontrollable cost. These result in high supply costs which in turn lead to overall low profitability for these enterprises. Low profitability and market share have forced the

enterprises to focus on market expansion rather than introducing modern management and logistics practices. It has become a vicious cycle causing disorderly competition, poor commercial creditability, and deterioration of the business environment, which in turn, make it difficult to provide hospitals with better quality and lower cost services.

2. Purchasing process uses out-of-date ordering approach that is older than the re-order-point method. In the traditional inventory management, orders are placed as soon as the inventory falls below the re-order point so as to ensure an appropriate amount of stock (Durham & Robert, 1973). However, this method often requires the ordering to be done early, which results in overstock of consumable medical supplies and increased inventory cost. This is not necessary and is not appropriate. At the same time, there may be shortage of inventory caused by the mismatch between supply and demand. Foreign hospitals require close connections among various steps of the supply process within the hospital, and establish an integrated “demand-centered” logistics process (Jia, 2008). In 1984, scholars including Van Liew (1984) described a comprehensive medical supply management system, and proposed through analyses solutions for solving problems in classifying consumable medical supplies, the optimal order quantity, the optimal inventory quantity, and the supply delivery strategy. As a special type of supplies, it is difficult to guarantee the effectiveness of managing the expiration of consumable medical supplies using the traditional inventory management approach. If the process is not effective, the cost of consumable medical supplies will gradually increase, and ultimately, the hospitals and patients have to pay for the cost.

3. The process of managing consumable medical supplies is mainly based on sampling. However, this method can’t provide accurate and timely monitoring and control of the whole lifecycle of consumable medical supplies which account for the largest proportion of medical supplies using the hospitals. For the management process based on the traditional approach, because of the high error rate, product quality problems, expiration issues, it is difficult to keep effective tracking and control.

4. Problems related to the hierarchical structure of the Chinese administrative system. In the United States and EU, the administrative and supervisory institutions use a simple

unitary structure which enables them to effectively and consistently carry out their administrative and supervisory policies. China has a hierarchical administrative structure based on province, city, county, and district levels (Zhang, Qin, Liu, Huang & Zheng, 2006), which has led to low market entry for products, lack of norms and standards for classification management and coding system. As a result, classifications are incomplete, name norms are not standardized, and management is not unified, lacking systematic and comprehensive long-term development planning. Adverse events caused by various types of nonstandard productions often occur.

1.2.2 Problems in the Present Logistics Management of Hospital Consumable Medical Supplies

Three problems exist in the traditional “acquisition → inventory storage → distribution” supply management model.

1. A large amount of capital is tied to inventory, increased inventory cost, and leads to an increased inventory cost.

2. When clinical units put forward purchasing plans, the purchasing department is unaware of which orders are urgent and which orders can be delayed. It is difficult to coordinate when clinical units are in urgent need for supplies and yet the supplier can't supply which, as a result, negatively affect clinical process.

3. High-value consumable medical supplies are charged after being used by patient. However, the hospital already made payment in its procurement process. The hospital is in a very difficult situation when quality problems occur. China does not have regulations that require manufacturers of consumable medical supplies to recall defective products or to issue warnings (China Food and Drug Administration, 2000).

Constrained by factors such as technology, capital, and personnel, the problems in the procurement process in logistics management of hospital consumable medical supplies are especially serious. Because of the large number of suppliers, the purchasing staffs do not conduct rigorous examinations of the qualifications of each supplier. They don't know market demand and supply (He & Xue, 2007). Some suppliers even bribe the purchasing staff whose personal interests may influence purchasing decisions. As a result, the purchased supplies may have errors in terms of quality, quantity, price, and specifications,

compromising the interests of hospitals. Therefore, hospitals need to impose strict control over the purchasing process. The purchasing staff must not only comply to the “three certificates” regulations to ensure the legitimacy of consumable medical supplies, but also carefully read and be familiar with the performance indexes of various consumable medical supplies in order to prevent selecting inappropriate products that may lead to misuse. Moreover, training and professional ethics education of purchasing staff should also be strengthened so as to constantly improve their competence.

Problems in hospital inventory management: overstocked supplies, inventory backlog, and shortage of supplies. Overstocked supplies and inventory backlog significantly impeded the increase of supply logistics efficiency, resulting in an increased inventory carrying cost and shortage cost, increasing capital amount tied to inventory, and causing hospitals to suffer economic loss (Yang, 2008).

1.2.3 Needs to Reengineer and Optimize Consumable Medical Supply Management Process

The need to reengineer and optimize consumable medical supply management process is manifested in the following aspects:

1. Medical institutions: Reduce or even eliminate existing inventory, eliminate hospital internal inventory storage facilities, and reduce personnel involved in purchasing and inventory management. Provide hospitals with effective and quality inventory management services. Clinical units, purchasing units and administrative units should be able to enjoy the convenience afforded by new technologies and new service approaches. Solve hospital problems in the supply process including delivery, returning, and replacement of supplies, provide convenience to hospital medical equipment management, quality management, and tracking management. In addition, feasible solutions, such as daily supply, barcode management and delivery according to departments, can be adopted in the distribution of consumable medical supplies.

2. Suppliers: Solve the problems in product distribution, lower distribution cost and satisfy the needs for better terminal distribution service; lower inventory cost for suppliers, reduce warehouse management, and even free small and medium-sized suppliers with

warehouse professional delegated administrative service from warehousing management; resolve the problem of payment collection and delayed payment for suppliers.

3. Regulators: Solve the problems in regulation of production, business operation and admission for product entrance at the origin of the problems. Check the license and certification management of enterprises, records of enterprises and whether operations are within scope; check the ledgers of warehousing management, batch management, inventory management and product inspection reports; regulate distinctive products, such as usage records of implant materials and post operation follow-ups; statistics on consumable medical supplies in the region, including the total sales, utilization and pricing; dissemination regulatory information, such as pricing and related track records.

4. Manufacturers: supervise the production link and management in the logistics process; track records of adverse events; product quality issues due to excessive logistics processes and poor warehousing by small suppliers; high circulation cost in production; and low product competitiveness.

1.2.4 Research Questions

Facing the challenges of consumables management process reengineering and optimization, this research conducts field studies based on co-opetition theory, business process reengineering, total quality management, and zero inventory theory; provides insights of the issues, solutions and outcomes related to consumable medical supply management platform process, information platform and process based information platform in the hospital.

1.3 Research Methods, Content, Contributions, and Limitations

1.3.1. Research methods

First, this research studies and analyzes issues in China's consumable medical supply management process, summarizes the current state, and then puts forward needs in that process. The research also points out there is a significant gap on consumable medical supply management in China and abroad. Current consumable medical supply management in China has not yet adopted a co-opetition based management model.

Current research focuses on inner circulation in the hospital while neglecting external relationship with suppliers. Chinese scholars mainly apply qualitative research lacking modern management techniques and methods in quantitative analysis. The research methodology used in this study includes discussion of theoretical basis, conducting interview, case analysis and questionnaire survey in regard to information-based platform in hospitals.

1. Through interviews, this research analyzes issues in consumable medical supply management process and further discusses how to reengineer and optimize as well as taking upon information technology based approaches. There are three groups being interviewed, one of the group leader is director of the company who designed the information technology based reengineering and optimization of consumable medical supply management process. This approach facilitates interviewees and as a result, the participants serve as “information provider”, rather than “interviewees” (Yin, 2002/2012).

2. On the basis of co-opetition concept, this research analyzes the management model based on cooperation after optimization of the procurement process. From three dimensions including logistics process, management function, and implementation model, this research elaborates on integrated procurement plan of medical interconnection service platform, integrated inventory management, integrated materials supply management and integrated payment management, all of which serve the goal of cost reduction to the greatest extent. Medical equipment interconnection service platform facilitates strategic alliance of manufacturers, suppliers, and hospitals. It enables external cost control and outsourcing of non-value-creating and non-core business activities. A hospital in Shanghai implemented such strategy in its consumable medical supply management, the effects of which were recognized.

3. Based on the traditional inventory management theories, the research analyzes high costs caused by redundant inventory, excessive non-value-creating and management processes in the consumable medical supply management. Through process reengineering and optimization, the thesis establishes an integrated logistics process based on JIT and zero inventory, the thesis further points out some key issues in the logistics process.

4. The research carries out a case analysis of hospital internal process and information platform after the hospital implements medical equipment interconnection service platform. The case, which is based on real-life data of inventory, quality, and cost of a hospital in Shanghai, aims to test the optimization results of consumable medical supply management process.

5. Based on the field interviews and the case study, a questionnaire survey was conducted with executives and managers from a large hospital in Shanghai which had implemented the medical equipment interconnection service platform. The purpose of the survey was to provide quantitative evidence of the changes in the satisfaction levels of the executives and managers towards the consumable medical supply management process between the pre-implementation and post-implementation periods of the platform.

6. On the basis of the current research on consumable medical supply management both in China and abroad, this research analyzes theory of JIT, theory of co-opetition underlying business process reengineering; combines information technology, supply chain management and cost control; and then compares three cases of consumable medical supply management process reengineering and optimization in China. The conclusion is drawn based on empirical test of a hospital in Shanghai that medical equipment interconnection service platform provides an ideal solution to the problem.

1.3.2. Research content

This research carries out analysis on the complete process of consumable medical supply management. On some links in the management process, the research uses quantitative prediction methods to analyze and summarizes the key cost center within links in the management process (manufacturers, suppliers, the supervisory department, and hospitals). Following zero inventory theory, co-opetition theory, and business process reengineering theory, the research proposes means to achieve the goal of consumable medical supply management process reengineering and optimization. The proposed processes are implemented and further tested.

This thesis is organized as following:

Chapter 1: Introduction. It introduces the research problems and analyzes the research background, research contributions, and explains research direction based on literature

review.

Chapter 2: Literature review. It elaborates theories of management process reengineering and optimization including co-opetition, business process reengineering, total quality management, zero inventory, and current research on consumable medical supply management information application.

Chapter 3: Research methods. This thesis undertakes a mixed methods approach including qualitative interviews, case studies, and quantitative study uses questionnaire survey.

Chapter 4: Empirical analysis of consumable medical supply management process reengineering and optimization from interviews and survey results gathered from Chapter 3.

Chapter 5: Conclusions. The research is summarized and conclusions were drawn. Limitations of the research and suggestions for future research are discussed.

1.3.3. Research contributions

1. This research puts forward a research direction for consumable medical supply management that is in compliance with the direction of medical reform of China, especially in the context of public hospital medical reform.

2. Under the circumstances that national financial support to hospitals is on the decline, this research seeks solutions to solve cost and quality issues rooted in the current outdated consumable medical supply management.

3. This research integrates information technology, inventory management, government supervision, complete supply chain service, and cost control into one service platform for consumable medical supply management. The research also empirically tests the feasibility of the proposed platform.

4. Previous studies mainly focused on hospital inventory management in consumable medical supply management, however there is a lack of discourse on the process side. Previous inventory management research mostly used quantitative methods at a single time point. This research carries out both quantitative and qualitative analysis on hospital inventory outsourcing focuses on inventory process optimization, from supplier to the

user by utilizing information technology. This research further contributes in building new theories and ultimately cuts down the cost occurred in the redundant processes.

5. With reengineering and optimization, consumable medical supply management process enables cost reduction through management service and realizes relatively zero inventory management model to reach optimal inventory management of circulation process.

6. This research puts forward the fourth-party logistics, namely the medical equipment interconnection service platform.

1.3.4. Research limitations

1. This research only focuses on consumable medical supplies, as a part of hospital materials management, it does not cover the reusable the consumable medical supplies, which is another important part of medical supplies.

2. Limitations of data collection. In China, only three Corporate Groups realized information technology in consumable medical supply management process. However each of the three groups focuses on different aspects. Therefore, the number of interviews carried out is limited. Chinese corporations practice commercial confidentiality for unfinished projects and as a result, access to data is limited. Finally, the public bidding price for the same product or service differs across regions, hospitals keep bidding related information private, hence affects the data collection efforts.

1.3.5 Chapter Summary

This chapter reviews traditional consumable medical supply management process, summarizes the existing problems, contrasts critical aspects of the existing demand and potential demand in the process. Furthermore, this chapter posits that the management process of consumable medical supplies needs to be reengineered and optimized so as to provide hospitals and patients, the end users, with more effective and secure management processes. Finally, this chapter discusses the research objectives, content, methods, potential contributions and limitations.

Chapter 2: Literature Review

This chapter reviews literature and theories related to reengineering and optimization of consumable medical supply management both in China and abroad focusing on consumable medical supply management process. The theory basis includes co-opetition, business process reengineering, total quality management, information-based platform, and zero inventory. This chapter also elaborates on how co-opetition theory and business process reengineering theory can explain the optimization of inter-organizational relationship in consumable medical supply management process and how information technology can assist hospitals to realize zero inventory of consumable medical supplies.

2.1 Co-opetition Strategy

2.1.1 Co-opetition Strategy Theory

Co-opetition theory originated from the context of today's complex supply chain environment addressing the nature of competition's own characteristics of confrontation. J. Nalebuff, management professor in the University of Yale, and Adam M. Brandenburger, management professor in the University of Harvard cooperated and published *Co-opetition: A Revolution Mindset that Combines Competition and Cooperation* in 1996. They believe that business operation of enterprises is a unique form of game that can achieve non-zero-sum and create win-win results.

The concept of Co-opetition: enterprises compete with each other, but also cooperate to an extent. It is a new concept of coexistent of competition and cooperation aims to create value and gain success for corporations in the Internet enabled economy. Co-opetition emphasizes the role of cooperation, which effectively addresses issues caused by over competition in the traditional view of business strategies. Co-opetition also contributes to business strategic management. Nevertheless, game theories make business co-opetition strategies as a new analytical tool for enterprise strategic management research. The core logic of co-opetition theory is creating a win-win situation, proposes enterprises shall analyze business interactions in a game-playing

mindset and build reasonable co-opetition relationships with other participants in commercial activities.

The concept of non-zero-sum-game: the sum of gains and losses in the game playing of each party is not equal to zero. Different from the uses of this concept in economics, one participant's gain of utility is not balanced by the loss of the utility of the other participant. Simply put, one's happiness does not build on the others' misfortune, one does not necessarily benefit from hurting others' interests. Therefore, there is a possibility where participants in the game cooperate with each other to achieve win-win results. Competition among interested parties could motivate members in the party. Following this logic, the co-opetition relationship among different participants will influence level of motivation within the party, as each party will see cooperation with other parties as positive external conditions and competition as negative ones. New enterprises do not have clear boundaries in this regard. Their operation process, operating system, and staff shall interact with customers, suppliers, partners, and competitors to form healthy relationships. Enterprises should not be isolated in their own bubble but to a united kingdom to gain competitive advantages.

2.1.2 Co-opetition Strategy Theory as a Support for Reengineering Consumable Medical Supply Management Process

The goal of co-opetition is to build and maintain a dynamic co-opetition relationship with all the other participants so as to achieve win-win results. Nalebuff and Brandenburger (1996) suggest that if a company wants to create values, it needs keen cooperation with its customers, suppliers, employees and other parties. This is a way to expand the current market and develop new market. In the consumable medical supply management process, manufacturers, suppliers, and the hospitals have a co-opetition relationship as they all share the same goal namely increasing market share. Supervisory institutes also favor aforementioned type of relationship as it enables accuracy in information gathering and data collecting and thus enhances the supervision efficiency.

2.2 Business Process Reengineering

2.2.1 Definition of Business Process Reengineering

The word “process” is defined in *Oxford English Dictionary* (The Clarendon Press, 1978: 1408) as: a series of actions that are carried out in order to achieve a particular result; one or a series of continuous operations.

2.2.2 Core Principles of Business Process Reengineering

The core principles of business process reengineering are: process-centric, people-oriented management and target-guided approach (Han, 2004). Process-centric is the core principle. Enterprise reengineering aims at transforming the function-oriented approach into the process-oriented approach, changing the original leader-centric management system into a people-oriented team management system based on the need of the process. The ultimate goal of business process is to create guiding principles that are best suitable for customers’ needs.

2.2.3 Status of Research on Business Process Reengineering in China and Abroad

Business process reengineering in American hospital management emerged from the 1990s and became widely used in the field of hospital management since then. According to the data analysis of investigation report on medical institution reconstruction and reformation issued by American Hospital Association, only 15 hospitals started to implement business process reengineering plan prior to 1991, however, in 1992 the number went up to 46, and in 1995 the number was tripled to 144. Since then, the growth slowed down. The Massachusetts State Hospital reengineered emergency department in order to mitigate overcrowd and long waiting time for patients (Lewandrowski, Corboy, Lewandrowski, Sinclair, McDermot & Benzer, 2003). Packwood reported the case of one London hospital using business reengineering theories to summarize the feasibility, impact, and critical factors of BPR approach (Packwood, Polltt & Roberts, 1998).

Chinese scholars started to pay attention to the research of hospital management process since late 1990s. The influential pioneers include Ma (2005) from Beijing Medical University. Su (2000) and Huang (2005) put forward zero inventory concepts into hospital. Jiang (2007) studies business process optimization of hospital materials

management, introduces process optimization solutions for consumable medical supply delivery and establishment of consumables supermarkets. The relationship between hospital information technology application and business process reengineering has also been studied extensively in China (Lai & Song, 2004; Zheng, 2008).

2.2.4 Basic Approaches to Business Process Reengineering

There are two major approaches in business process reengineering, namely, systematic reengineering approach and brand new design approach. The first approach, which emphasizes on analyzing the existing process and using the result as the basis for the new process. The second approach on the other hand, fundamentally challenges the old way of providing products or services and seeks to design the new process from scratch. This approach can be summarized by the ESLA principles, which stand for, namely, eliminate, simplify, integrate and automate (Peng, 2004).

2.3 Total Quality Management

2.3.1 Definition of Total Quality Management

Total quality management (TQM) is a management philosophy driven by customer needs and expectations. TQM focuses on managing quality with staff participation. The purpose of TQM is to gain long-term customer satisfaction and benefits the organizations and the society as a whole. TQM is defined as a management approach focused on quality and consists of organization-wide efforts in the purpose of gaining long-term success where customers are satisfactory and all participants of the organization and the society enjoy the benefits in ISO8402. Feigenbaum (1991) defined TQM as an effective yet economic integrated system that considers marketing research, design, manufacturing, and post-sales service holistically to meet customer expectations, control, maintain and improve quality among different departments in a corporation.

2.3.2 Evolution of Total Quality Management

There are four stages of the development of TQM. In the first stage, Japan adopted TQM from the United States; in the second stage, statistical and computer technology were used extensively in quality management; in the third stage, contents and

requirements of total quality management became standardized; in the fourth stage, the importance of quality management was realized in business management with maturity of relevant theories. People also came to realize that product quality is not only concerned with production process but also related to many other factors in the process. Only when all the factors that affect quality are considered and coordinated in the management process can the product quality be ensured. Therefore, TQM requires “four Ts and one M”, four Ts stands for total process, total staff, total enterprise and total procedure, whereas M stands for multiple methods.

W. Edwards Deming is the most well-known quality management master in the world. Deming did not publish many works in his lifetime, but all the works he published are of great importance. In the 1960s, he published a book related to sampling theory, twenty years later, the Center for Advanced Engineering Study in MIT published a series of Deming's works, including *Quality, Productivity and Competitive Position* (Deming, 1982), *Out of the Crisis* (Deming, 1982), *The New Economics* (Deming, 1994). Before the 1970s, Deming's theories are more about technical and statistical approaches in management. In the 1980s, his focus gradually shifted to management and in the 1990s, Deming advanced statistical quality management theories, and further proposed concepts on governing and benefitting the people. In his book *Quality, Productivity and Competitive Position* published in 1982, Deming points out that the major reason for America's industrial circle being defeated repeatedly in the world market competition is that senior managers in the American enterprises are not at all competitive. They don't plan ahead and do not foresee problems until it is too late. As a result, a lot of resources in human capital, material, equipment, and time are wasted. Furthermore, Deming puts forward concepts vastly different from the traditional economics views that encourages using competition to stimulate progress. On the contrary, he suggests embracing cooperation rather than competing with each other to achieve win-win situation for all participants.

Ever since TQM concept was introduced to China from Japan's Komatsu Co. Ltd in 1978, it has been paid great attention to. Especially after the establishment of Chinese socialist market based economic system, quality management progresses together with

improvements of market based economic system. The TQM contributes significantly throughout 30 years of China's economic reform and opening-up policy. However, the boat of TQM has not always been smooth in the sail, there is imbalance under the tremendous pressure of fast-speed economic development. Some profit driven enterprises were anxious to gain quick success and instant benefits neglecting quality as a result, issues emerged one after another in various ways. This phenomenon exerted a great influence on efforts for development. The passing rate from national quality supervision spot check has not made much progress with serious quality safety issues occurring one after another. All of the problems show that there are still many quality management drawbacks in the current situation and much room for development (You & Wu, 2009).

2.4 Traditional Inventory Theory VS. Zero Inventory Theory

2.4.1 Basic Theories of Traditional Inventory Management

The traditional inventory management approach emphasizes uninterrupted production as the core, product and services as the goal and on time delivery as the content. The inventory management system only issues orders and urges delivery. It also determines the time to order goods using order point method, and determines the optimal quantity of each order using the economic order quantity method. The order point method is a method characterized by prediction of future material needs based on history. The essence of this method lies in compliance with the "inventory replenishment" principle, according to which a certain amount of inventory is kept in the warehouse at any time to keep it readily accessible throughout production. The economic order quantity method is a method where economic lot size formulas are used to calculate the minimum order quantity that enables the sum of ordering cost and inventory cost to stay at the minimum. Although these methods may seem to be scientific and the inventory models constructed with these methods used to be called "scientific inventory models", it is not the case in practice. These methods are founded on the basis of a set of assumptions that can hardly withstand any real world scenarios. The hypothesis of the traditional inventory management approach is that the needs for various kinds of materials are independent from each other.

The traditional inventory management approach takes no consideration into the links among entities. The order points of the items are determined independently. However, in actual practices, the quantity of various items should be properly allocated to produce final products. The traditional inventory management approach is in compliance with the needs of traditional manufacturing. Enterprises produce goods according to plans assuming no major fluctuations in the production quantity. Therefore, the demand for materials is also even. However, in the modern manufacturing industry, enterprises are geared towards the market, they have uneven and unstable demand for materials, furthermore, and the demand for inventory could also be seasonal. Therefore, the economic order quantity method is obsolete and unnecessary.

2.4.2 Concept of Zero Inventory Management

The idea of zero inventory originates from Japan back in the 1960s and 1970s. In the beginning, zero inventory was introduced as a way to avoid overstocking raw materials and semi-finished products. Later on, zero inventory management was used not only in production, but also extended to other processes such as purchasing, logistics, and sales. Therefore, zero inventory maximizes benefits with minimum inventory and capital investment. It is the highest level of material management, significantly reduces unit cost and as a result, gains competitive advantage (Wang, 2000).

2.4.3 Purpose of Reengineering Consumable Medical Supply Management Process: to Achieve Relative Zero Inventory Management

Zero inventory in management of reengineering and optimization of consumable medical supply management process does not mean that the stock of certain items is zero, but implementing some specific inventory control strategies to ensure the stock is minimum. Therefore, the connotation of “management of reengineering and optimization of consumable medical supply management process” refers to the stock of certain items is “zero”. In other words, there is no regular inventory. “Zero Inventory” is a special form of supply chain management approach that is feasible under the premise of abundant social stockpiles. From the perspective of rationalization of logistics activities, management of reengineering and optimization of consumable medical supply management process should bear the

following three implications: coordinating among different processes; eliminating unnecessary intermediate steps; IT enabled real-time information exchange between management process and demands.

2.5 Status of Research on Consumable Medical Supply Management Process in China and Abroad

Study on management of consumable medical supplies mainly discusses inventory management and information management. The following literature review covers the current status of aforementioned two aspects.

2.5.1 Status of Research on Consumable Medical Supply Management Process in China and Abroad

Inventory management of consumable medical supplies includes two parts: the first part refers to inventory function of consumable medical supplies throughout the whole supply chain, right from manufacturers to hospitals; the second part refers to logistics function of consumable medical supplies in the supply chain.

Apart from timely purchase of necessary consumable medical supplies, a hospital still needs a certain amount of stock to guarantee regular and timely supply of consumable medical supplies and avoid backorder. However, too much stock of consumable medical supplies will cause problems for purchasing, while insufficient inventory poses difficulties to clinical use. Therefore, an appropriate quantity of consumable medical supplies inventory is important to capital turnover in purchasing, supplying and other steps in the supply chain.

Foreign studies on inventory of consumable medical supplies have gone through several stages, from single-echelon inventory quantitative order method to multi-echelon inventory management and then to supply chain management. Studies of single-echelon inventory quantitative order method mainly focus on medical consumable supply methods, in which orders are placed from suppliers in a bottom-up manner. This method is used to solve inventory problems according to predictable random demand and available time for preparation before placement of order on the basis of experience (Durham & Robert,

1973). Stephen (1978) studies inventory management models for equipment that is reusable and needs disinfection treatment. In his research, he divides the equipment inventory into process and replacement inventory; process inventory on the other hand is mainly used for recycling in the medical operation process, another difference between the two inventory is that replacement inventory is for supplement of equipment that is lost or defective in the process inventory. These two inventory types shall adopt different inventory management models. Kapur and Moerg (1987) carries out research on using annual inventory turnover rate to generate optimal order cycle time. Dellaert (1996) analyzes inventory control methods for professional hospitals' central warehouses. Sinha and Matta (1991) study cost minimization for two-echelon inventory storage cost plus stock-out cost of the lower level inventory. Rogers and Tubakitani (1991) make research on fixed order lead time, order cycle of two-level inventory system under random demand, as well as definition issues of benchmarking inventory level. The focus of the research is to minimize stock-out cost of the lower level inventory within the budget range of total inventory investment. A comprehensive supply management system has come into existence after years of research. In this model, management problems are resolved from four aspects namely, economic order quantity, re-order point, optimum storage volume, and transport strategy. This model greatly reduced management cost and integrated studies on consumable medical supplies inventory. In the 1990s, researchers began process based inventory study. As a result, supply chain management emerged. The so-called supply chain management refers to comprehensive and integrated management of logistics, information flow, and capital flow, covering the whole supply chain, from manufacturing to distribution and then to sales. It also refers to management of up-stream suppliers and down-stream customers from the perspective of general supply chain, serving the purpose of creating more values to customers with lower costs (Martin, 2012). On the issue of lowering costs of hospital materials purchasing in supply chain, Ford's (2006) research applies supply chain management approach in medical materials purchasing, concluded with lower cost of medical materials supply chain. Young (1989) points out that using the relationship between hospitals and suppliers to manage major suppliers can increase the efficiency of medical materials purchasing. Applying public

procurement of medical materials can lower the procurement costs for hospitals (Chandra, 2011). More and more research studies the systematic methods to manage inventory in the circulation process in supply chain management. The systematic method adopted by Hewlett-Packard Company is an innovative method of managing inventory (Lambert, Stock, & Ellram, 2005/2011).

The research on international logistics and supply chain includes research on the development progress from third-party logistics to fourth-party logistics. The third-party logistics providers are companies that specially provide logistics service to their customers. They may be supplies distribution centers themselves with added value services such as repackaging, they deliver packages through their shipping department. The fourth-party logistics is originated from Accenture. Due to globalization and complexity of the supply network, an enterprise's own efforts and capabilities are not sufficient to maintain good management of the network. Under such circumstances, professional organizations emerged aim to apply its knowledge of supply chain and cooperate with the third-party logistics service providers to manage and integrate the supply chain. The fourth-party logistics requires the best service providers with independent information system, so as to ensure a cost-effective and sustainable supply chain. There are four essential elements to form the fourth-party logistics: systemic structure and integrated technology; a command center for the supply chain; the ability to gain information and knowledge from the Internet; and cooperation with the best resources providers (Martin, 2012).

The research on inventory management of consumable medical supplies began in the 1980s, about thirty years ago in China. During the planned economy period, the purchasing quantity and inventory level of consumable medical supplies were decided by the state government, a level-to-level systematic planned management approach was used. Supply was allocated hierarchically and systemically. After the establishment of the market-oriented economic system in China, hospitals gradually take over the decision right on purchasing function from state government. Relevant staff in hospitals took charge of the purchase and inventory on the basis of their experience. However, due to the

lack of scientific order methods and unstable number of customers, overstocking occurred. The excessive stock not only took up too much storage that led to a waste of human resources but also resulted in serious occupation of capital. Moreover, the amount of waste increased as the chain of suppliers became longer. Besides, logistics cost also increased due to the excessive number of distributors and steps in the logistics process. In the last decade, the emergence of studies on the supply chain of medical supplies in China started to focus on hospital-supplier cooperation, centralized information management platform and unified management of hospital industrial group. Song and Song (2005) analyze problems existed in Chinese medicine reform and medical system reform from a macroscopic perspective. They point out that Chinese enterprises should establish and improve their own supply chain management system if they are to survive. Chen (2007) explains the content and meaning of supply chain management system in the hospital, analyzes the basic structures and implementation patterns of hospital supply chain management system, and gives suggestions on improving hospital resources management from the perspective of system innovation. Chen (2005) conducts analysis on the logistics cost structure for hospital medical materials and puts forward optimization methods to reduce hospital logistics costs.

2.5.2 Status of Research on Information System-enabled Consumable Medical Supply Management Process in China and Abroad

Information management of consumable medical supplies covers human resources, financial resources, material resources, as well as information centralization process in the whole supply chain, which starts from manufacturing to distribution and then to sales.

Computers have been used in many foreign hospitals for over 40 years. Americans started their hospital information systems (HIS) research in the 1960s. In the 1970s, there was a significant development of HIS. During this period, university hospitals and medical centers in the U.S., Japan and Europe began to work on system development, laying the foundation for hospital information management. In the 1980s, the hospital information management in U.S. and Japan finished their transformation from small-scale management to intelligent and integrated management. In 1995, Hammer and Champy, two scholars in America, put forward business process reengineering which later was

widely used both in China and abroad (Hamel & Prahalad, 1995).

In China, hospital information research did not start until the late 1980s. In 1987, Li and Xia (1987) carried out Pareto classification of drug inventory by using language programming, based on which different modules were established, reasonable inventory of drug was realized and purchasing plans were made. In the late 1990s, Chinese scholars started their research on hospital management process. The necessity of reconstruction and reengineering of hospital management process explored in the study entitled “Reconstruction and Reengineering of Supply Process of Hospital Supplies” (Zhao & Han, 2005); inventory management for low-value and high-value consumable medical supplies was discussed in “Inventory Management of Consumable Medical Supplies” (Sun, 2008); and inventory management of consumable medical supplies in hospitals was analyzed in “The Optimization of Consumable Medical Supplies Inventory Management” (Wu, 2011).

Up to now, much progress has been made in research on consumable medical supplies management in China. However, when compared with some foreign countries, China is still far behind. Though there are a certain number of studies on inventory control and management of consumable medical supplies, information integration and process, few of them put all the pieces together. There is not a single integrated information process management system which links involved processes and parties in the supply chain together, from manufacturers to end users. As a result, problems concerning the human error can be found in every link of the process, resulting in low efficiency and high cost throughout. Furthermore, every link of the supply chain uses independent information systems, leading to low level of centralized information. Thus, information and functions are isolated, and connections still need to be linked manually.

2.5.3 Status of Research on Results of Reengineering Consumable Medical Supply Management Process in China and Abroad

Level of application and relevant international technologies: large distribution enterprises, such as MCKASSON in the U.S., are equipped with the ability to provide distribution services nationwide. Tens of thousands of business varieties are provided by

the enterprise, from drugs to medical equipment. Moreover, e-commerce platforms and management supervisory services are also in the business scope; enterprises such as Medline and PSS World Medical can provide nationwide distribution services as well as e-commerce platform services even though they are small in size; specialized enterprises, such as NDC and IMCO, can provide purchase, distribution, storage and training services. It is worth mentioning that NDC, whose annual sales volume exceeds 6.6 billion US dollars, provides services for 300 regional medical institutions in North America. What's more, NDC also provides e-commerce platforms for member enterprises and medical institutions, as well as data services platforms and product promotion platforms for manufacturing enterprises, realizing information-based integrated management platform for medical materials' inventory management (Lambert, Stock, & Ellram 2011).

As to the current status of research on consumable medical supplies management in China, Li (2010) conducted an experiment of zero inventory management of consumable medical supplies in Workers' Hospital in Tangshan City, Hebei Province by adopting the management mode of tertiary industry. Ren and Gao (2010) pointed out the importance of information management for Gansu Province Hospital of Traditional Chinese Medicine in its consumable medical supplies management and carried out simple practicability analysis. Chen et al. (2009) used bar code technology to conduct whole-process management of hospital supplies in Fuzhou General Hospital of Nanjing Military Command and fulfilled partial zero inventory management of consumable medical supplies. Zhu (2013) carried out information management to solve inventory management problems brought by different varieties, different terms of validity, different batch numbers and different preservation conditions using bar codes; He (2009) carried out classification management of hospital supplies and conducted a comprehensive analysis of human cost, inventory cost and depreciation cost of supply management in hospitals. The aforementioned studies all emphasize information-based management of consumable medical supplies; however, their limitations are evident as the research only focuses on one point or one aspect of the process. A systemic information-based management platform is yet formed.

Internationally, hospital inner logistics transport system had adopted the approach of

Automated Guided Vehicle (AGV). AGV system (AVGS) also refers to trackless ride system and AVG transport system. It is a mobile robot that automatically guides transportation under the control of computers and wireless local area networks. The vehicle uses magnets or lasers for navigation and follows provided trails in the floor and stop at the appointed destination to finish transportation. It is being used to move medical materials in hospitals. AVG has provided a highly flexible and automated transportation method for logistics of modern manufacturing industry. It is mainly used to replace labor-intensive trolley. Hospitals in developed countries and regions introduced this logistics transportation system a long time ago; its application has broadened and a full range of vehicles are available today. Medium and/or large hospitals in America, Germany, Japan, and Singapore have been equipped with logistics transportation system.

In the current stage, the logistics approach used in most hospitals in China is a combination of professional delivery team, trolley, and multiple elevators. Such approach has obvious shortcomings with susceptibility to infection, high error rate, complicated environment, and excessive costs for human resources. To summarize, there are various problems in the consumable medical supplies management in China, mainly in the following aspects. In terms of system, an integrated management model has yet to be established; as to process management, internal hospital management is given more importance while the external management with suppliers is neglected; finally, in regard to cost control, the cost occurred in the supply chain process is understudied.

2.5.4 Chapter Summary

Based on the co-opetition theory in order to realize zero inventory management, this chapter discusses the research on implementation of information management of hospital supplies both in China and abroad, points out the problems existing in the current management of consumable medical supplies and further explains the importance of reengineering and optimization of the process. More specifically, a comprehensive platform for management of consumable medical supplies should be formed to realize information management for the complete process. The traditional management process, which covers a long chain and multiple points from delivery of qualified consumable

medical supplies to hospitals' usage, should be reengineered into a three-point management process, covering manufacturers, platforms and hospitals only. Under the reengineered and optimized management, an interconnected platform featuring professional management, intensified control, information-based monitoring, and timely services shall be established. A more effective management system can be achieved through such a platform, connecting the upstream manufacturers, suppliers, and to the downstream hospitals.

Chapter 3: Research Methods

This chapter elaborates on research methods that this thesis uses to study consumable medical supplies management process reengineering including interviews, empirical studies, questionnaire, and surveys.

3.1 Interview

3.1.1 Interview Purpose

The purpose of the interviews with executives from three representative manufacturing enterprises of consumable medical supplies is to recognize the consumable medical supplies management approaches of these enterprises and to analyze the necessity and rationality of these approaches to reengineer consumable medical supplies management process. With the insight knowledge provided in the interviews, the research on consumable medical supplies management process can be more advanced and mature.

3.1.2 Interviewees

Interview site 1, Shifeng Medical Equipment CO., Ltd in Sichuan, which has adopted an e-commerce marketing mode of medical equipment.

Interview site 2: Tuoren Group, which has created a “centralized distribution & supply” service mode of medical equipment and consumables called CGPO.

Interview site 3: Shanghai Kindly Enterprise Development Group, which has introduced a medical equipment interconnection service platform.

Table 3-1 List of Interviewees

Enterprise	Position	Sex	Age	Years of Work Experience	Focus
Site 1, Shifeng Medical Equipment CO., Ltd	Chairman of the Board	Male	48	29	General market and industrial development
	Chief Marketing Officer	Male	40	16	Market share
	Information Manager in the Subsidiary Company	Male	38	12	Information management and market relations
	Customer Service Director	Female	35	12	Customer concerns
	Warehousing Manager	Male	39	15	The importance of barcode in the warehousing process
	Financial Manager	Male	42	18	Cost of capital and profits
	Chairman of the Board	Male	50	28	Production and market expansion approach
	Vice Chairman	Male	44	20	Logistics cost control
	GPO Project Leader	Male	40	16	Information and integration management
	Chairman Secretary	Female	45	20	Purpose of projects
Site 2: Tuoren Group	President	Male	58	34	Control and platform design
	Vice President	Male	55	34	Feasibility analysis and market environment analysis
	General Manager	Female	37	12	Platform project appraisal and information management
	General Manager	Male	49	30	Production and cost control management
	General Manager	Male	48	24	Management of production deployment of five major parts
	General Manager	Male	42	18	Realization of medical equipment interconnection service platform
	CFO	Female	40	16	Saving on financial costs
	Marketing Service	Male	40	16	Influence of platform to market

Source: The author.

3.1.3 Interview protocol

The interview protocols are illustrated below:

Table 3-2 Interview Questions

Question	Content
Question 1	Current marketing and management approaches of consumable medical supplies.
Question 2	Management of consumable medical supplies in the company's industrial park with reengineering model.
Question 3	Current consumable medical supplies management process reengineering.
Question 4	The company's orientation of reengineering model.
Question 5	Analyze the basic theories adopted by the company's reengineering model.
Question 6	The supplier link in the company's reengineering model.
Question 7	Analyze the company's compliance with state policies of reengineering model.
Question 8	Consumable medical supplies management information application of the company's reengineering model.
Question 9	Challenges facing consumable medical supplies management process reengineering in the company's reengineering model.
Question 10	The actual operation of the company's reengineering model.
Question 11	Advantages of the company's reengineering model.
Question 12	Disadvantages of the company's reengineering model.
Question 13	Share your opinions on the self-assessment of the company's reengineering model.

Source: The author

3.2 A Case Study of Medical Supply Interconnection Service Platform

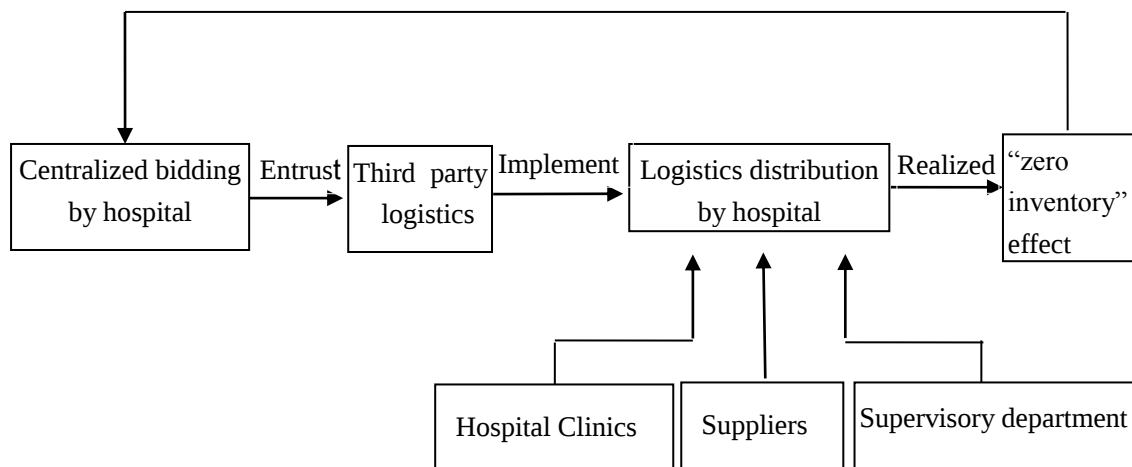
3.2.1 Implementation Background

The main purpose of consumable medical supplies reengineering is to put forward solutions to simplify process, to improve management, and to reduce costs. It is a significant task to persuade hospitals, the biggest beneficiary and the final institution that verifies the results of the solutions, to have the willingness to accept consumable medical supplies reengineering. It is an equally important task to ensure that after the hospital accepts the new platform after reengineering, the consumable medical supplies reengineering will meet usage requirements and the final purpose of the hospital. In 2011, a hospital in Shanghai started to implement hospital materials management platform that is part of the medical equipment interconnection service platform. The implementation of the platform verified the effects of consumable medical supplies management after reengineering.

3.2.2 Implementation Purpose

According to its scope of validity, the supply process of consumable medical supplies can be divided into two stages, namely, hospital internal process and hospital external process. Hospital internal process refers to the working process done inside the hospital, such as the procurement plan formulated by departments. The hospital external process is the working process completed outside the hospital system, such as manufacturing process and activities carried out by suppliers in the logistics chain. In order to gain knowledge of hospital internal process performance and to assist hospital in cutting cost of consumable medical supplies, this research focuses on the case of a hospital in Shanghai, which has used the platform for two years. The purpose is to testify the practical significance as well as the effects of consumable medical supply management process reengineering in real practice.

Figure 3-1 Purpose of Hospital Internal Process Reengineering



Source: The author

3.2.3 Problems Addressed for Implementation

In this study, a well-known large hospital in Shanghai, China was examined. The hospital has two branches. It is a leading institution in hospital management. When it put forward reengineering of consumable medical supplies in 2008, the proposal was executed by Shanghai Kindly Group which had formed a team to carry out the proposal. This real case of hospital zero inventory management is an early and advanced case in China, hence an ideal subject for research study of consumable medical supply management process reengineering. However, even with such a favorable background, the hospital is still facing the following four types of problems.

Problem One: Obsolete management philosophy and unreasonable organizing structure

For a long time, the hospital, as an institutional unit and a non-profit government welfare unit, has been ignoring the importance of management. Management of the internal control of the hospital was enhanced only after restructuring of the hospital. The hospital places little emphasis on management of consumable medical supplies. So that non-systematic management is applied in the convenience of the staff.

Problem Two: Delayed logistics information on consumable medical supplies

The hospital has achieved the construction of systematic information, internal network, and the automation of the charging system, clinical system, and office

administration, as well as information-based management of registration, queuing and pharmaceuticals. However, management of consumable medical supplies is still primitive. Data entry, vouching, and verification are all done by manual work. Consumable medical supplies are divided into seven categories. The data and information of varieties, volume, amount of money, manufacturers, and suppliers are typed in manually as well, and have led to excessive use of labor force in the hospital, such as excessive staff in charge of inventory, distribution, and settlement which in turn have led to an escalation in cost.

Problem Three: Extensive management of consumable medical supply inventory

Procurement of consumable medical supplies is mainly based on the declarations from doctors' experience as reference from each department. In order to ensure normal supply, all departments will proportionally increase the amount of consumable medical supplies without scientific proof when handing in the declarations. Hence, the inventory is increased at the primary stage. When reporting the declaration, departments make decisions on the brands and specifications basing on their experiences and practices. Therefore, hospitals may have to purchase same consumable medical supplies from several brands. And for each of the consumable supplies, small demands place the hospital in a disadvantageous position for bargaining. At the same time, various brands of same consumable supplies accumulate the error rate of distribution. Since there is no integrated management to check the consumable medical supplies data, data needs to be repeatedly checked on by five points including departments, warehouses, accountants, equipment departments, as well as the directors and vice presidents. Repeated work occurs in four steps, namely, verification of reported orders, examination, and approval of inventory discharge, approval of the amount of money and approval of payment. All these lead to increased ineffective work, postponement of information dissemination, and increased error rates. In the manual data entry, only paper records are kept. Sometimes paper records are lost or the data entry is inaccurate.

Problem Four: Difficulties in controlling the consumable medical supply inventory

The new platform covered seven categories of consumable medical supplies in

2008. There are almost 20,000 records on product specifications and information. The current situation of low-value consumable medical supply inventory is to avoid fluctuations in demand, uncertain ordering period, and sales on credit of suppliers, which have resulted in a large stock to satisfy the demand of clinical departments, leading to unreasonable stock and excessive occupation of capital. The process of high-value consumable medical supplies is complex, and resulted in large investment in materials and labor to ensure sufficient supply. Besides, strict requirement for inventory leads to an increase of inventory cost. As expiration data management has to be exercised on all consumable medical supplies, excessive inventory and unreasonable inventory will lead to violation of the first-in first-out principle in cost accounting. In addition, expiration of products and losses are induced by the inconvenient conditions of warehouses leading to excessive waste of capital and escalation in hospital cost.

3.3 Questionnaire Survey

3.3.1 Purpose of Questionnaire Survey

Consumable medical supply process management can be categorized into traditional management and new-mode management. The traditional management refers to traditional consumable medical supply management while the new-mode management refers to process management after reengineering. The questionnaire was administered to gain an in-depth knowledge of the situation of consumable medical supply management in the hospital as well as to facilitate reengineering of consumable medical supply management in the hospital.

3.3.2 Respondents of Questionnaire

The respondents of the questionnaire are 100 executives and managers from the First People's Hospital in Huaihua City with responsibilities related to warehousing department, equipment department, and information department.

3.3.3 Procedures of Questionnaire Survey

Each questionnaire includes 40 questions, among which questions 1-20 are related to traditional management, and questions 21-40 are concerned with the new

management. All questions are multiple choices with one answer. There are five choices for each question, including strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. In total, 100 questionnaires were handed out, tracked and recovered. This survey is anonymous from reliable sources.

3.3.4 Questions in the questionnaire survey

Table 3-3 Questionnaire on Satisfaction

(5 point scale where 1=strongly disagree and 7=strongly agree)

No	Question content
1	There are obvious drawbacks in the traditional management of hospital.
2	Traditional management is not consistent with medical reform's objectives.
3	Traditional management is not sufficiently information-based.
4	Traditional management has a low level of specialization.
5	There are too many process links in traditional management, causing difficulty for cost accounting.
6	The cycle of order management is too long in traditional management.
7	The error rate is extremely high in traditional management execution.
8	Traditional management tracks recognition of management system.
9	Communication between leaders and employees is rather smooth in traditional management.
10	Communication among different departments is rather smooth in traditional management.
11	In traditional management, work efficiency is affected by unsmooth coordination and communication among different departments.
12	In traditional management, different departments shuffle responsibilities.
13	In traditional management, coordination process is too lengthy.
14	Traditional management has limited the development of the hospital.
15	In traditional management, hospital's capital turnover rate is very low.
16	In traditional management, warehousing cost is high.
17	In traditional management, there are too many logistics links leading to high costs.
18	In traditional management, risk control is reasonable.
19	The traditional management is detached from medical reform's objectives.
20	The traditional management is not in compliance with the state's financial support for development.

- 21 In the new management, processing mechanism of adverse event is clear.
 - 22 In the new management, supervisory process is clear and definite.
 - 23 In the new management, high degree of automatic warehousing management is reached.
 - 24 In the new management, the cost of hospital human resources is lower.
 - 25 In the new management, distribution and delivery are more reasonable.
 - 26 In the new management, job responsibilities and performance management are clear.
 - 27 In the new management, service docking is on a regular basis.
 - 28 In the new management, warehousing cost is Reduced to zero.
 - 29 The new management realizes real-time communication in the management.
 - 30 In the new management, there are fewer logistics links.
 - 31 The new management has lowered the financial cost.
 - 32 In the new management, there's less coordination between different departments with clearer responsibilities.
 - 33 The new management accorded the hospital's development orientation which is to put information management in the first place.
 - 34 The new management has reduced the risk of hospital management in logistics and servicing.
 - 35 The new management is managed through an integrated platform.
 - 36 The new management has reasonably applied e-commerce model.
 - 37 The new management conforms to requirements of 2014 directions of Chinese National Development and Reform Commission.
 - 38 The new management has met medical reform requirements of 2014 China's Ministry of Industry and Information Department.
 - 39 The new management corresponds to 2014 hospital development orientation of Health Development Planning Commission.
 - 40 The new management is in accordance with 2014 China's Ministry of Finance's support on hospital's development.
-

Source: The author.

Chapter 4: Data Analysis and Results

4.1 Interview Results

Interview results are elaborated as follows:

1. Understanding and analysis of the current marketing mode and management of consumable medical supplies

Table 4-1 Analysis of Marketing Mode and Management

Example	Description
Example 1	It is clear that the marketing of medical products in China is still not regulated and organized. To be specific, one hospital is served by hundreds of suppliers; a single product is handled by several levels of distributors; while there exist thousands of medical equipment enterprises in one city. The market for medical products is in chaos.
Example 2	Patients, medical staff, enterprises, and hospitals are all dissatisfied with the traditional mode. The traditional mode has resulted in a waste of human resources, material resources, and financial resources, and has led to high risks of commercial bribery, as well as unnecessary links.
Example 3	From the perspective of hospitals, there are numerous categories and various medical product specifications, leading to a high error rate in hospital management. Low-value consumable medical supplies occupies too much room of the warehouse, posing great difficulties to the identification of expired drugs. Furthermore, warehouse management and supplier management are complicated and involves bribery, constraining the capital of hospitals.

Source: The author.

2. Targeted analysis of consumable medical supply management in the three enterprises' industrial parks:

Table 4-2 Targeted Analysis of the Industrial Parks

Example	Description
Example 1	Shifeng Medical Equipment CO., Ltd extended its product chain by introducing manufacturers into its industrial park. It paid more attention to the marketing services and launched a professional e-marketing platform for medical equipment.
Example 2	The Tuoren Group health technology industrial park built up a nationwide logistics center of medical equipment and consumable supplies, and set up a wholesale market of medical equipment and consumable supplies in China. The Tuoren Group is the first enterprise in China to establish the CGPO mode.
Example 3	Shanghai Kindly Enterprise Development Group established the "6+1" mode in 2008. In 2011, it reengineered its consumable medical supply management and established an interconnection service platform for medical equipment which realized zero inventory.

Source: The author

Table 4-3 Analysis of the Existing Reengineering Modes

Example	Description
Example 2	The “Peking University People’s Hospital Mode” of Join Town Pharmaceutical, a listed medical circulation company, was first adopted. Under this mode, demand for medical equipment is measured comprehensively, and the whole hospital is managed uniformly. This mode could solve the problems of hospitals' management of suppliers, it failed to reform the whole process of circulation. To some extent, it serves as a prototype with instructive significance. Shanghai Kindly Enterprise Development Group conducted an experiment in a certain hospital. During the experiment, an information platform was used to manage the whole process, which changed the hospital's management of agents and warehouses. After three years of experiments and improvement, an information-based management approach of medical equipment has been formed. In recent years, pilot programs of third-party logistics of medical equipment have been launched in Shanghai. Package service of consumable medical supplies for public hospitals has also been introduced in the provinces of Henan, Shandong, and Heilongjiang.
Example 3	“Peking University People’s Hospital Mode” of Join Town Pharmaceutical is a comparatively extensive logistics supply chain mode for medical equipment. However, it has only changed the management mode of medical equipment in downstream medical institutions, with no improvement in the logistics process.

Source: The author

3. Analyses of the major positioning of the three medical companies

Table 4-4 Analyses of Major Positioning

Example	Description
Example 1	With its production base in Sichuan Province, the company is known as “the best medical company” in the medical industry in the southwest region of China. It mainly produces medical polymer consumables, among which the most representative product is bag type infusion instrument. And the company gains fame in the sector for its fine management.
Example 2	Tuoren Group, which boasts the best medical anesthesia products in China, is convinced that consumable medical supplies management reengineering is an inevitable process.
Example 3	As China’s biggest producer of medical polymer consumables, the company has been trying to reengineer consumable medical supply management process since 2006 to meet the demands of the new medical reform.

Source: The author

4. Analyses of the companies’ theoretical bases

Table 4-5 Analyses of Theoretical Bases

Example	Description
Example 1	Taobao theory can be applied to study the process of information management of consumable medical supplies.
Example 2	Tuoren Group adopts CGPO model. Similar to Porter’s Five Forces Analysis Principle, the model advocates centralized procurement and supply as well as cost reduction. It can also be used to study information management of consumable medical supplies.
Example 3	Shanghai Kindly Group adopts supply chain information platform model. It uses zero inventory management theory and includes information management research of consumable medical supplies, thus forming an interconnection service platform for medical equipment.

Source: The author.

5. Analyses of supply chain process

Table 4-6 Analyses of the Supply Chain Process

Example	Description
Example 1	Through building an industrial park, small and medium-sized medical equipment manufacturers have been provided with a platform to reduce their input cost so that they can increase the varieties of products for the whole industrial park.
Example 2	Tuoren Group will follow the model of Yiwu Small Commodity City to build a medical equipment commodity city. By holding the Spring and Autumn Exhibitions every year, the company can attract customers from all around the country and establish a membership system for them. The Tuoren Group will also provide a list of nationwide centralized logistics distribution service outlets, meet the cultural needs of customers, and establish institutes, societies, and united cultural bases for its members.
Example 3	Some suppliers are manufacturers in the industrial park, while the majority of them are the original suppliers of the hospital. All the suppliers will be integrated into a platform for unified management. The suppliers can use the platform information for free at the early stage but have to charge fees for warehouse management.

Source: The author

6. Analyses of the companies' conformity with national policies

Table 4-7 Analyses of Conformity with National Policies

Example	Description
Example 1	The medical e-commerce platform has passed the e-commerce certification system. Its medical equipment supply certificate has fulfilled the medical equipment management requirements of national policies. Sichuan Sifeng Group has set up an independent company and obtained approval for these two certificates.
Example 2	Currently, the medical industry upgrading model characterized by “three zero principles”, which means zero contact, zero inventory and zero risk, has been formed. In recent years, national policies have become more clearly defined. So medical logistics bases have been developed across the country in order to meet the needs of the national medical reform in medicine circulation industry. As a crucial part of the medical industry upgrading, the consumable medical supply industry has become one of the key areas in the national medical reform. The construction of the consumable medical supply logistic bases will meet the needs of market pattern during the policy buffer golden period in the future.
Example 3	As shown in the nine tables, the problems in policy, technique and market that may occur in the medical equipment interconnection service platform have been mapped out and tested on this platform. In addition, the platform operator has been certified as a third party to be responsible for the logistical distribution of the medical equipment.

Source: The author.

7. Analyses of information management of consumable medical supplies

Table 4-8 Analyses of the Information Management of Consumable Supplies

Example	Description
Example 1	Because the e-commerce platform of medical products is dedicated to research on information management of consumable medical supplies, a large amount of money needs to be invested. This requires online operators, manufacturers, and suppliers to jointly bear the cost so that the platform can enjoy sustainable development.
Example 2	Tuoren Group is now prepared to set up an e-commerce transaction platform and aims to gradually build it into a medical e-commerce platform providing services both home and abroad through integrating the current e-commerce resources, designing an integrated e-commerce system and establishing an improved technical maintenance and guarantee system. Now it has introduced the most advanced consumable medical supply information platform and launched pilot programs in a variety of medical institutions in different regions. With the scope of the pilot programs expands, the electronic information platform will be eventually geared to the CGPO model. The market will advocate the principles of being fair, open, and just.
Example 3	Since 2006, the company has been studying the model of the consumable medical supply electronic logistics supply chain. The industry experts approved that its electronic information management platform can be used as a tool to manage the consumable medical supplies. After several years of research and assessment by industry experts, the information platform has been operating tentatively in a hospital of Shanghai since 2011, with recognition from the hospital and the government. Now, it has basically realized zero inventory information management of consumable medical supplies.

Source: The author

8. Analysis of resistance in the reengineering process of consumable medical supply management

Table 4-9 Analyses of Resistance in Process Reengineering

Example	Description
Example 1	The access rules set by the medical e-commerce platforms have influenced the interests of some illegal and unqualified manufacturers. Commercial Platform B hopes to sell its products directly to hospitals through the e-commerce platform, which inevitably encounters resistance from distributors since their interests have suffered.
Example 2	The CGPO of Tuoren Medical Equipment Shopping Mall requires the establishment of a large supplier's alliance. This will partially harm the interests of small-sized distributors and suffer from pullbacks from them.
Example 3	The medical equipment interconnection service platform will be met with resistance from hospitals, peer competitors, imperfect information platform and so on.

Source: The author

9. Analyses of companies' practical operations

Table 4-10 Analyses of Practical Operations

Example	Description
Example 1	Currently, there is no hospital that fully depends on the e-commerce for its medical equipment management. The platform is mainly used to sell its own products to hospitals. At present: the platform is still in the process of product construction. By using this platform, Customers have been trained and some theoretical knowledge has been provided to them so as to increase the acceptability of the platform among them.
Example 2	An introduction: GPO refers to Group Purchasing Organization. The Health Industry Group Purchasing Association (HIGPA) defines GPO as an entity that helps medical institutions (for example: hospitals, family care centers and home health agencies) to save cost, to increase efficiency through centralized procurement, and to bargain with manufacturers, retailers and sellers. GPO can help its members to sign contracts with suppliers, thus helping medical institutions to provide high quality and cost-effective medical services. Tuoren Group invented CGPO by drawing upon ideas from the group purchasing method widely used in foreign countries. Adopting such a method, professional agencies in China's medical service industry bargain with manufacturers, retailers, and other sellers under the consignment of medical institutions which are in need of medical equipment. With comprehensive guarantee capacity derived from the advantages of teams, products and logistics distribution, Tuoren Group can provide centralized distribution and supply services for medical institutions, thus helping them save cost and improve efficiency. Now, the CGPO model has been applied to a number of hospitals such as Shanghai Oriental Hospital, Tianjin Taida International Cardiovascular Hospital, the Second Affiliated Hospital of Shandong University, and Shanxi People's Hospital.
Example 3	The warehouses in the eastern and western yards of a hospital in Shanghai have been outsourced and consigned to another party for management. The medical departments can apply for medical equipment through the information platform, thus testing the zero inventory method of the platform at a maximum level. After negotiations, the warehouse custodian, the hospital, and suppliers have been included in the platform for unified management. The logistics fee at the early stage is free but the warehouse management cost will be charged in later stages of adoption.

Source: The author.

10. Self-assessment of companies' advantages

Table 4-11 Self-assessment of Advantages

Example	Description
Example 1	The e-commerce platform for medical products is comprehensive. The company could combine relevant product chains, develop and maintain enough hospital and civilian medical customers, and return a small portion of profits customers in a short time. The second time pricing system can be adjusted when the platform reaches its equilibrium point. Platform operators, manufacturers, and suppliers need to undertake the investment in the platform; therefore the platform can have sustainable development for long time. Customers can select the suitable products that they need on the platform. Generally speaking, the medical management process from manufacturers to customers is flawed with problems such as huge waste of human resources, excessive logistics links, multi-level inventory management, and high capital occupation. The e-commerce platform reduced the circulation points from manufacturers to customers, cut down on the inventory management level, and reduced occupation of capital.
Example 2	The hospital has blazed a new trial against the chaotic situation of the traditional consumables market so as to standardize the medical market and bring the consumables distribution under strict regulation; the government has tightened its supervision over consumables and reduced product transportation steps and guaranteed the after-sale service for products; brand products and quality products have been promoted and counterfeited; and shoddy products have been eliminated; the hospital can lower management cost and achieve relative “zero inventory” of consumable medical supplies. When the purchasing price of consumable medical supplies becomes low and stable, not only patients but also other people and the country will get benefits; the hospital has substantially reduced the number of suppliers, and curbed malpractices in purchase and sales; capital flow, logistics and information flow have been integrated into one. Manufacturers, logistics distribution and hospitals together have been linked together; visibility, accessibility, controllability, and efficiency of the hospital supply chain have been approved.
Example 3	The table gives a full description of the medical equipment interconnection service platform. To be specific, the centralized warehouse management has reduced the number of consumable medical supply logistics points, and scientific management has brought down the attrition rate of products; on the information management platform, the government supervision department can carry out certificate management, batch management and sampling management, and trace adverse events on this platform. Meanwhile, unqualified and malignant competitors will be eliminated from this platform; through the information platform, customer can place purchasing orders according to the quantity, time and place, thus avoiding the cumulative inventory cost as a result of over-production; when the number of platform customers increases and the product centralization strategy is adopted, the comprehensive bargaining power will be strengthened, thus ensuring cost reduction of hospitals.

Source: The author.

11. Self-assessment of Companies' disadvantages

Table 4-12 Self-assessment of Disadvantages

Example	Description
Example 1	Questions 15, 16, 17 and 19: The warehousing and logistics management of the medical product e-commerce platform is an important part of this challenging job. The e-commerce platform should operate in a more standardized and professional way and develop its own logistics team. Because the input cost for application of information technologies is relatively high, there is still not a hospital that fully operates entirely on an e-commerce platform for its medical management now. Relatively speaking, the medical e-commerce platform is still not practical.
Example 2	The sound operation of CGPO requires a logistics information platform to match. However, the existing logistics information platforms on the market do not meet the requirement.
Example 3	The medical equipment interconnection service platform can be constantly improved through experiments and has operated in some private hospitals for two years. But a cooperative platform like this could not be operated by private enterprises alone. Instead, it needs to be co-operated by many parties, including manufacturers, operators, and logistics. Now the platform is still confronted with many resistances.

Source: The author

12. Comprehensive analyses of this interview

Table 4-13 Comprehensive Analysis

Example	Description
Example 1	Drawing from the theory of Taobao, the e-commerce platform for medical products provides more choices for hospitals while simplifying circulation of consumable medical supplies in an aim to establish a management process covering from manufacturers to e-commerce platforms and then to hospitals. The demand for e-commerce platforms comes from manufacturers, to whom additional circulation links result in not only a waste of money and resources but also unnecessary losses. It is the concept of self-established logistics teams that serves as the foundation for e-commerce platforms. However, due to the excessive cost of logistics teams, e-commerce platforms aim to achieve long-term survival through the sharing of investment on platforms by manufacturers, platform developers, and suppliers. This is contradictory to the idea of circulation reduction. E-commerce platforms have been well-qualified and achieved policy compliance. But in practice, there is no specialized e-commerce platform for hospitals. Instead, there is only verification conducted by hospitals on e-commerce platforms with self-owned products and a dozen products introduced from manufacturers. As a result, both the time and number of products for verification are insufficient.
Example 2	CGPO model is a relatively new theory of operation on Chinese consumable medical supplies. Stemming from the relatively mature entity model of GPO (Group Purchasing Operation), CGPO has a mature theory and practical operation samples on non-consumable medical supplies. Tuoren Medical has hosted the spring and autumn sessions of Medical Equipment Fair for years. The number of companies present at the Fair has grown from dozens to hundreds, showing that the Fair can serve as a platform for manufacturers to gather together. Meanwhile, integration of medical equipment shopping malls proposed by Tuoren Medical has been established upon the launch of Tuoren Health Industry Park in 2012, providing a foundation both in entity and in products integration. The demand for CGPO model stems from adaptation to the new medical system reform policy of state-owned medical enterprises, such as China National Medicines, Jointown and China Resources. To some extent, the holistic hosting plan for medicine is a new model adopted by Tuoren Medical that is suitable for the national medical system reform policy. However, application of informatization technologies is only at the stage of preparation and introduction. Some initial plans have been worked out for a standard coding system of consumable medical supplies. Sample hospitals include Shanghai East Hospital, TEDA International Cardiovascular Hospital, The Second Hospital of Shandong University, and Shaanxi Provincial People's Hospital. The weakness of the second example lies in information management.
Example 3	The medical equipment interconnection service platform, which was put into use in 2006, is an experimental paradigm of reengineering and optimization of consumable medical supplies. After eight years of verification from initial small-scale product experiments to later fixed-location experiments in a hospital in Shanghai and a unified distribution for community clinics in a district in Shanghai, the current medical equipment interconnection service platform that meets the requirements of medical reform in China has been formed. With its all-round functions displayed in several tables and its demand coming from manufacturers, hospitals and guidance of government policies, the platform realizes an integrated management process covering major points including manufacturers, the government, suppliers and hospitals. Meanwhile, the platform is aimed at reducing resistance from stakeholders as much as possible by cutting the number of logistics locations in circulation, and increasing acceptance from manufacturers and suppliers through consultation with hospitals.

Source: The author.

Based on the empirical examples represented above, it can be seen that establishment of medical equipment service platform is an inevitable development trend. Such establishment can also help achieve reengineering and optimization of consumable medical supplies management process. However, some difficulties are yet to be addressed:

First, because medical equipment interconnection service platform is a model innovation that brings revolutionary changes to the traditional way of sales, there might be difficulties in the conceptual shift;

Second, due to revolution in the mode of sales, some vested interest groups are bound to be adversely affected. It might take a long time to eliminate this obstacle.

Third, as the most important users of medical equipment interconnection platform, medical institutions are accustomed to a dominant position in the medical market. How to shift the conventional thinking pattern for medical institutions due to their dominancy will be the key to the successful operation of the platform.

Fourth, establishment of the medical equipment interconnection platform belongs to reform of the mode of sales. Therefore, the suppliers and end users should have the ability to accept, learn, and use information interconnection technology. The suppliers and users' acceptance of changes brought about by information technology reform will also affect the speed of the popularization of the platform.

Fifth, competition will arise between market service model innovation and the traditional market service concepts, posing enormous challenges to existing distributors and agents. And the competition will last a relatively long time before a dynamic check and balance is reached.

4.2 Consumable Medical Supply Management Process Reengineering and Information System Platform

Based on the interviews above, it can be seen that medical equipment interconnection service (information) platform is an inevitable development trend that can also help achieve reengineering and optimization of consumable medical supply management process. In the following sections, elaboration will be given on the policy compliance of the medical equipment interconnection service (information) platform, application of platform theory, platform total quality management approaches, elements of the platform, ideal state of the platform, and a comparison before and after the use of

platform as well as before and after consumable medical supply management process reengineering and optimization. This thesis study is carried out from five aspects below, inventory management comparison, business process reengineering comparison, level of information application comparison, cost difference comparison, and comprehensive comparison.

4.2.1 Policy Compliance of Medical Supply Interconnection Service Platform

As China is a country with a political economy, reform has to comply with its national policies and meet the needs of the national medical system reform first. From 2000 to 2012, a series of laws and regulations and guiding documents have been introduced to guide the reforms of the medical system. National policies are the major and indispensable support for the medical equipment platform. Apart from this, national policies of information, finance, and logistics are equally important for medical equipment platform. Therefore, whether or not the hardware and software provided by the medical equipment interconnection platform are legal is one of the critical issues that cannot be neglected. Since 2004, a series of laws and regulations have been introduced: documents that specify the general orientation and quality standards of medical equipment which include Guiding Opinions on Medical Industry Development During the Eleventh Five Year Plan Period (China's National Development and Reform Commission, 2006) issued in 2006 and Standards on Production Quality Management of Medical Equipment (Trial) (China Food and Drug Administration, 2009) released in December 2009. Documents on circulation include Opinions on Strengthening Pharmaceutical Supervision and Management and Improving Development of Modern Pharmaceutical Logistics (China Food and Drug Administration, 2005) issued in 2005 and Opinions on Further Standardizing Centralized Medicine Purchase in Medical Institutions (China's Ministry of Health, 2009) published in 2009. Documents on electronic and information-based commerce include Management Measures on Internet Medicine Information Service (China Food and Drug Administration, 2004) promulgated in 2004 and Interim Provisions on the Examination and Approval of On-line Drug Transactions (China Food and Drug Administration, 2005) issued in 2005. All these laws and regulations provide legal bases for the medical equipment interconnection platform.

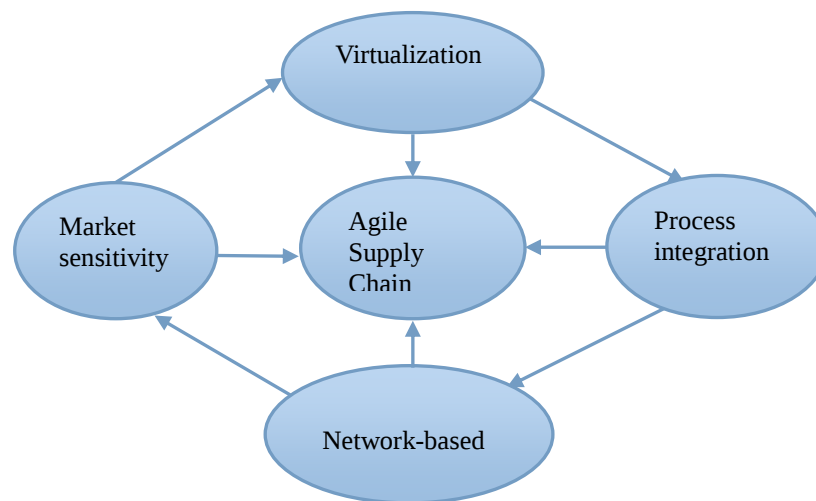
After ensuring that the platform complies with national policies and laws, business process reengineering principle is strictly followed by the core value that the medical equipment interconnection service platform is based on the zero inventory theory and cooperation-competition strategy.

4.2.2 Theoretical Applications of Medical Supply Interconnection Service Platform

1. Application of Zero Inventory

Zero inventory not only means that the hospital has relatively no inventory, but also represent that the inventory is zero in the whole process from the beginning to the end of the supply chain, in other words, from manufacturers to hospitals. Many processes of the supply chain are very long since various activities are combined in the form of a system. In other words, they are linear; one connected with another (Christopher, 2012). So the majority of the activities will not be value added. The form of process that takes inventory activities at every juncture example can generally be reengineered into synchronized operation.

Figure 4-1 Sketch Map of Agile Supply Chain



Source: Christopher and Hoek (1999)

Now, we are stepping into the age of service supply from the age of product supply. The whole industry economy has shown the trend of service development (Qian, 2010). The medical equipment interconnection service platform integrates manufacturers, suppliers, as well as the warehouse; the logistics and information services of the three parties of the hospitals provide the necessary consumable medical supplies with the right quantity, good quality, and reasonable price in real time.

2. Application of Co-opetition Strategy on the Platform

The competition strategy in the new age is themed on “cooperation” and “cultivation of competition partners”. This strategy is characterized by long-term interdependence and mutual growth with the competitors, and aimed at building a long-term competitive environment and maintaining stable market share. The cooperation-competition theory is

a typical type of cooperation game.

a. Cooperation game can help alleviate the impact of fierce confrontational competition on enterprises.

Currently, the three parties of consumable medical supplies (manufacturers, suppliers, and hospitals) are all performing repetitive work. Their work content involves efforts into duties of a non-work nature, such as warehousing, logistics, and information construction. The operation process of these types of work is competitive. Therefore, by transferring them into the platform and using inventory management to reduce consumable medical supply logistics nodes, the three parties can achieve scientific management and lower wastage rate of finished products. Enterprises who comply with mutual cooperation will respectively abide by principles of different links, enabling these links to combine and form a stable supply chain. In this way, cost for inventory, check, transactions, and market competition will be reduced. By implementing information application, fixed quantity orders can be placed at a fixed time and in fixed location, thus all three parties can realize production according to needs and avoiding increase of inventory cost in all links from manufacturing onward. Thus, the total number of users will increase, products will be integrated, the comprehensive competition ability of the platform will increase, and decrease hospital cost will be effectively ensured.

While cooperating with hospitals, manufactures and suppliers are also competing with each other to earn more market share. This completion results in frequent occurrence of vicious price competition, impacts of inferior products, and slander of competitors' brands in market competition. Such confrontation-oriented competition will finally increase costs. Therefore, while implementing cooperation-oriented industry competition strategy, industry barriers should be built up to avoid entry of new competitors and ease competition intensity. Within cooperation partners, labor division and collaboration are conducive to complementary advantages and formation of more effective professional labor division, so as to lower the overall cost of products and realize each cooperation enterprise's development strategy of "low cost" and "professionalism". Furthermore, information-based approaches can be used to meet the requirements of certificate management, batch management, spot check management, and adverse event tracking on government monitoring departments to reject unqualified information and vicious competitors.

b. Reflection of win-win co-opetition on the platform

Manufacturers, suppliers, third-party logistics distributors, intermediary traders, and

hospitals on the platform are interdependent links. All of these links are value-creating, necessary and indispensable components of the whole reproduction chain. Enterprises on the supply chain are both competitors and cooperators. The purpose of competition of each organization is to maximize self-interests, whereas the purpose of cooperation is to maximize the interests of the whole supply chain.

c. Implementation of supply chain competition and cooperation on the platform

By establishing cooperative relationships with enterprises in the supply chain, the platform forms alliances, thus reducing delivery time, improving the quality of products, and lowering purchasing cost. The supply chain management mode is driven by market demand, and centered on customer needs. Therefore, the mode connected cooperative partners, including manufacturers, suppliers, third-party logistics distributors, and other service providers, into a comprehensive network structure, and formed a very competitive strategic alliance platform. The purpose of cooperation between different parties is to meet the needs of users, react rapidly to the needs of patients, bring the core competitiveness of enterprises on the value chain into full play, and create overall competitive advantages.

Under the cooperation and competition in the platform supply chain, the time point for supplying consumable medical supplies of the required standard, quality and quantity will be neither ahead nor behind the schedule. The key to the method that reduces the inventory of consumable medical supplies is the accurate estimation of the use condition in the hospitals. It is significant to analyze, study, and predict the supply and demand tendency of consumable medical supplies. Accurate estimation emphasizes on the marketing research, the information collection, and relevant studies. Based on the comprehensive knowledge of the historical and current situation, more abundant information and more detailed analysis will guarantee the complete coverage of the database and the high accuracy of the prediction. The integrated service network and platform of medical apparatus and instruments consist of purchasing from the manufacturers and marketing to the hospitals or (through the delivery platform) to the suppliers. The management of warehouse, inventory, delivery, and finance on the platform will be adjusted to reduce the repetitive management cost as much as possible. Such adjustment will provide the terminal hospitals with the supply chain service including purchase, delivery, and inventory. On the platform, the firsthand information of the production phase, the supply mode, the management of delivery and the use amount in

the hospital of the consumable medical supplies will be collected to build the best database for the manufacturers to perform the controllable production plan management.

4.2.3 Approaches to Platform Total Quality Management

The quality of consumable medical supplies is critical to life and health safety because of their common use and limited expiration period. According to government regulations, consumable medical supplies should be registered for use and checked randomly. Penalties will be executed if medical malpractices occur due to quality-related problems of consumable medical supplies. These problems include damages that occur during transportation to hospitals, contamination and other quality problems because of poor inventory environment. The platform solves the above problems by offering a total quality management and supervision solution that allows medical regulatory authorities to supervise product certificates, raw materials, finished products, and their use in treatments.

Take the delegated integrated distribution model of consumable medical supplies adopted by over 20 hospitals in the Jiading District of Shanghai as an example. The Platform offers hospitals a combination of procurement and distribution services that reach hospitals at the grass-root levels and helps hospitals connect consumable medical supply inventory to the medical equipment interconnection service platform. The Platform has become a good model for delegated integrated distribution of consumable medical supplies.

4.2.4 Elements of Medical Supply Interconnection Service Platform

The basic idea of the medical equipment interconnection service platform is to build a fourth-party logistics medical equipment platform that can be monitored and checked of its quality based on the principles of zero inventory, cooperation-competition strategy, and business process reengineering. The medical equipment interconnection service platform consists of the following two elements:

First, Platform building and integration

The basis and reengineering of platform supply chain originates from the idea of fourth-party logistics. On the platform, there are many clients, including manufacturers, suppliers, third-party logistics distributors, service providers, and hospitals. Based on the idea of supply chain management, the theory of supply chain management can be introduced to business process reengineering. The introduction enables companies to better integrate their own core competitiveness instead of outsourcing non-core business to cooperation partners, so as to achieve the purpose of reasonable allocation of internal

and external resources (Zhang, 2007). Using the idea of fourth-party logistics, the platform separates the noncore corporate business modules of manufacturers, different levels of suppliers and hospitals, such as warehousing management, information application, and logistics transportation, and moves them out to the platform without affecting the normal operation, in order to achieve professional integration.

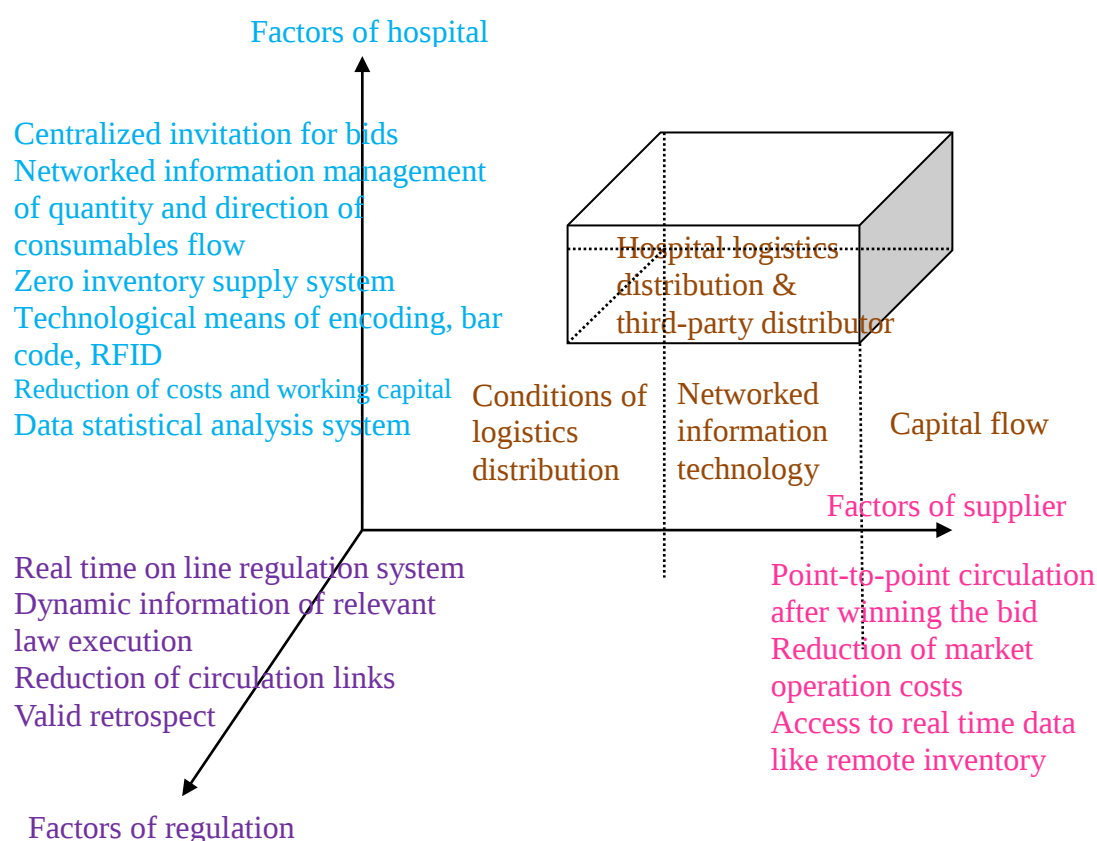
Second, Information Management of Logistics and Supply Chain on the Platform

The hospital invites bids of centralized ordering according to procurement rules, and then decides on suppliers, products, and prices after reviewing them. The hospital offers logistics distribution fields for distribution of medical appliances and entrusts distribution to third-party logistics distributors. Distributors deploy hardware and software resources and facilities for logistics distribution and bring products from all suppliers into the logistics distribution platform. In this way, the hospital can unify logistics distribution and reap economic benefits by realizing “Zero Inventory” after reengineering and optimization. The process includes three aspects:

First, distributors put products from all suppliers on shelves and every product that has been included in the distribution platform has a label of commodity code and bar code. As a result, clinical department purchasers can choose products directly and confirm by RF scan after requisition.

Second, at every link of the whole hospital logistics distribution, terminal-to-terminal visibility is realized. With RFID reader, supply chain enterprises and relevant hospital departments can obtain real time data of requisition and inventory. Data and receipts of the whole hospital logistics distribution system are automatically generated on a networked information system.

Figure 4-2 Distribution Procedures of Medical Supply Interconnection Service



Source: The author

Third, the platform establishes normalized and standardized basic principles of data coding.

To ensure uniqueness of material coding, international standards (for example: GMDN data base, GS1 coding standard) and Chinese authoritative data (for example: classification coding and product condition of I, II and III) together are referred to verify goods and materials, and thereby a standard product library is formed. Each material has a standard code, a medical insurance code, and a hospital code. As a result, the coding data used by all businesses and hospitals can be matched.

In establishing a reasonable and complete data model, the basic work of data coding is complicated because lots of basic data cannot be collected correctly and coding is the biggest difficulty. There are four main factors as discussed below:

1. Uniqueness

Data coding is both the foundation of establishing norms of data collection and a key factor that affects the overall impression and success of the information system. Reasonable classification and coding of medical equipment should be carried out and each

object of management should bear a unique code. This is because a computer system performs strictly in accordance with various kinds of coding, which exists throughout the entire information processing such as classification coding of medical equipment and pharmaceuticals. Different codings are highly correlated. When establishing data coding standards, the above factors should be fully taken into consideration to coordinate and unify different kinds of codings. When preparing data for information system in the future, standardized and normalized administration and execution should be strictly carried out according to different kinds of codings that have been worked out. Therefore, the data standardization, data circulation and data sharing are realized throughout the supply chain.

2. Source reliability

Most medical equipment has certificates related to national and local standards, which explain in detail registration certificates and performance of the medical equipment. So for both general and specific categories of medical equipment, there are real certificates for reference. There are standard systems of data for reference. Due to its timeliness requirements, this part of data needs timely tracking and adjustments to form a correspondent feedback system (China Food and Drug Administration, 2009).

3. Standardization

The classification and value of coding is directly related to the level of automation and efficiency of information processing, information retrieval, and information transmission. The normalization and standardization of information coding affects information exchange and information sharing. According to basic principles, coding should be scientific, systematic, extensible, compatible, and comprehensive. From the perspective of systems engineering, partial problems are considered in the whole system to realize overall optimization. Information coding systems and standards that meet the requirements of supply chain management should be established under a top-down principle from international standard to national, industrial and enterprise standards. Only with standard and unified information classification and coding can all information systems achieve effective integration and sharing.

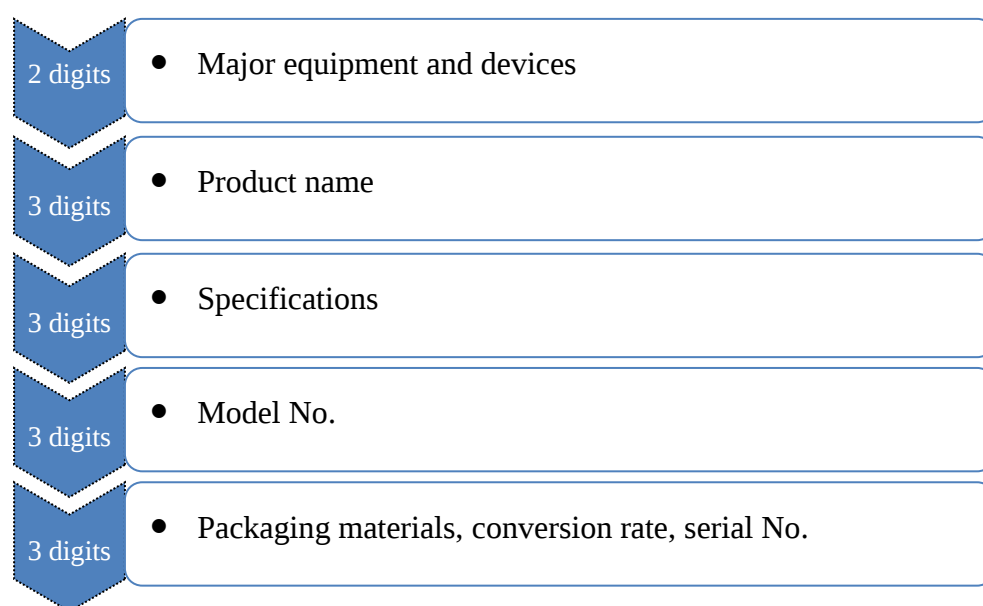
4. Coding theories and systems

Coding should be carried out according to the specific classifications in *Classified Catalogue of Medical Equipment* and *Product Registration Certificate of Medical Equipment* issued by China Food and Drug Administration. System categorical data can

be divided into equipment, products (equipment & manufacturers), commodities (products & dealers), and goods (commodities & distributors).

Because there is a wide variety of medical equipment, a system of five-grade data coding management is established according to both the *Classified Catalogue of Medical Equipment* issued by China Food and Drug Administration.

Figure 4-3 Coding Principles



Source: The author

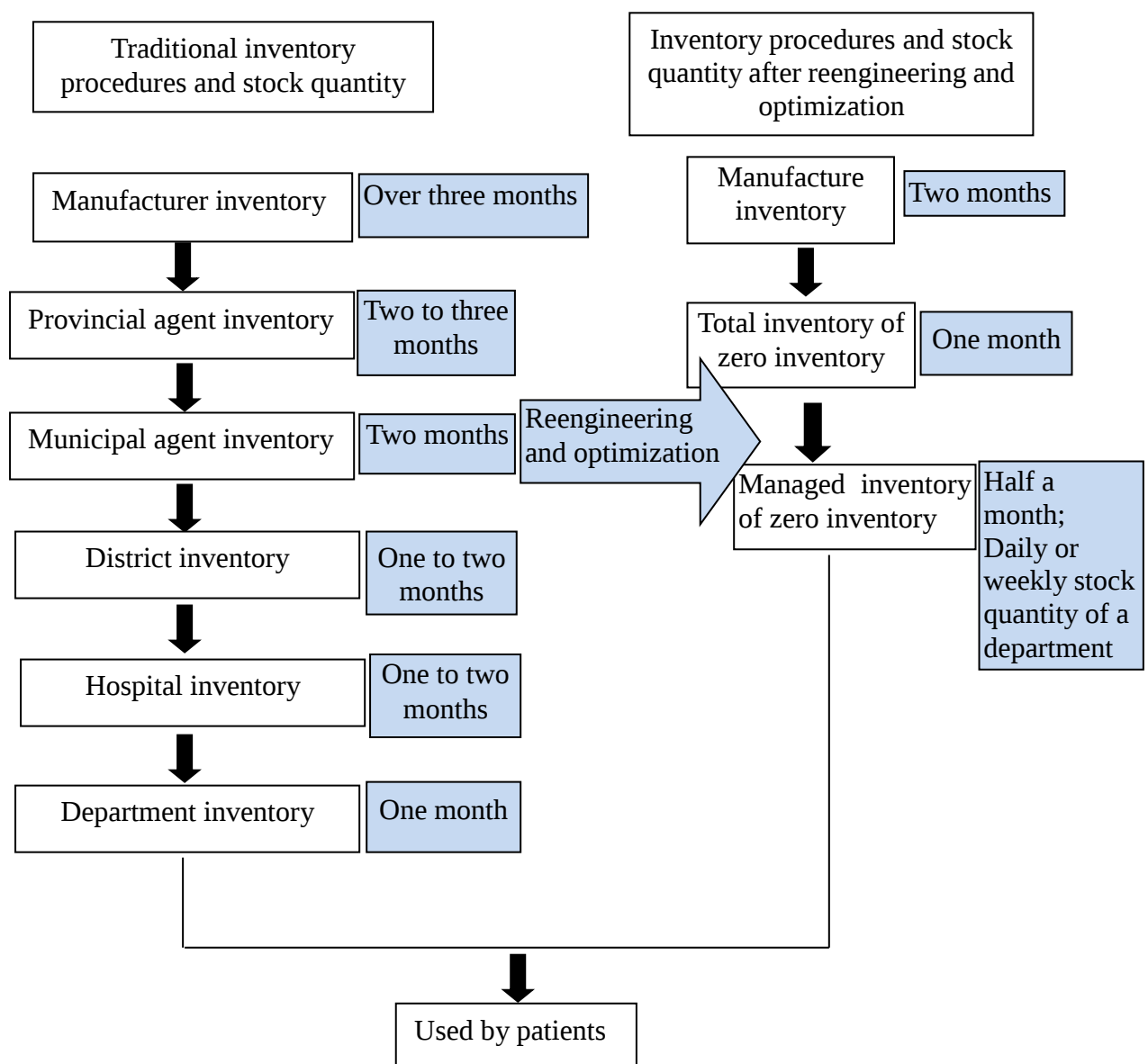
4.2.5 The Ideal Status of Medical Supply Interconnection Service Platform

1. Logistics and supply chain should be reengineered and optimized to establish a “Zero Inventory” management pattern

The hospital outsources its distribution activities, which is a noncore business, to third-party logistics distribution centers. Each department of the hospital works out a demand plan of its own for everyday medical appliances and sends the plan to the supply department through the hospital’s internal supply system. Then these plans are examined and gathered to generate a purchase order that is sent to the hospital’s logistics distribution center through the Internet platform. Medical appliances are sorted out and delivered respectively to each one of the departments according to the order. The hospital will no longer set up a storage room because property rights of goods and materials will be transferred only when clinical requisition occurs. Therefore “Zero Inventory” of the hospital’s medical equipment products is realized and the hospital’s working capital is cut down. At the same time, problems of overstock of consumables and wastage of inventory are resolved because of “Zero Inventory”.

According to consumable medical supply management reengineering and optimization, inventory transfer means transferring a hospital's warehouse outward to the platform. The hospital's consumable medical supply inventory was transferred to the upward side of the supply chain, so the inventory costs of consumable medical supplies are shouldered by the centralized medical equipment Internet service platform. In this approach, inventory placed upward results in fast delivery from storage. This approach is also used in sales and optimal management of consumable medical supplies by the hospital so as to achieve results of no storage room in the hospital, no wasting of human resources and the lowest capital occupation. This process is shown in the following figure.

Figure 4-4 Comparison of Inventory Before and After Optimization



Source: The author.

2. Exhibition of logistics distribution is established: Products chosen by the hospital are exhibited on the logistics information platform according to different departments. Every clinical department can choose what it needs freely in accordance with its own characteristics.

3. An e-commerce platform is established to raise safety and transparency of the purchase system. By implementing Internet application, users are offered medical equipment trade e-commerce platform that is safe, reliable, open and easy to maintain (China Food and Drug Administration, 2005).

4. Information system framework and main operation procedures (The following figure uses the distribution platform of Shanghai Jiading District as an example).

5. Rigorous regulation system: Medical equipment is a special product because it relates to people's health and life. So there are different requirements for regulation throughout all links from manufacturers to hospitals. The platform is committed to form a regulation system that covers the process from purchase of raw materials to usage of equipment by patients. Such a regulation system includes regulation of three certificates, production process management, storage logistics, product adverse event, hardware environment, and monitoring points.

The medical equipment interconnection service platform is a platform that integrates information, hierarchical storage management, logistics management, settlement management, and government regulation. The platform combines virtual services and real storage logistics as well as service and management. It is a platform for product regulation that connects manufacturers and users throughout the whole process with the application of information technology. It safeguards interests of different stakeholders at all links on the platform. It helps reduce the cost of consumable medical supplies and raise the management competitiveness of hospitals.

4.2.6 Comparative Study: Before and After Reengineering and Use of Information System Platform

1. Inventory management comparison

Inventory management is an important part that affects hospital profits. It is imperative to compare the management before and after reengineering and optimization. The following is a comparative analysis of inventory type, inventory quantity, and inventory process.

According to Catalogue of Medical Equipment released by China Food and Drug Administration in August, 2002, consumable medical supplies can be divided into seven categories: materials including intervention materials, and artificial organs, intermediary materials, biomedical polymer materials and products, extracorporeal circulation and blood processing equipment, medical health materials and dressings, medical suture materials and adhesives, as well as dental materials (Du, 2009). In this section of the study, consumable medical supplies are categorized into low, medium, and high value products, and conventional and unconventional products. Different types of consumables have different characteristics, which post requirements on stock and logistics. This is especially true with low value consumables: Low-value consumables consist of a large number of types, often with huge quantity and complex specifications. Moreover, low value consumables tend to have a large inventory and occupy a lot of warehouse spaces

because they tend to be significantly influenced by the prices of raw materials and cannot be out of stock.

The huge quantity of low value consumables stored in the warehouse all have requirements on conditions and terms of storage, resulting in high warehousing cost and high logistics cost. Therefore, we must have reasonable inventory of low value consumables. The reengineered and optimized platform can satisfy the needs, because it moves hospital warehouse out to the platform warehouse so as to ensure hospital use some part of the inventory of manufacturers cannot be moved out, whereas the inventory of different levels of distributors can be moved to the first and second entity warehouses.

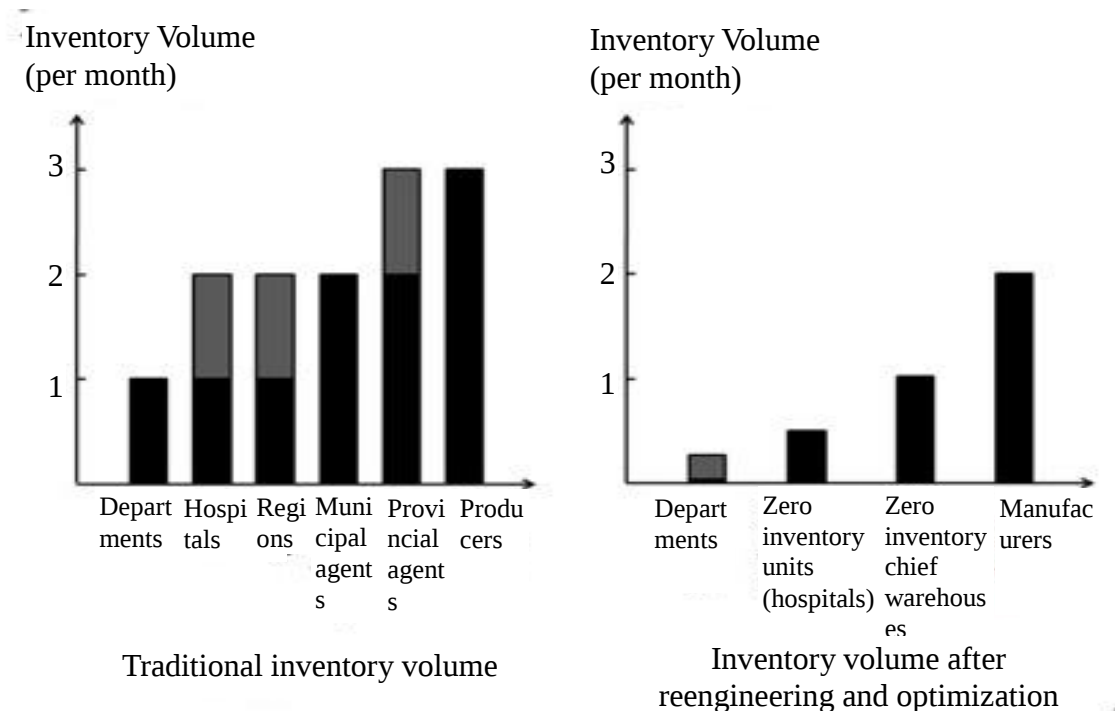
Table 4-14 Comparison between Traditionally Stocked Products and Those After Process Reengineering

Varieties of Conventional Inventory Products		Varieties of Inventory Products after Reengineering and Optimization	
Departments	Inventory for all departments	Departments	Conventional daily products required by departments
Hospitals	Inventory for hospitals (high-value, medium-value, low-value, conventional and unconventional products)	Zero-inventory warehouses (hospitals)	Low-value consumable medical supplies for hospitals' conventional products, high-value unconventional products allocated from primary warehouses based on demand
Regions	Inventory required by regions (high-value, medium-value, low-value, conventional and unconventional products)	Zero-inventory primary warehouses	Zero-inventory primary warehouses covering comprehensive products required by regions (high-value, medium-value, low-value, conventional and unconventional products)
Municipal Agents	Inventory required by municipalities (high-value, medium-value, low-value, conventional and unconventional products)		
Provincial Agents	Inventory required by provinces (high-value, medium-value, low-value, conventional and unconventional products)		

Source: The author

The insufficiency of all product types stated in the above includes the problem of excessive stock, which can be addressed by the medical equipment interconnection service platform. On the new platform, the integrated inventory management enables distribution of products among departments. Hospital warehouses are moved outside to the platform. All hospitals need to do is to have enough inventory in departments for medical diagnosis, significantly reducing hospital inventory, to almost zero.

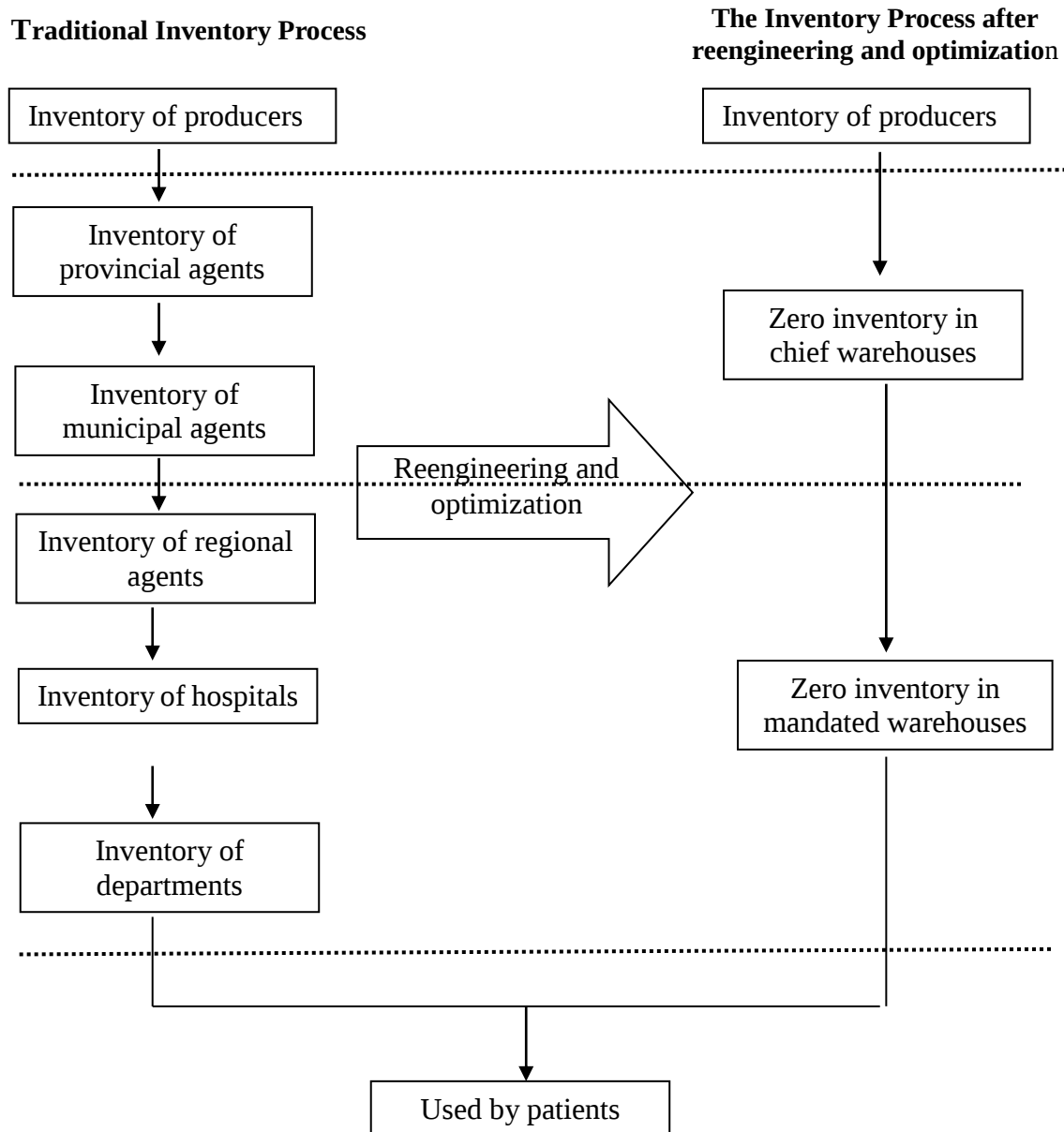
Figure 4-6 Comparison of Inventory Quantity between Traditional Process and That After Reengineering



Source: The author

After the reengineering and optimization, five to six chief warehouses are set up in different regions according to the planning principal in the medical equipment interconnection service platform. Each warehouse is responsible for monthly stock with comprehensive varieties for five to six provinces within the designated region. The products include all product types. Secondary entity warehouses or those entrusted by hospitals are set up within the reach of hospitals by a two-hour drive. Stock in secondary warehouses covers all consumable medical supplies required by departments in the hospital, including unconventional high-value products and supporting instruments for surgery machines. The secondary warehouses accommodate to those hospitals that have not mandated the management of medical equipment.

Figure 4-7 Comparison between Traditional Inventory Process
and That after Reengineering and Optimization



Source: The author

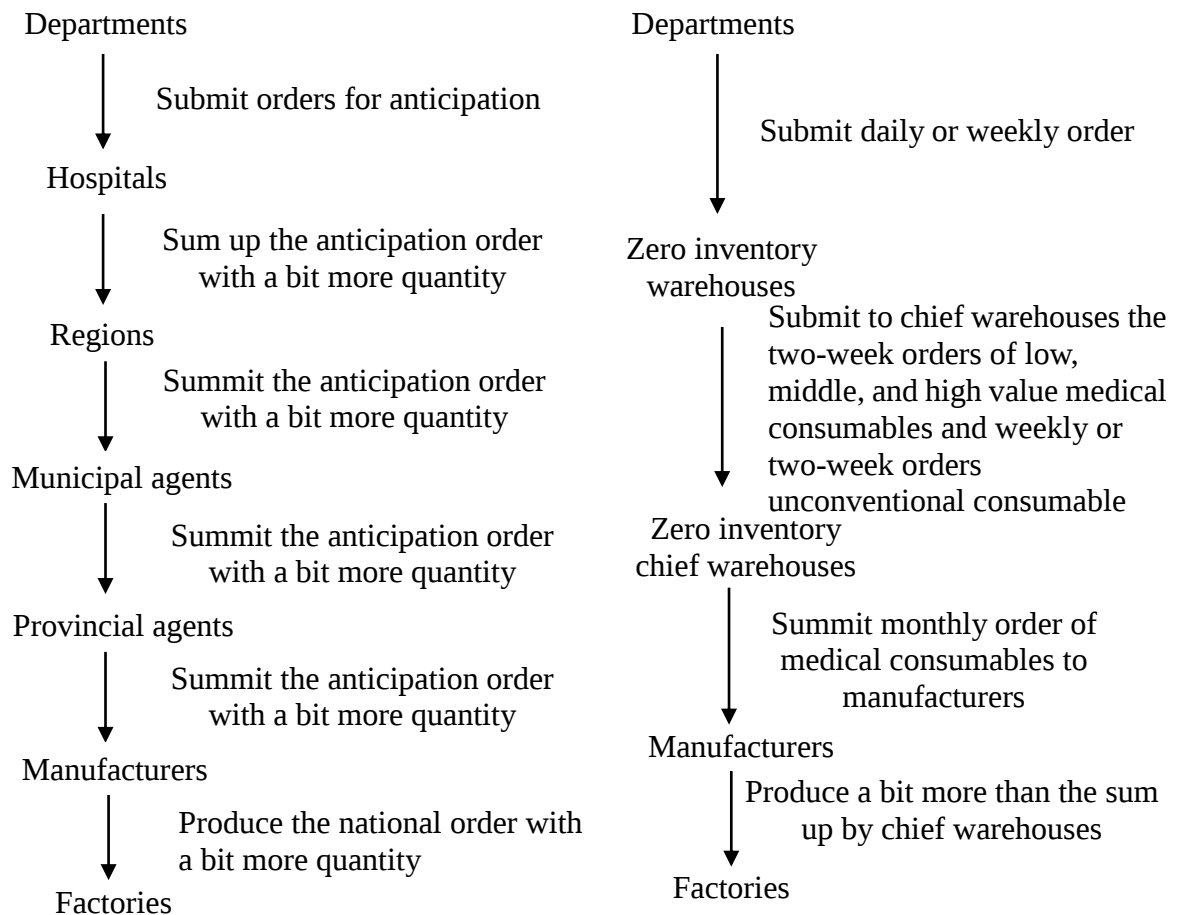
2. Business Process Comparison

Business process in this study refers to the ordering process and the logistic process. In accordance with the principle of simplification and integration, the business process of consumable medical supplies management process is reengineered and optimized.

The ordering process after the reengineered and optimized medical equipment interconnection service platform: calculations are done in a scientific and statistic way according to actual data. Quantitative forecast is provided in the area of brands, varieties, specifications, and quantity required by hospitals on the platform. Through calculations and forecast, demand for the next certain period can be decided and submitted to

manufacturers for ordering.

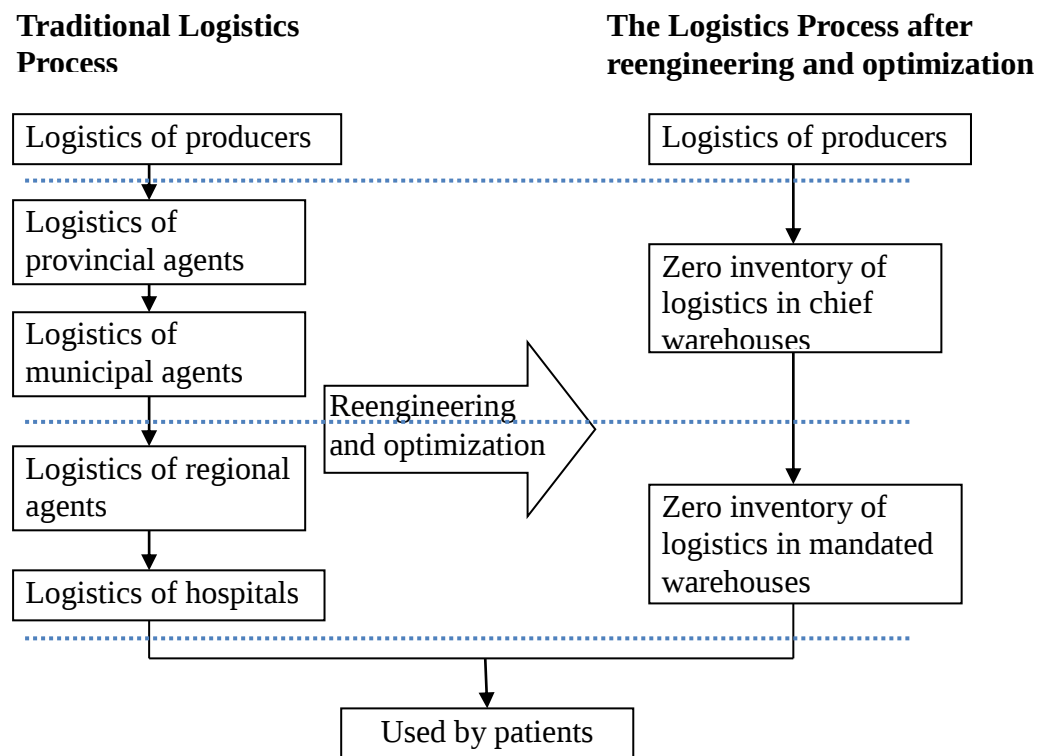
Figure 4-8 Comparison between Traditional Ordering Process
and That After Reengineering and Optimization



Source: The author

The reengineered and optimized medical equipment interconnection service has the following characteristics: the whole logistics process is standardized, products are tracked by bar codes, logistic vehicles are managed and tracked by visual management and warehouses hardware and logistic facilities for special products are monitored by governments. Also, this interconnection service provided logistic transportation to hospitals of the new platform and value added logistic services from hospitals to departments.

Figure 4-9 Comparison between Traditional Logistic Process
and That After Reengineering and Optimization



Source: The author

3. Informatization comparison

The current informatization in hospitals mainly includes internal network construction, toll collection, clinical systems, and automation of administration (Shi & Liu, 2004). The information application level of hospitals is rather lagging behind. For manufacturers of consumable medical supplies, the information application is mainly done in the process of manufacturing and the management process for the enterprises, such as information-based management of a single product being put in or taken out of warehouses and their financial management while the tracking process and after-warehouse information-based management of products are not involved. Information-based management of different levels of suppliers and distributors is limited in the area of products going in and out of warehouses and automation of office and financial management inside the enterprises. The information-based government monitoring refers to information recording after spot-check and to record the three certificates of all enterprises at all phases in the process. Judging from descriptions of information application in hospitals, manufacturers, distributors, and government, information-based medical consumable management is characterized by separate stages and lines

without intersection and consistency. In addition, data source mainly comes from manual work, thus leading to a high error rate.

After the reengineering and optimization, medical equipment interconnection service platform is highly informationized and is represented as follows. Generating data source for the hospitals for further diagnose from data analysis of inventory is conducted in terms of changes of orders submitted by hospitals. Data analysis is conducted on the used goods returned due to reasons other than quality problems. Hospitals can utilize the data to analyze the root of inventory errors on the basis of analyzing the departments targeted at by the data, so as to improve the accuracy of the data. The increase of accuracy of inventory data in hospitals leads to the enhancement of the accuracy of the business process therefore effectively reduces the cost caused by the inaccurate data.

4. Comparison of Costs

Table 4-15 Comparison of Manufacturers Before and After Reengineering
Consumable Medical supply Management Process

Manufacturers:

Comparison content	Planning method	Ordering method	Warehousing management	Human resources	Financial management
Before reengineering	Plan with estimation	Orders are placed in advance	Inventory for 3 months		Payment in advance
After reengineering	Plan as needed	Orders with feedbacks	Inventory for 1 month		Controllable payment
The lowest percentage of saved cost	1%	1%	2%	1%	2%

Source: The author

Table 4-16 Comparison of Suppliers Before and After Reengineering and Optimization of Consumable medical supplies Management Process

Suppliers:					
Comparison content	Planning method	Ordering method	Warehousing management	Human resources	Financial management
Before reengineering	Plan according to estimation	Orders are placed in advance	Inventory for 2 months	Face to face, one to one	Payment in advance
After reengineering	Plan according to demand	Orders according to the demand	Inventory for 1 month	Electronic management	Controllable payment
The lowest percentage of saved cost	1%	1%	1%	1%	1%

Source: The author

Table 4-17 Comparison of Medical Institutions Before and After Reengineering Consumable Medical supply Management Process

Medical institutions:						
Comparison content	Planning method	Ordering method	Warehousing management	Logistics management	Human resources	Financial management
Before reengineering	Plan according to estimation	Place orders in advance	Inventory for 1 month	3 process points	Face to face, one to one	Payment in advance
After reengineering	Plan according to demand	Place orders according to demand	Zero inventory	1 process point	Electronic management	Controllable payment
The lowest percentage of saved cost	1%	1%	1%	2%	1%	1%

Source: The author

Table 4-18 Comparison of Consumable Medical Supplies Before and After
Reengineering: From the Logistics Perspective

Logistics process:

	Description
Before	Traditionally, logistics links of consumable medical supplies go through manufacturers, provincial operators, municipal operators, operators, hospital warehouses and hospital departments.
After	There are three logistics links after reengineering including manufacturers to third-party logistics platform, and third party logistics platform to hospital departments.
The lowest percentage of saved cost	Cost of low-value consumables is reduced by 5%, cost of intermediate-and-high-value consumables less than 1% respectively. On average, the overall cost can be reduced by 3%.

Source: The author

Table 4-19 Comparison of Supervision Process Before and After Reengineering
Supervision process:

	Description
Before	Supervision was carried out according to certificates and licenses of every logistics link. Products were examined randomly.
After	Supervision of three licenses runs through the whole process. The batch number, expiration date, and logistics are supervised throughout the whole process.

Source: The author

Table 4-20 Comparison of Information Management Before and After Reengineering
Medical equipment interconnection service platform:

	Description
Before	Manufacturing, supervision, logistics, and financial reconciliation rely on manpower, which results in high labor cost and error rate.
After	The management of the whole process is accomplished by the informationized platform with lower labor cost and lower error rate.

Source: The author

5. Comprehensive Comparison of Management Advantages Before and After Reengineering

Table 4-21 Comprehensive Comparison Before and After Reengineering

Name of the Platform	Conventional Management	Management after Reengineering
Manufacturers	Limited by the marketing operation, manufacturers are likely to standardize their management to adapt to the market, otherwise it may be squeezed out of the market by unfair competition and competitors.	The main goal is to provide qualified products for Zero-inventory warehouses so that they have enough time and energy to develop and improve the internal management and product quality. Profits are increased by reducing operational cost and original manufacturing cost, hence providing the most up-to-date and most needed products.
Provincial Agents Municipal Agents Regional Agents	Limited by the market, agents see making profits as their ultimate goal. To accomplish sales tasks, agents might compete unfairly otherwise will be pushed out of the market by their counterparts. Because the agents' only sales part of varieties for hospitals, they have little ability to bargain at the two ends of the market.	Reasonable reengineering is done to improve market distribution, providing the manufacturer a larger potential market. Hospitals can ask manufacturers to improve products, guarantee product quality and even reduce product prices. Through improving distribution process and reducing cost, hospitals can get bargaining prices. This can also provide a comprehensive management plan for the hospital inventory. Warehouses that have moved outside hospitals will become a point on the platform. The information-based management is more acute than ever, which accelerates the expansion of hospitals on the platform. The increasing number of hospitals enlarges the demand for consumable medical supplies on the platform, strengthening the connections between manufacturers. At the same time, to ensure healthy development of the platform, vicious competitors and products that are below quality specifications and without quality guarantee will be excluded from the platform, so that three parties involved could enjoy expansion in healthy operations. The platform is supervised by government during the whole process from production to management and to utilization in hospitals. The whole process is information-based, making the platform more competitive.
Hospitals	Insufficient monitoring on source of products thus the products for hospitals are not guaranteed for premium quality. Most hospitals are struggling with how to deal with unqualified products. They also suffer from long product distribution, insufficient control on product prices and relative high cost of inventory management.	The government monitors the whole production process so that the government can locate the root causes of problems. The platform has the ability to manage and bargain. After removing the warehouses, the cost of human resources, management, materials and inventory will be reduced. Thus, increasing the acceptability of the platform to the hospitals.

Source: The author.

4.3 Hospital Internal Process Reengineering Information System Platform

The problems confronting the hospital being studied in this thesis regarding the hospital internal process will be alleviated by using the medical equipment interconnection service platform. The process and realization approaches of hospital internal process are elaborated in the following sections.

4.3.1 Implementation of Hospital Internal Process Reengineering

Hospital internal process reengineering consists of the following three aspects:

1. Hospital internal process warehouse and personnel design: hospitals will gradually separate such functions as purchase, warehousing, transportation, and distribution from their own functions. By establishing a long-term, stable, and cooperative alliance relationship with the third-party medical logistics distribution companies on the medical equipment interconnection service platform, logistics distribution contracts will be signed by the supplier and customer to realize the integration of the upper and lower ends of the hospital consumable medical supplies supply chain. Hospitals only purchase from the third-party medical logistics distributor, whereas the distributor takes care of purchase, inventory management, and distribution to clinical departments. By changing the way of supply, the hospitals are prepared for creating a zero inventory condition. More specifically, hospital warehouses are outsourced to the medical equipment interconnection service platform and benefit from the rent according to the local logistics warehousing standards. The staffing of the hospital warehouses is kept to provide services to platform warehouses and charges a reasonable amount of service fees. In this way, hospital warehousing cost and labor cost are reduced to nearly zero. In addition, revenues are generated by renting out warehouses and value-added people services.

2. Hospital internal process procurement and payment design. After the department purchase quantity is submitted to the Equipment Office and the deputy director for review, inventory is counted and prepared directly in the platform hospital, which does not occupy the hospital warehouse space. As to procurement budget

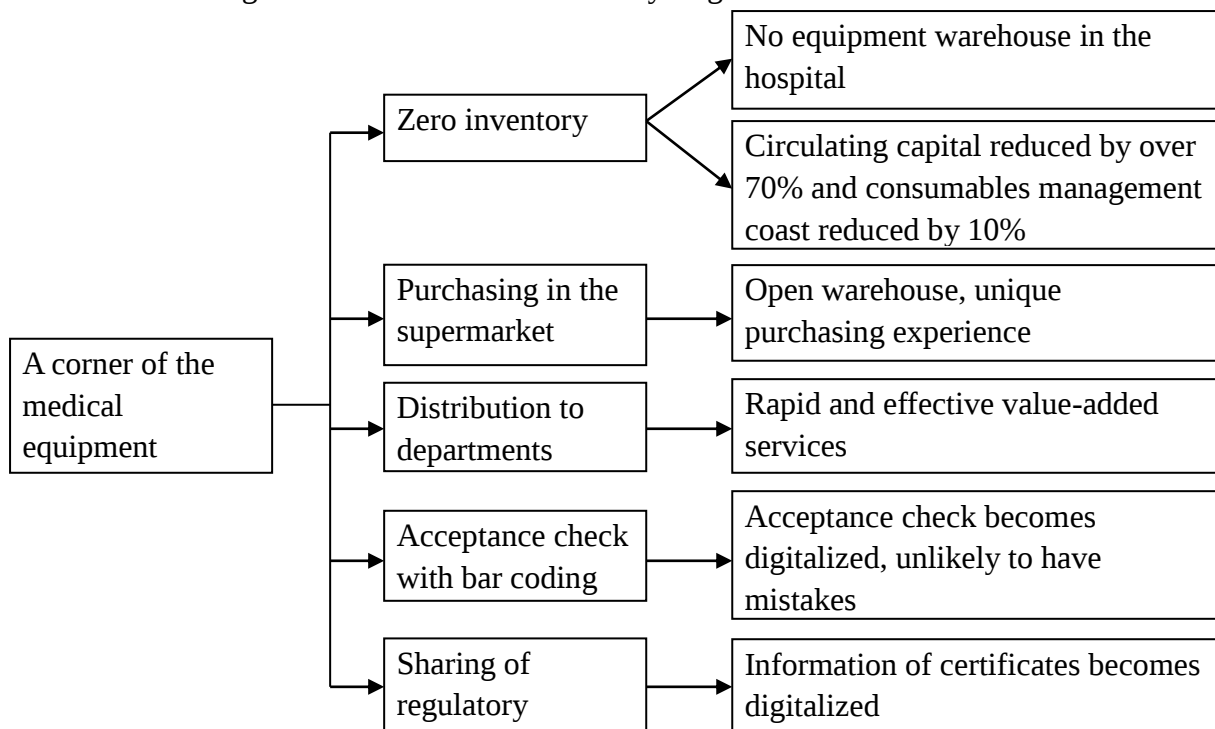
process design, the inventory sent from the platform warehouse will be received by departments with signature confirmation. The electronic signature confirmation receipts are used as verification for hospital accountants and are settled every month, realizing the management process design for the payment amount of used consumable medical supplies. In this way, hospitals almost do not need to plan budget for consumable medical supply purchase, basically achieving the purpose of reengineering and optimization in the form of payment after using consumable medical supplies.

3. Hospital internal process consumable medical supply management process design. Through the connection interfaces, the expiration dates, batch number, registration number and manufacturer information of consumable medical supplies can be examined and checked from the interconnection service platform, therefore ensuring the effectiveness of management. In addition, comparison of the database generated from electronic confirmation receipts signed by departments is made to monitor whether or not the products collected by hospital departments are qualified products or whether or not they are within the validity period. This process has significant effects on reducing medical malpractices thus helps to check problems in logistics links more quickly even when medical disputes occur.

4.3.2 Advantages, Functionalities and Approaches Realized After Hospital Internal Process Reengineering

1. After reengineering and optimization of consumable medical supplies, all clinical departments will be able to finish the whole process of application, distribution and collection at real time through the medical supplies management platform, leading to an integration of services such as procurement, warehousing and clinical distribution. The advantages are as follows:

Figure 4-10 Process of Third-Party Logistics Distribution



Source: The author.

Circulating capital is saved and overstock is avoided. To be specific, circulating capital of the hospital is cut down by at least 20%; intermediate links in circulation are reduced; and consumable medical supply management cost are lowered by at least 10%. In the past, the hospital had to purchase in advance a certain amount of consumable medical supplies, and then stock in the warehouse for future clinical use. Because of this, the hospital had to allocate a certain amount of capital for turnover. However, when the integrated medical logistics distribution services including procurement, warehousing and clinical distribution are outsourced, the hospital can enjoy zero inventory and spend less on purchasing because the property right of the consumable medical supplies in the hospital warehouse belongs to third-party logistics distributors rather than the hospital. The property right will only be transferred to the hospital when the consumable medical supplies are confirmed in clinical departments. Therefore, the hospital has no inventory, thus reducing the purchase budget.

Consumable medical supplies are accessible at any time when needed with rapid and timely delivery. Processes such as application, collection, bookkeeping, and delivery can be done through the information platform, which will automatically

generate reports of relevant data. After directors of relevant departments sign their names and confirm the receipts of consumable medical supplies, the whole application and reception process will be completed. Since the interconnection platform operates 7/24, clinical departments are able to file application at any time, which is much more convenient and totally different from how consumable medical supplies used to be delivered.

Product information is transparent due to digitalized management. The “three licenses”, expiration dates and other information of the purchased consumable medical supplies are all stored in the information management platform and can be queried and retrieved at any time.

2. Quota management is adopted to deal with application and collection of medical supplies of clinical departments

Unlike the purchase of medical equipment, consumable medical supplies are often purchased irregularly according to the needs of the clinical departments. In order to further streamline processes and provide convenience for clinical medical staff, quotas are estimated and generated accordingly by year, month and week. Quota management is realized through the clinical quotas statistical report that is generated automatically by the hospital’s medical supplies management information system. The consumables are delivered regularly and their amount is adjusted regularly, which not only simplifies the application process, but also meets the needs of clinical departments in a timely manner, laying a solid foundation for the performance assessment of the hospital’s medical supplies management.

3. Establish and improve suppliers’ catalogue and product information system to increase procurement reliability. In the medical supplies management system that is established based on the reengineering of consumable medical supplies management process, further integration of third-party distributors and supplement information and resources of suppliers and products to establish a larger and more comprehensive data base for qualified suppliers and consumable medical supplies, creating beneficial conditions for the hospital to improve its procurement management level.

4. Further strengthen the normalization and standardization of product

management

The hospital medical supply management system provides information of qualified suppliers and products. The system fills in the basic data of the qualified products supplied by companies that meet the following conditions. The businesses included in the system must possess *Enterprise License for Manufacturing and Selling of Medical Equipment* and *Product Registration Certificate of Medical Equipment*, issued by provincial or state drug supervision and administration departments as well as *Hygienic License* and *Enterprise License for Selling of Medical Equipment* issued by public health departments. As for high-value consumables, the hospital adopts the method of reverse logistics method, namely, the consumables, based on standardized purchase, application and collection, will first be delivered to clinical use before being put into warehouses and discharged from warehouses. Basic medical supplies in the information system are used to establish spare accounting records for high-value consumable medical supplies so that necessary consumables can be delivered in the needed amount, at the needed time and via the needed channel.

5. Adjust and optimize hospital financial accounting, integrate medical supplies management with hospital performance assessment

Before the fifth day of every month, the application and examination table of consumable medical supplies of different clinical departments will be generated automatically by the medical supplies management system submitted to the department for examination and verification. After the final review of the accounting department, the table will be sent to the head of the financial department for approval. Since the new management approach of reengineering and of consumable medical supply management process was implemented, by reducing logistics links such as procurement, warehousing and collection, the hospital has become much more efficient. At the same time, the financial examination process has been optimized and the amount of invoices and receipts has been reduced, greatly alleviating the workload of financial staff, without violating regulations of the financial management system.

4.3.3 Technical Support, Operational Mode and Advantages of Medical Supply Management Information System Process after the Internal Hospital Process Reengineering

Given increasingly higher levels of hospital management and faster development of hospital reforms, competition among hospitals will inevitably become fiercer. In order to gain a competitive edge in the fierce market, a hospital must intensify internal management and improve operational efficiency. While usage of software systems in different hospitals has brought opportunities to build information platforms, these software systems are unable to carry out accurate cost management of consumable medical supplies usage in clinical departments. Since the hospital is unable to accurately analyze the cost, a computer medical supplies management system must be established. Initiation of system software of various kinds in hospitals has brought an opportunity to information platform reengineering.

Currently, the collection of consumable medical supplies is calculated mainly through manual computation. The filling of receipts, bookkeeping, and account checking are all done manually. However, the new medical reform has increased the types of consumable medical supplies and medical equipment as well as the business volume. As a result, manual accounting alone is unable to meet the new work demands.

Therefore, the current situation has created an opportunity for the establishment of relevant supply management systems. Establishment of a supplies management system can help hospitals accurately understand to which departments the consumable medical supplies go and carry out a statistical analysis on relevant data for cost accounting. In addition, application of technologies such as product coding, bar coding, electronic order and procurement data analysis makes the procurement management of consumable medical supplies more scientific, standardized and comprehensive, thus resolving the difficulty of manual bookkeeping. The logistics management platform can integrate the follow-up quality control medical supply management within the hospital and cost control management of departments with the hospital's internal performance assessment after procurement management, building a solid foundation for the establishment of an integrated information platform of hospital procurement and management and an information management system of hospital logistics. It also paves

the way for the hospital to realize effective management and build a decision-making system for hospital executives.

1. Design needs and technical structure of hospital medical supply management platform

Design of the system should follow the national standard of hospital information system and, at the same time, be systematic, standardized, and automated. In addition, the system should be practical, easy to operate and quick to learn. Both system software and hardware should be highly reliable and secure. Last but not least, the system should be scalable, which means both the software and hardware can be maintained and extended in the future. The user interface should be as friendly as possible. Simple operations should be done without manual input. The system should be compatible with various end devices to guarantee the convenience of input and output. Visual programming language C++ is used to develop the medical supplies management system, while the mature MS SQL Server 2005/2008 is used to manage databases, which substantially increases the degree of information integration and sharing. In addition, the visualization of user interfaces makes the use of system simpler and more convenient.

Based on the above analysis of needs, in combination of the common structure principles of the hospital systems, the hospital medical supply system is designed to be two closely-related subsystems: self-service application and collection subsystem for departments (touch screen self-service end-device) and business process management subsystem (WEB Browser, quota, collection, examination and approval of logistics department, department confirmation, ERP interface of orders and suppliers, statistical forms and fundamental data management)

2. Realization and usage of functions of hospital supply management system

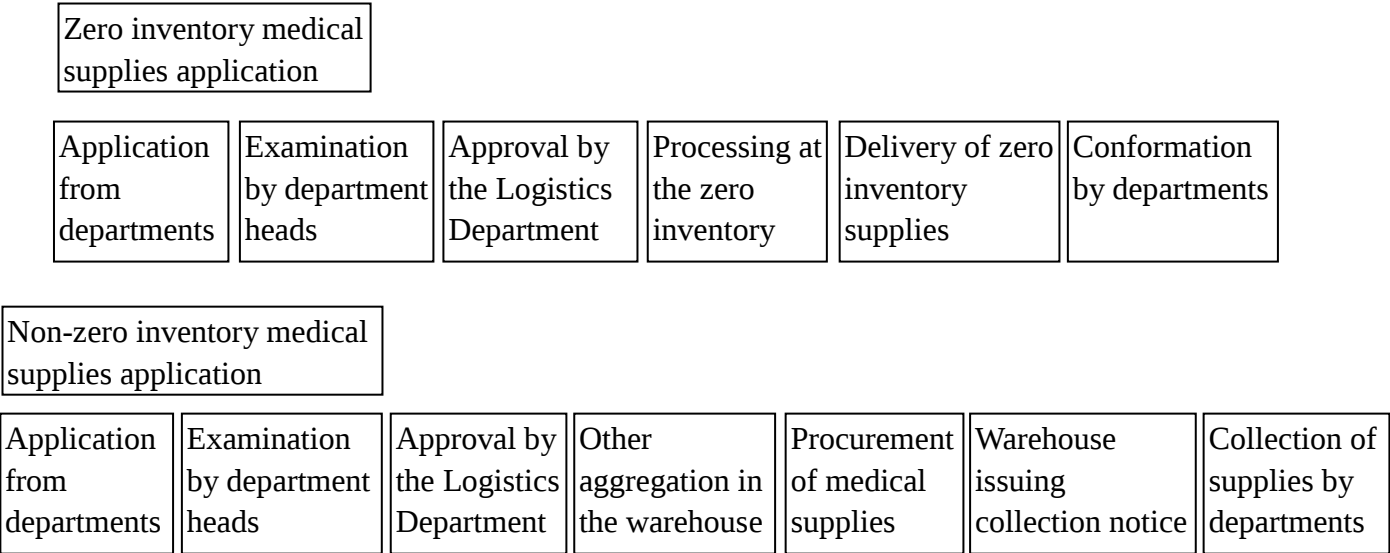
This section introduces the system development platform and describes the usages of several function modules in the system.

a. Function descriptions of the supply management system

The client application adopted in the supplies management system is installed in the touch screen self-service end device. Rather than installation of the software, it can

be logged on through web browsers in other end devices. As shown in the following figure, the process of the system can be explained in two aspects: (1) zero inventory business process and (2) hospital procurement process:

Figure 4-11 Application Process of Medical Supplies within the Hospital



Source: The author

b. User login

Figure 4-12 Login Interface



Source: The author

The user can enter his/her employee ID and password to log into the system. He/she can also swipe the department magnetic card through the slot in the touch screen

end device. The according department name will be shown on the screen, and then requires the department to type in a 6-number pass code. If the password is correct, the user can log into the system. The main interface of the system is shown in the next figure:

Figure 4-13 Main Menu Interface



Source: The author

c. Supplies collection

The category of medical supplies can be divided into multiple levels. After a user selects the general category and detailed category of medical supplies, information such as name of supplies, descriptions of supplies, unit of measurement, types of procurement (outsourced procurement, hospital procurement), monthly quotas and remaining quotas will be shown on the system interfaces. The user can type in the needed quantity via the virtual numeric keypad on the screen and type in comments using Pinyin or handwriting. Once an application is filed, the system will automatically check the supplies quota. If more supplies are needed than the preset amount in the quota, the user will be required to file an emergency application. This process is shown in the following figure:

Figure 4-14 Interface of Supplies Collection



Source: The author

Figure 4-15 Interface of Application Confirmation

Application of supplies

Applying department : 3A病区(2220100) Applicant: Ms. Zhang Date of application: 2011/12/13

Supplies : Sanitation supplies Medical supplies

Name code : Search

Category	Name and code of supplies	Specification	Name of supplies	Unit	Planned quota	Remanent quota	Quantity	Comments
Medical supplies	Sterile injector 1111111 Zero	Specification	Sterile injector	piece		0		
Medical supplies	Disposable anti-ultraviolet infusion set 2661922A Zero	BB105A 0.7# Plastic without stickers (KDL)	Anti-ultraviolet infusion set	piece	10	10		
Medical supplies	Disposable anti-ultraviolet infusion set 2661922B Zero	BB105.1A 0.7 Light proof bag without stickers (KDL)	Anti-ultraviolet infusion set	piece		0		

Add to the list

List of currently applied supplies

Name and code of supplies	Name of supplies	Specification	Unit	Planned quota	Remanent quota	Quantity	Comments	Operation
Disposable anti-ultraviolet infusion set 2661922B Zero	Anti-ultraviolet infusion set	BB105.1A 0.7 Light proof bag without stickers (KDL)	piece		0	50		Correct Delete

Submit to department head Empty

Regular plan : Save

Note: Zero Refer to zero inventory Self Refer to hospital procurement

Source: The author

The application and collection process of supplies include: List of supplies application, save as a regular plan, confirmation of supplies list, inquiry of supplies collection status, confirmation of collection (please refer to Appendix 1 for specific rules on supplies collection process).

d. Quota management

Details of quota management are as follows. Every department sets a quota for the quantity of supplies based on its monthly usage. If the applied products are within the quota, the distributors will respond to the order immediately without examination and approval from the General Affairs Department. The supplies can be directly purchased and delivered for clinical use upon examination and approval by department heads.

Quota management includes: monthly plan management, emergency application and collection process, and collection management.

Monthly plan management involves monthly plan declaration, monthly plan for clinical department, list of application and collection of monthly planned supplies, list of plans, backup monthly plan list, submission of monthly plan by departments, and examination of monthly plan by the General Affairs Office; Collection management involves system confirmation of outsourced supplies distribution, confirmation of self-purchased inventory, collection confirmation, and statement summary. The statements available from the system include: (Please refer to Appendix 2 for detailed rules of quota management)

Figure 4-16 Detailed Statement of Supply Application

Detailed Statement of Supplies Application

Department : Status : Keyword

Date of documentation : to Date of application ☐ Documented at the very day

Date of application : to Date of approval ☐ Application at the very day

Types of supplies:

No.	Application department	Date of application	Supplies	Specification	Quantity	Comments	Applicant	Purchaser	Status
120	Digestion Department	2011/11/28	Disposable detained needle 2680000E	Butterfly wing-shaped detained needle (without dosing pot) (I.V-II) 24G (KINDLY)	1 piece		WEB administrator		Examination finished
119	Digestion Department	2011/11/28	Disposable detained needle 2680000D	Pen-shaped detained needle (I. V-I) 18G (KINDLY)	1 piece		WEB administrator		Examination finished
117	Digestion Department	2011/11/28	Disposable anti-ultraviolet infusion set 2661922B	B105.1A 0.7 paper plastic light proof bag without sticker (KINDLY)	3 pieces		WEB administrator		Waiting for approval of purchasing director
116	Digestion Department	2011/12/5	Disposable anti-ultraviolet infusion set 2661922A	B105A 0.7# paper plastic bag without sticker (KINDLY)	2 pieces		WEB administrator		Waiting for approval of purchasing director
114	Digestion Department	2011/11/22	Disposable intravenous infusion needle 2669912B	0.5*20 single wing PE (KINDLY)	1 piece		WEB administrator		Waiting for approval of purchasing director
113	Digestion Department	2011/11/22	Disposable intravenous infusion needle 2669912B	0.45*15 single wing PE (KINDLY)	1 piece		WEB administrator		Examination finished
112	Digestion Department	2011/11/22	Disposable anti-ultraviolet infusion set 2661919A	JL047 0.7PE (KINDLY)	1 piece		WEB administrator		Examination finished
111	Digestion Department	2011/11/22	Disposable anti-ultraviolet infusion set 2661922B	B105.1A 0.7 paper plastic light proof bag without sticker (KINDLY)	2 pieces		WEB administrator		Examination finished
110	Digestion Department	2011/11/22	Disposable anti-ultraviolet infusion set 2661922A	B105.1A 0.7 paper plastic light proof bag without sticker (KINDLY)	1 piece		WEB administrator		Waiting for approval of general office director

Source: The author

Figure 4-17 Summary Statement of Supply Application

Department : Types of supplies: Situation :

Keyword: Application date: to Collection at the same day

Serial	Categories	Supplies	Supplies...	Specification	Quantity
0501	Medical supplies	2661919A	Disposable anti-ultraviolet infusion	JL047 0.7 PE (KINDLY)	1 injection
0501	Medical supplies	2661922A	Disposable anti-ultraviolet infusion	BB105A 0.7# paper plastic without sticker (KINDLY)	1 injection
0501	Medical supplies	2661922B	Disposable anti-ultraviolet infusion	BB105.1A 0.7 paper plastic light proof bag without sticker (KINDLY)	5 injection
0501	Medical supplies	2669912A	Disposable intravenous infusion needle	0.45*15 single wing PE (KINDLY)	1 injection
0501	Medical supplies	2669912B	Disposable intravenous infusion needle set	0.5*20 single wing PE (KINDLY)	1 injection
0501	Medical supplies	2680000D	Disposable detained needle	Pen-shaped detained needle (I. V-I) 18G (KINDLY)	1 injection
0501	Medical supplies	2680000E	Disposable detained needle	Butterfly wing-shaped detained needle (without dosing pot) (I.V-II) 24G (KINDLY)	1 injection

Collection of supplies is counted according to the types of all the hospital supplies so that leaders can have a precise knowledge of the use of medical supplies.

Source: The author

4.3.4 Requirements on Hospital Itself for Hospital Internal Process Reengineering

1. After reengineering the internal process, the hospital administrators are required to be more competent in applying information management. In addition, information operators in every logistics link of the internal process of the hospital should also be able to carry out the new practical operations.

2. The training department of the hospital should provide professional training to all staff involved in all the logistics links of the internal process. A set of operational standards should be established so that operations can be carried out in a skillful and error free manner. The consumable medical supplies are coded to form a standardized and unified information product coding system, which facilitates information identification and sharing. It needs a long period of training to shift one's habitual cognition to standardized cognition.

3. The Financial Department of the hospital should summarize the financial data, provide timely financial accounting, and submit precise consumable medical supplies data to the platform for analysis. In this way, the platform can allocate consumable medical supplies in a more reasonable way, and minimize hospital cost in consumable medical supplies. Correct, timely, and effective passage of information is a bond and bridge for hospital departments to communicate and coordinate with each other. According to modern database theories accurate and timely acquisition of information and standardized processing have become the key to business efficiency and success (Zhou, 2001).

4. Requirements brought about by the integration of internal hospital process and the medical equipment interconnection service platform:

In the application of information technology aspect: the hospital should abandon the original management pattern that focuses mainly on manpower and to establish a systematic and comprehensive information management system.

In the standardized management aspect: errors and habitual behaviors should be changed after the establishment of the platform as a standardized and normalized management system.

In the financial system aspect: the financial systems of the hospital and the platform are integrated with limited access right. The hospital can choose different forms and degrees of integration systems based on its needs.

4.3.5 Advantages of Hospital Internal Process After Reengineering

1. Comparison of Hospital Suppliers in Different Management Patterns

Table 4-22 Comparison of Hospital Suppliers in Different Management Patterns

Traditional management		Management after reengineering and optimization	
Level of hospitals	Number of suppliers		
Key provincial hospitals	Around five hundred	Zero inventory	One
Level 3A hospitals	Over three hundred	hospitals	
Level 2A hospitals	Around two hundred		
Level 1A hospitals	Around fifty		
Community clinics	Around ten		

Source: The author.

2. Comparison of Information Technology Application in Different Management Patterns

Table 4-23 Comparison of Information Technology Application in Different Management Patterns

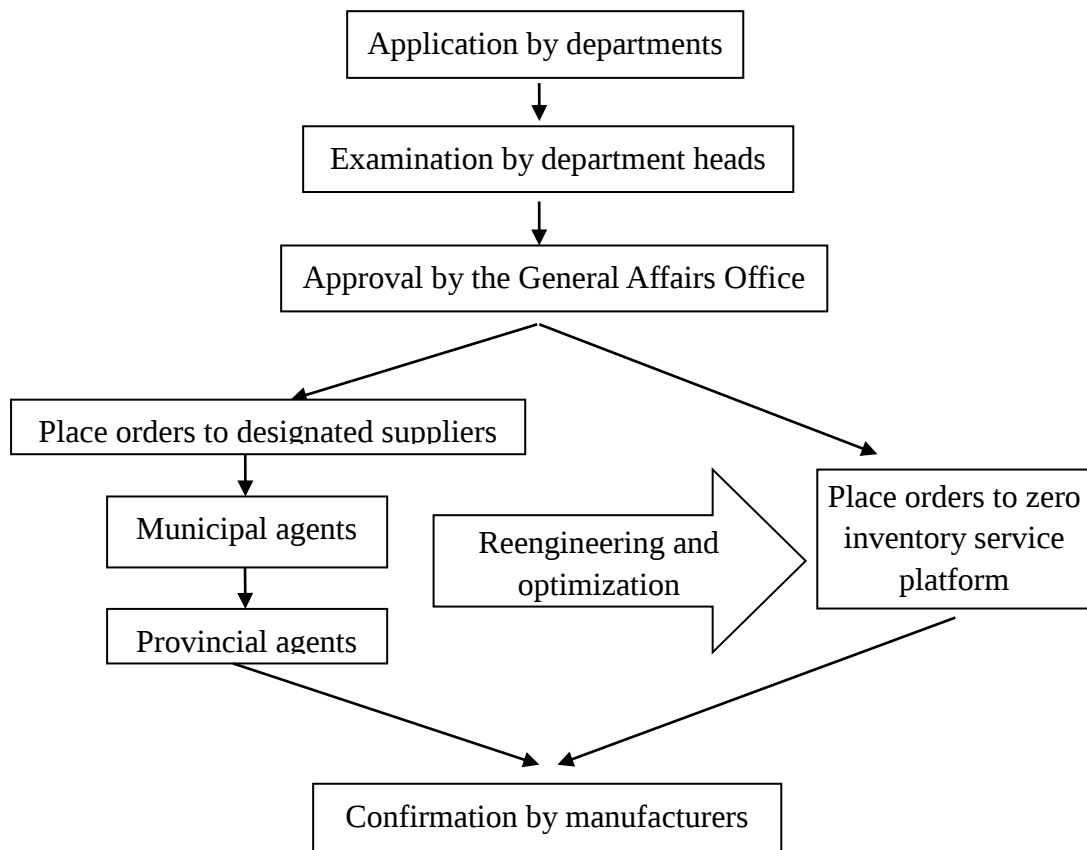
Traditional management		Management after reengineering and optimization	
Level of hospitals	Level of IT application		
Key provincial hospitals	High-level of IT application, but there is no holistic warehousing management information to carry out real-time supervision.	A comprehensive zero inventory information system	It is possible to integrate with other information systems basing on hospital needs, which can realize the real-time supervision.
Level 3A hospitals	IT is applied in part of the hospital and the level is increasing. But there is no holistic warehousing management information to carry out real-time supervision.		
Level 2A hospitals	The level of IT application is ordinary. Parts of operations are done manually. There is no holistic warehousing management information to carry out real-time supervision.		
Level 1A hospitals	Low level of IT application. Most operations are done manually. There is no holistic warehousing management information to carry out real-time supervision.		
Community clinics	Basically there is no IT application. Work is highly dependent on manual operation.		

Source: The author

Applying information technology in the hospital in a creative manner can reduce the hospital costs, increase the speed and accuracy of information decision-making and keep the hospital competitive in the fierce market competitions. It can also reduce the number of mid-level managers, staff and streamline the hierarchical structures, providing strong support for the change of hospital processes (Pan & Zhang, 2004).

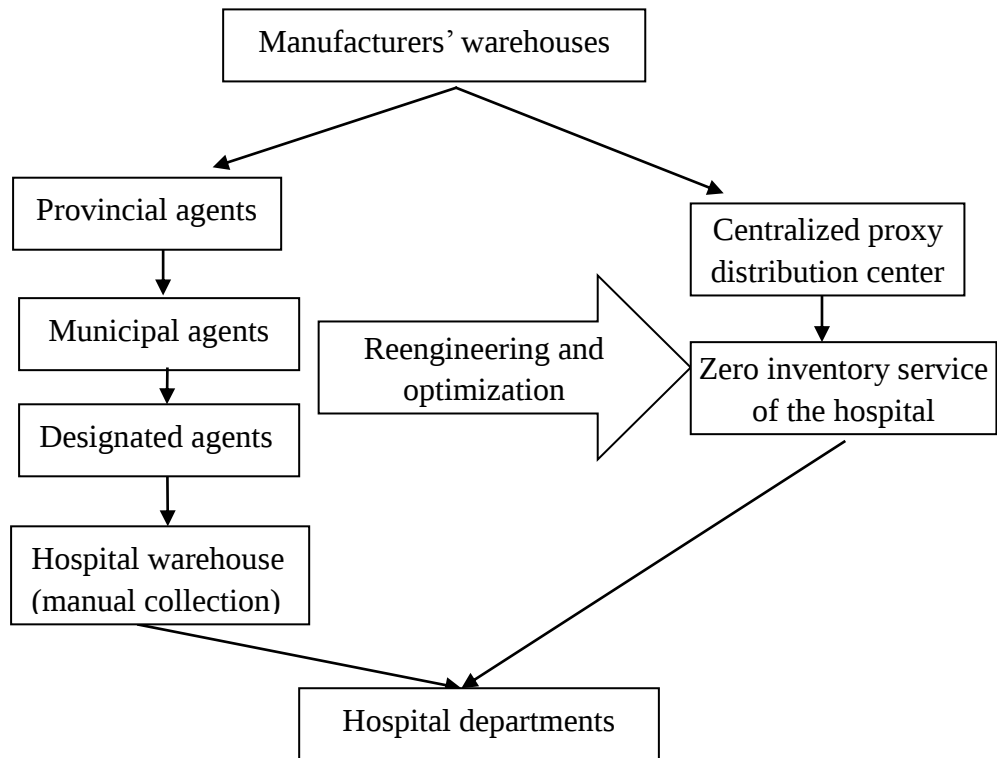
3. Comparison of Hospital Consumable Medical Supply Ordering Process

Figure 4-18 Comparison of Consumable Medical Supply Ordering Process



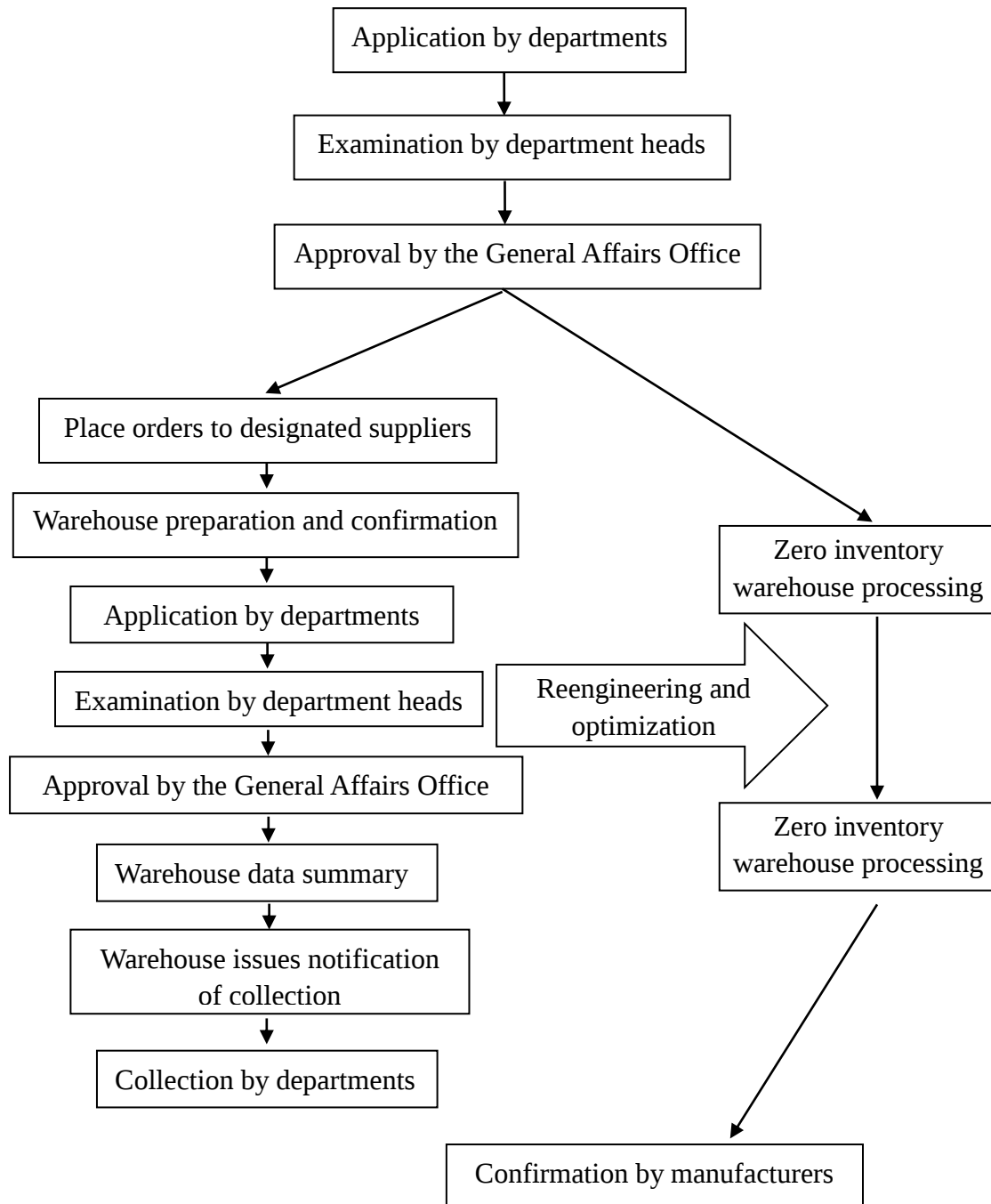
Source: The author.

Figure 4-19 Comparison of Consumable Medical Supply Logistics Process



Source: The author.

Figure 4-20 Comparison of Consumable Medical Supply Collection Process



Source: The author.

4. Characteristics of hospital internal process after reengineering

There are a series of characteristics of the process after reengineering. For example, the production and ordering process is reduced, error rate is decreased, waste of interim stock is reduced, logistics links are streamlined, mistake rate is lowered and turnover loss and cost are also reduced. The management process of consumable

medical supply collection has been equipped with electronic barcode scanning system. Department application links are suggested to be changed in this way: departments do not have to file application for consumable medical supplies because they have already been stocked by zero inventory services based on the amount consumed last month and the average amount consumed for recent months. The whole process shall be confirmed and verified by the electronic information platform. With reduced interim logistics links and a lower error rate, there is no need for hospital warehouses. As a result, hospital cost is reduced. The zero inventory platform is highly flexible and secure. With digitalized operation and accurate data, the occurrence of human error is nearly zero.

5. Comparison of public hospital data after reengineering of hospital consumable medical supply management process

As for the eastern and western branches of the sample hospital in Shanghai, originally there are 25 warehouse administrators and transportation staff, with per capita labor cost of 720,000 Yuan per year. After reengineering, the labor cost has been reduced by 1.8 million Yuan every year. The total area of warehouses is originally 1,700 square meters. After reengineering, the warehouses are rented to the medical equipment interconnection service platform at the price of 40 Yuan per square meters, generating annual revenue of 816,000 Yuan. The two branches of the hospital spend 200,000 Yuan in maintaining distribution vehicles and 114 million Yuan in purchasing consumable medical supplies every year. If the hospital's capital is occupied for two months on these expenses, which is the least period of time on average, the capital occupied will be 19 million Yuan every year. Through reengineering of consumable medical supply management, the sample hospital being studied is able to get an extra 21,816,000 Yuan capital surplus than before, which can be used to promote performance in other fields of the hospital.

4.4 Questionnaire Survey Results

This section is divided into two parts including result presentation and result analysis.

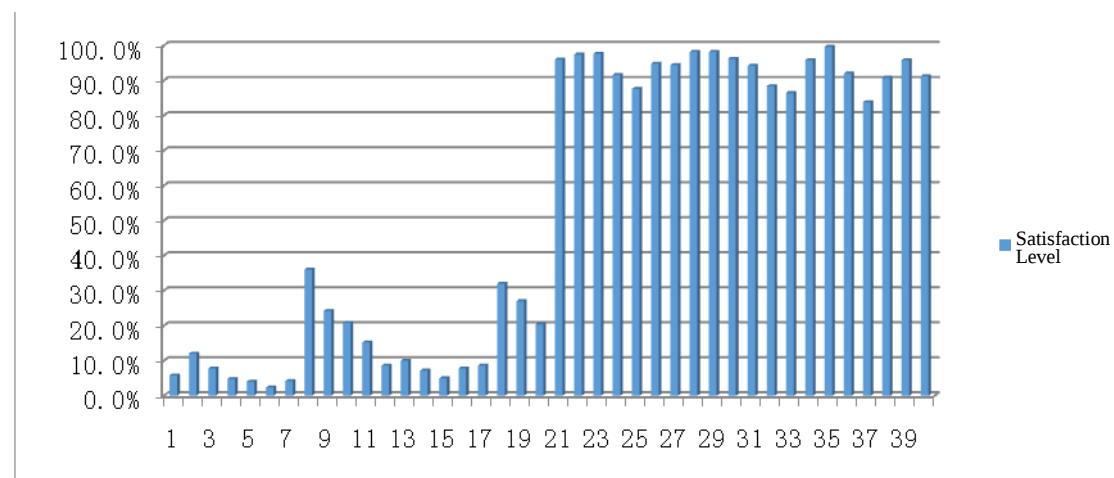
Result presentation is divided into bar charts illustrating of the survey results and presenting of the percentage for each question and each option (because the latter is too lengthy, please refer to Appendix 3 for details).

4.4.1 Details of Questionnaire Survey Results

1. Statistical Figure of Satisfaction Level Questionnaire Results (general statement)

Questions 1 to 20 are results of the survey on traditional management of consumable medical supplies, whereas questions 20 to 40 are results of the survey on new management of consumable medical supplies.

Figure 4-21 Statistical Results of Satisfaction Level Questionnaire Analysis
(General Statement)

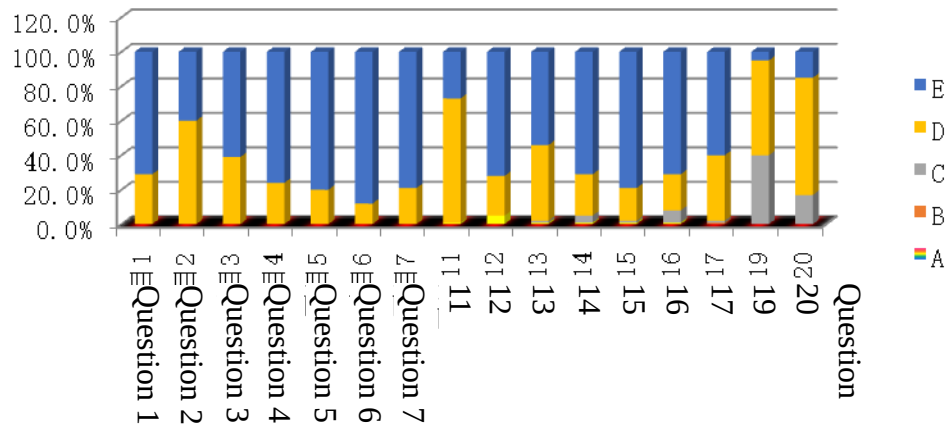


Source: The author.

2. Descriptive statistics of Satisfaction Level Questionnaire Results (Separate Statement 1)—results of the survey on traditional management of consumable medical supplies

The satisfaction level decreases from A to E, with A representing the highest satisfaction level and E representing the lowest. A refers to Strongly Agree, B Agree, C Neither Agree Nor Disagree, D Disagree, and E Strongly Disagree.

Figure 4-22 Statistical Results of Satisfaction Level Questionnaire Analysis
(Separate Statement 1)

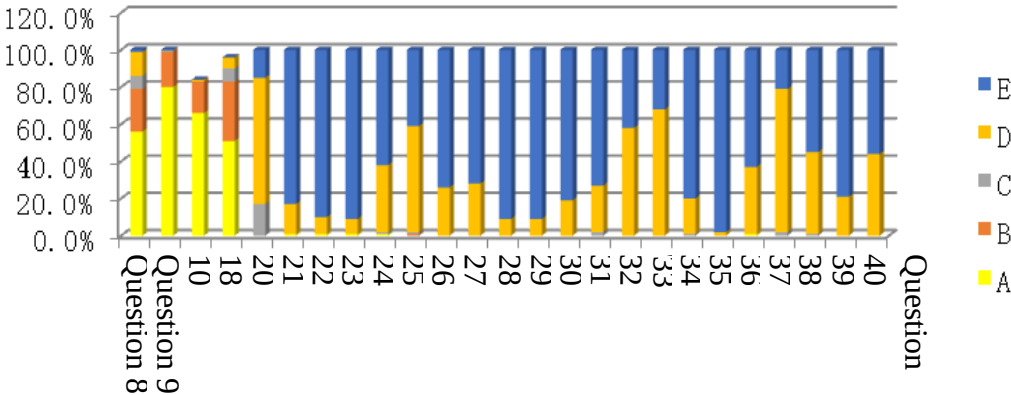


Source: The author.

3. Descriptive statistics of Satisfaction Level Questionnaire Results (Separate Statement 2) (question 8, 9, 10 and 18 are results of traditional management of consumable medical supplies, whereas 20-40 are results of new management of consumable medical supplies)

The satisfaction level increases from A to E, with A representing the lowest satisfaction level and E representing the highest satisfaction level. A refers to Strongly Disagree, B Disagree, C Neither Agree Nor Disagree, D Agree, and E Strongly Agree.

Figure 4-23 Statistical Results of Satisfaction Level Questionnaire Analysis
(Separate Statement 2)



Source: The author.

4.4.2 Analysis of Questionnaire Survey Results

1. Overall Descriptions of Results

It can be clearly inferred from the general statements and separate statements of the above figures that the respondents are far more satisfied with the new management than the traditional management. From the percentage of each question and each option in the appendixes, it can be inferred that: 93.5% of the respondents are satisfied with the new management of consumable medical supplies, significantly higher than their satisfaction with the traditional management of consumable medical supplies, which is 13.2% suggesting that the new management of consumable medical supplies is more scientific and advantageous than the traditional management.

2. Detailed Descriptions of Results

Separate descriptions 1: it can be illustrated from the percentage of each option under each question in Appendix 3 that: Under the traditional management of consumable medical supplies, there are 13 aspects with a satisfaction level of less than 15% among respondents suggesting that more than 85% of the respondents think that these 13 aspects have deficiencies. The deficiencies are reflected in the following aspects: (1) Traditional management performance in hospitals, (2) compliance with the orientation of the current medical reform, (3) coverage of information application, (4) degree of professionalism, (5) compliance of logistics links and processes with cost accounting; (6) inventory cycle time of order management, (7) execution error rate, (12) Severity of buck-passing among different departments, (13) Level of process coordination, (14) Constraint level on hospital development, (15) Hospital capital turnover efficiency, (16) Warehousing cost, (17) High cost resulted from many logistic points, (18) Effectiveness of risk management, (19) Compliance with detailed regulations of the medical reform, and (20) Compliance with the development of the national finance support. The fact that the satisfaction level is less than 15% indicates that the above aspects should be given priorities to in the reform of traditional consumable medical supplies, so as to manage consumable medical supplies scientifically and reasonably.

Separate descriptions 2: it can be concluded from Appendix 3 that: Under the new management of consumable medical supplies, there are 19 aspects with a satisfaction level above 85% among respondents. Only one aspect has a satisfaction level below 85%, which is the new management compliance with the orientation requirements put forward by the National Development and Reform Commission in 2014. This means that the new management of consumable medical supplies needs to be further strengthened on the basis of complying with the orientation requirements put forward by the National Development and Reform Commission in 2014. However, the following 19 aspects have shown better results: (21) Clarification of malpractices handling mechanism in the new management; (22) Clarification of monitoring process of the new management; (23) High level of automatic warehousing management in the new management; (24) Low hospital labor cost under the new management; (25) Distribution is highly reasonable under the new management; (26) Job responsibilities and performance management are clear; (27) Normalization of service connection; (28) Relatively zero warehousing cost; (29) Real-time coordination in management; (30) Reduced number of process nodes; (31) Lowered hospital financial cost; (32) Reduced coordination between different departments, and clear responsibilities; (33) Compliance with the hospital's positioning of giving No. 1 priority to technology management; (34) Lower the hospital's logistics and service management risks; (35) Platform integrated management; (36) Reasonable application of e-commerce model; (38) compliance with the requirements on medical reform put forward by China's Ministry of Industry and Information Technology in 2014; (39) Compliance with the hospital development orientation mapped out by China's National Health and Family Planning Commission; (40) Compliance with the support given to hospital development by the China's Ministry of Finance in 2014.

4.5 Summary of Analysis Results

This research uses three methodologies: interviews, case studies and questionnaire surveys. The interviews were conducted with executives in consumable medical supply manufacturing and supplier companies. The case studies were based on two aspects. The first aspect is how the inter-organizational network external to a hospital has changed as a result of institutional changes and technology platform development. The second aspect is how the processes and systems internal to a hospital have changed as a result of the hospital's process reengineering and joining the new external supply network. The questionnaire surveys were conducted with executives and managers from different departments and units of a large hospital. The use of three different methods is strength of this research and provides triangulation of the analysis results. The table below summarizes key findings across the three methods.

Table 5-1 Integrative analyses and comparisons across three research methods

	Interviews	Case Studies		Questionnaire Surveys
		External to the hospital	Internal to the hospital	
Focus of the Data Collection and Analysis	Problems existing in the current consumable medical supply management situation, solutions to the problems, main targeting areas of the solutions.	Separate out the non-core business processes/modules, such as inventory management, information management, logistical transportation, from the manufacturers, supplies at different levels, and hospital, while ensuring that the normal operations are not affected, move these processes/modules to the integrated platform, in order to achieve professionalized integration and management.	By enhancing computerized information system management, coordinated financial management systems, and standardized process management, while ensuring that the normal operations are not affected, transfer non-core specialized business processes to external platform) to maximize the reduction of costs.	Whether or not the followings are consistent with the direction of national health reform: labor costs, warehousing costs, management of information technology to achieve real-timeconnections, financial cost, controllability, reduction of logistical process steps, and application of e-commerce.
Challenges Involved in the Process Reengineering Changes	Organizations may have biased views of process reengineering, using different reengineering methods, the upfront capital investment is too large.	Doing innovative reengineering and optimization of the consumable medical supply process and integrating with external entities requires training and agreement. At the same time, it may affect the interests of some stakeholders. of the chain.	New information systems, financial systems, and standardized management processes impose new requirements on internal staff's ability to learn and adapt; the management model may create interruptive effects on internal staff's interests.	Challenges are overcome as evidenced by the increased satisfaction towards the reengineering effort.
Before Process Reengineering Changes	Not satisfied with the state of consumable medical supply management, there is a consensus that the process needs reengineering changes.	Too many steps involved in the process, outdated warehouse and inventory management; fragmented, unorganized and poor management; quality management is not controllable; increased product costs.	Tens to hundreds of suppliers, poor warehouse and inventory management, high labor costs, increase pressure for capital.	Very low satisfaction toward the pre-reengineering process.
After Process Reengineering Changes	Three different reengineering methods have been utilized.	Unified process management, combine warehousing management, information technology, logistics and transportation into a professional integrated management process.	Faced with one supplier, hospital is able to achieve relatively zero inventory, close to zero warehousing labor cost, and the financial pressure is reduced.	Very high satisfaction toward the post-reengineering process.
Results/Conclusions from the Process Reengineering	Reengineering and optimization is an inevitable.	Professional management, reduce process costs and achieve integrated management.	Hospitals have money and ability to enhance the professional level of clinical processes.	The post-reengineering process of consumable medical supply management is more scientific and appropriate than the pre-reengineering process.

Source: The author.

The selection of the participating executives in the interviews is based on my own experience and research related to consumable medical supplies management, and is able based on my new learning through studying theoretical literatures including cooperative competing theory, business process reengineering, total quality management, inventory management concept, and current Chinese and foreign research on consumable medical supply management. The main design foci include: problems existing in the current consumable medical supply management situation, solutions to the problems, main targeting areas of the solutions. The interview data collection drew on three industry experts' theoretical understanding and practical experiences, and their analyses and reflections on the different reengineering methods that they had used in resolving the key challenges and problems they faced. The main content of the interviews focused on how organizations separated out the non-core business processes/modules, such as inventory management, information management, logistical transportation, from the manufacturers, supplies at different levels, and hospital, while ensuring that the normal operations were not affected, moved these processes/modules to the integrated platform, in order to achieve professionalized integration and management. The outcomes of the reengineering efforts were verified by the questionnaire surveys conducted with hospital executives and managers. The main content of the questionnaire focused on labor cost, warehousing cost, real time information systems processing and connections, financial cost, process controllability, reduced steps in the logistical process, application of electronic comment models, compliance with the direction of national medical reform, and comparison of satisfactions before and after the reengineering effort.

Innovation is always challenging. All executives participating in the interviews agree on the overall direction of reengineering the consumable medical supply management process and on the necessity of reengineering. But they were concerned about the large investment required for the reengineering effort. The case study shows that the reengineering of the processes, both internal and external to the hospital, would affect the existing value chain process and affect the interests of different stakeholders

involved; this is the most significant challenge in the overall reengineering effort. At the same time, the reengineering effort requires the organization to take the time and process for necessary training on the new computerized information management and standardized management processes. There is a skill gap between what the reengineered process requires the staff to have and what the staff actually possessed. The integrated hospital management, both internal and external to the hospital, created an interruptive change to the human resources system.

The executives participating in the interviews raised some questions and doubts about the pre-reengineering process of consumable medical supply management. They also provided various solutions to resolve the different problems. The main problems examined in the case study of the hospital changes of processes, both internal and external, included: warehousing cost, supplier management, cost management, and controllability. The questionnaire survey results suggest that hospital executives and managers had very low satisfaction scores toward the pre-reengineering process of consumable medical supply management. There were thirteen items that had satisfaction scores below 15%, with the lowest satisfaction score of 2.4%, and an average score of 13.2%.

The executives participating in the interviews provided feedbacks on three different methods used in reengineering of the consumable medical supply process. The first method was utilizing China electronic specialized medical equipment sales platform. The second method was utilizing the consumable medical supply CGPO model that was first in China. The third method was utilizing the method that was the focus of this research, the integrated medical equipment and supply service exchange platform. The case study and survey data suggest that the integrated exchange platform was based on the reengineering of the whole consumable medical supply process, both internal and external to the hospitals. The results suggest that the hospital was able to achieve relatively zero inventory management, reduced costs of capability, labor and management. The survey results suggest that the hospital executives and managers have high satisfaction ratings toward the post-reengineering process of consumable medical supply management. There were nineteen items that had satisfaction scores

higher than 85%, there was only one item that had a satisfaction score lower than 85% (83.8%), with an average satisfaction score across all items of 93.5%.

Although the executives who participated in the interviews had used different reengineering methods, they agree on the problems existed in the pre-reengineering process of consumable medical supply management, and on the necessity of reengineering. There is an increased pressure from the external stakeholders of the hospitals that require the process to be changed to achieve professional management, reduced process cost, and integrated management. With the hospital, there is a need to, without affecting the normal operations of the hospital, transfer out none core business processes in order to reduce the overall consumable medical supply cost. By doing so, the hospital would have additional capital and ability to enhance clinical capabilities. The consistent and overwhelmingly high satisfaction scores shown in the survey study results provide evidence of the appropriateness and business benefits from the reengineered process of consumable medical supply management.

Chapter 5: Conclusions

A comprehensive study on consumable medical supplies management process has been carried out in this research. Cooperation-competition strategy, total quality management, zero inventory theory, information application in medicine, medical management process reengineering and optimization theory, all of which are manifested in the development of the platform, and have been studied in this thesis. The implementation processes of several empirical examples have been analyzed; and the current reengineering methods of consumable medical supply management have been compared. As a result, it is concluded that a medical equipment interconnection service platform is an ideal alternative for the traditional management of consumable medical supply management process. The results of reengineering efforts and the platform implementation are verified through actual operations in a certain hospital.

First, supply chain-based consumable medical supply management process reengineering is established under the principle of cooperation-competition tactics. Cooperation-competition is the intrinsic requirement of supply chain management. Supplies, manufacturers, intermediary parties, and consumers are inter-dependent links in the supply chain. Each of these logistics links is value-creating, indispensable and inevitable parts of the whole re-production chain. Companies in the supply chain are both competitors and cooperators. The purpose of competition is to maximize self-interests, whereas the purpose of cooperation is to maximize the overall interest of the whole value chain. In the current international practice, the premise for the study of cooperation-competition strategy is in a single product economy. But the premise of the study of cooperation-competition strategy in this thesis is the parallel existence of the Chinese government's regulation of economy and the market economy. Basing on China's medical reform, a research orientation that suits the status of public hospital reform has been put forward, and new feasibility of applying the cooperation-competition strategy under multiple forms of economy has been examined.

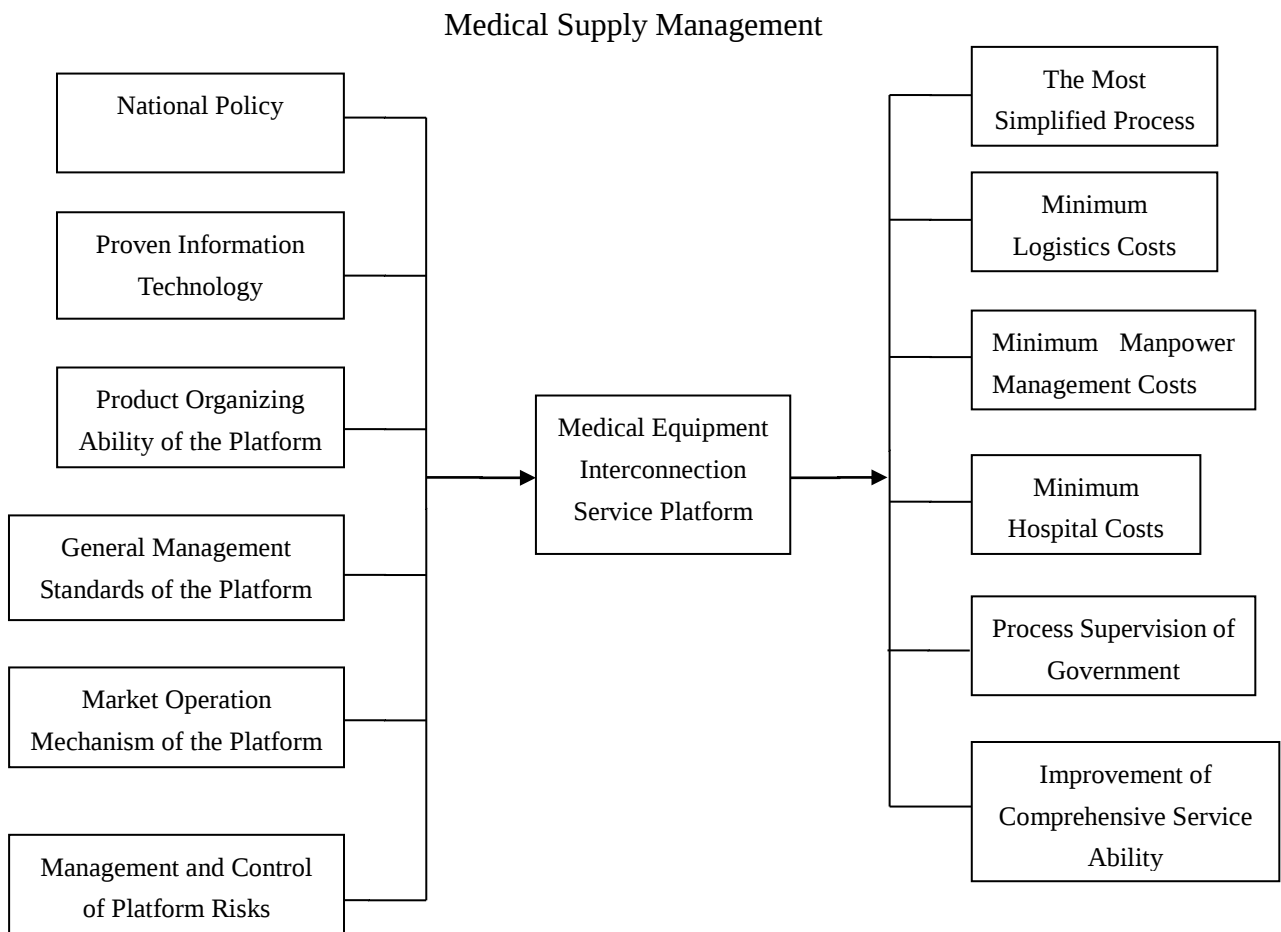
Second, before reengineering, consumable medical supply inventory had been a tough problem. Inventory management of consumable medical supplies is multi-level and ultra-normal way of inventory management. Principles of estimated plan, lead order, extra-quantity plan report and preparation and monthly distribution are followed, resulting in increased severity of inventory problems at every level. The medical equipment interconnection service platforms formed after the reengineering efforts realized zero inventory management of hospital inventory. In this way, inventory will be planned according to hospital needs and demands, orders will be placed according to needs and demands, information will be managed electronically, and distribution will be made daily. This has resulted in reduced inventory capital cost, inventory management cost, and logistics cost for the hospital and increasing the hospital information-based management of consumable medical supplies. With decreased hospital social insurance budget from national finance, control of medical and pharmaceutical cost has become more mature. As the second largest cost producer of a hospital, consumable medical supply management is suffering from serious backward management, and has a more and more profound influence on hospital total cost. The present research transforms the pervious consumable medical supply management approach characterized by predictability, batch management, multi-links, and regular inventory into a management approach characterized by real-time management, small batches, few links, and relatively zero inventory.

In this thesis, the medical equipment interconnection service platform is established on the basis of extant theoretical analysis. The value and advantages of the platform is demonstrated with theoretical basis and verified through empirical examples. Improvement is made regarding the unilateral parts of the original management process. The overlapping parts of the process are combined, enabling a comprehensive reengineering of consumable medical supply management process.

Reengineering principles of consumable medical supply management process are analyzed, confirming the foundation laid by medical equipment interconnection service platform and verifying the advantages of consumable medical supply management

process after reengineering.

Figure 5-1 Flow Chart of Process Reengineering of Consumable



Source: The author.

The establishment of a medical equipment interconnection service platform requires the following aspects: support of national policy, user acceptance, application of market behaviors on the platform and market promotion of the platform, comprehensive management regulations of the platform, hardware facilities, platform information technology, as well as risk management and control.

1. Support of national policy means that the platform needs to conform with the various policies, regulations and rules: the orientation of national health care reform, national policy reform of and laws and regulations for e-commerce and internet, rules of operation against functions of national foreign exchange rate and bank interest rates, national policy reform of and laws and regulations for medicine and medical equipment, and national policy reform and laws and regulations of modern logistics.

2. Users of the platform include: specialized stores, such as state-owned large

stores and private stores, manufacturers, overseas product agents, overseas purchasers, medical institutions and government departments that include department of supervision, department of drug administration, department of health, industrial and commercial department, and department of media supervision.

3. Market operation mechanism of the platform consists of the following aspects: market layout, including city classification, network construction, market planning and funding; marketing strategy, which can be carried out in various forms, such as training, forum and academy; marketing target, such as core cities, first-tier cities, second-tier cities and third-tier cities; marketing group, which is responsible for market expansion, market service and technology application; users, such as medical institutions, specialized stores and state-own procurement agents; suppliers, including Chinese manufacturers, foreign manufacturers and foreign agents; government functional departments, such as department of drug administration, department of health and other functional departments; public relations, which cover government functional departments, users, suppliers, and expert systems.

4. General management standards of the platform cover the following aspects: group development management, which includes management group, service group, market group, logistics group, technology group and operation group; price system management, which consists of pricing strategy, pricing principles, limits of pricing authority, price control; quality system management, which covers standards, licenses, products and processes; settlement system management, including risk control, receivables and payables, deadline of settlement and means of payment; marketing system management, covering marketing planning, product training, product promotion and district management; salary system management, including salary, welfare and subsidy; incentive mechanism management, such as the management of award, performance and share options; and the management of management and control mechanism, which ranges from crisis management and control, regions and development to technologies and markets.

5. Hardware of the platform includes: hardware and infrastructure of information

technology, office hardware and facilities, storage place, storage facilities and logistics hardware facilities.

6. Information technology of the platform includes coding technology, e-commerce technology, bar-code management technology, visualization of the whole process, data collection, data objects, warehouse logistics technology, standard databases and network technology platforms.

7. Risk management and control of the platform covers several aspects: policy risk, such as policy reform risk and capital loan risk; management risk, which exists in management process and system and manpower management; market risk, which comes from the competition with traditional modes, fluctuation of foreign exchange rate, and changes of bank interest rates; behavioral risk, which might result from enterprise culture and vicious events; legal risk, such as contract risk, settlement risk and supply-related risk; product risk, which is related to product quality, date of delivery and inventory management; technical risk, which comes from technology hardware infrastructure, software developer, optimization of information and technology and internet technology innovation.

There are some requirements on each point existing in the platform for the formation, promotion, and application of the medical equipment interconnection service platform. For example, information coding of products provided by manufacturers must be consistent; hospitals must improve their information management ability, especially the management ability of logistics and inventory, and obsolete the original manual operation; hospitals must improve the standardized management and establish a normalized and standardized management system, in which new requirements are made on the original system management and excludes errors or habitual behavior.

Previous studies on consumable medical supply management mainly focused on inventory management, little research has studied the whole management process. The present research proceeds from the macro process reengineering to form a medical equipment interconnection service platform to achieve consumable medical supply management. The platform affects the relatively micro hospital internal consumable

medical supply management processes, realizes relative zero inventory management in hospital process and optimal inventory management in circulation process, verifies the advantages and innovation of the research through the data of hospital consumable medical supply cost, and put forwards fourth-party logistics organizations for the first time.

Total quality management has not been put forward in studies on consumable medical supply management before. The present research is conducted under the premise that quality not only has been affected but also gets improved. There were too many nodes from circulation to utilization of the original consumable medical supply process. Different hidden quality problems existed in every node, such as influence of different raw materials on quality, influence of production techniques and control on quality, quality problems caused by circulation, and real-time quality problems caused by inventory. Total quality management adopted by the platform can realize quality monitoring and tracking of the whole process from raw materials to patient use through coding which improves management services and ensures quality control on the basis of lowering costs.

The most appropriate forecast method has been adopted using the scientific way of forecast in the empirical research of reengineering of consumable medical supply management. After reengineering of consumable medical supply management, operation cost of hospitals, production cost of medical consumable suppliers, inventory and logistics cost of distributors are all reduced. Furthermore, government supervision and patient satisfaction are improved while risks are lowered.

Although the present research, which is based on an empirical research that has lasted for two years, verifies the rationality and effectiveness of reengineering of consumable medical supply management and achieved some results, more research on the issue need to be further investigated. Limitations of this research are discussed below.

First, the present research only studies consumable medical supplies, which are a part of hospital supplies management. It does not study the non-disposable products,

logistics and sensory control consumables, which are also important parts of consumable medical supplies.

Second, the scope of theories is limited. Initially Porters' Five Forces Analysis Theory was used as a theoretical basis for this study. During the research and revisions of the thesis, it was found that interpretations and applications of Porter's theory differ significantly in China. There are misunderstandings in the combination of advanced theories and the Chinese culture, resulting in deviations of the research in the initial period. Multiple-theory perspective is seldom used in Chinese domestic research. As a result, there were some mistakes in the application and interpretation of the theory in the beginning stage.

Third, the number of hospitals used in the empirical research is small. When a large number of hospitals use this platform simultaneously, the validity of the information and results still need to be further tested. In addition, since the data collected in the research is limited and the data cannot be released because of confidentiality, most of the comparisons are presented in a generalized form. What's more, the training of hospital staff is a difficult part of the reengineering efforts and platform implementation. Habitual behavior and operation, low level of information operation, unspecialized logistics, and comparatively low acceptance of the use of bar code have caused difficulties to the collection of empirical data to some extent. As a result, this research is not yet able to put forward a comprehensive training course or scheme for the standardized platform.

The present research started in 2009. It lasted four years from theoretical study to hospital empirical study. During the two years of thesis writing, over 200 hospitals had started similar reengineering efforts and platform implementations. From a couple of hospitals to hundreds of hospitals, the increasing number of hospitals that invest in reengineering and platform implementation is also a proof of the significance of the study. The present research is a beginning in China's consumable medical supply process reengineering. From macro process reengineering to introduction of information-based approaches, changes of one system will cause structural changes, which requires massive coordination and running-in in the process. Ways of

information application change with each passing day, and realization ways of process reengineering also change along with them. China's medical reform has been progressing, from hospital rating to medical triage, then to doctor multi-site practice, and long-distance consultation. Reengineering of consumable medical supply process needs to accommodate the progress of medical reform. The research will proceed with changes of relevant factors, such as standardization of total quality management in the process, progression of relative zero inventory into zero inventory, effects of cooperation-competition strategy on expansion of production and supply chain, as well as the link between information application and medical triage.

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Appendix 1

Supplies collection includes:

Supplies Application and Collection List:

After entering the needed supplies, users can click “Supplies Application and Collection List” to review the list of applied supplies. They can click the names of supplies in the list to change the quantity and notes or remove the item from the list.

Save as regular plan:

Users can save “Supplies Application and Collection List” as a spare list so that it can be loaded and used after some minor adjustments when there are applications next week or next month. Users can save the supplies list on the current page as a regular plan by clicking the “Save” button of the regular plan and entering the name.

Supplies list confirmation:

Users can submit the supplies list after verification and confirmation. Application and collection of supplies within the quota will be directly sent to the respective warehouse of the supplies after deducting the quantity of the quota. Warehouses will be responsible for goods preparation, allocation, and distribution.

Query of supplies collection and utilization status:

Departments can check the collection and utilization status of supplies, namely, in preparation, to be collected, collected, or canceled.

Collection confirmation:

Collection confirmation refers the on-site confirmation in the form of signature on receipt or confirmation on computer, end devices, and laptops by receivers who have verified the supplies to be correct after supplies have been distributed to clinics from the distributor.

Appendix 2

Quota management includes:

Manual input of quota: Staff of the General Affairs Department enters the quota respectively according to department, ways of supplies code, and quota quantity of next month.

Import EXCEL files: Staff of the General Affairs Department summarizes quotas into an Excel file in advance and import the Excel file into the system.

Quota check: The General Affairs Department can check the quota utilization of each item of supplies in each department.

1. Monthly plan management

Monthly plan declaration: This is a bottom-up way to determine the quota.

Monthly plan of clinical departments: After the general and detailed categories of supplies are selected, the system will reveal relevant information including name of supplies, descriptions of supplies, unit of measurement and types of procurement (outsourced procurement and hospital procurement). The user can type in the needed quantity via the virtual numeric keypad on the screen and type in comments by Pinyin or handwriting.

Application list of monthly planned supplies: A click on this “application list of monthly planned supplies” will reveal information on the supplies after the user types in all the needed supplies.

List of plans: The user is allowed to change the quantity and comments or remove the supplies from the list by clicking on the name of supplies in the list.

Save as backup monthly plan list: The user can save the “application list of monthly planned supplies” as the backup monthly plan. In the next month, this plan can load by itself and can be used as a new plan merely after minor adjustments.

Submission of monthly plans by departments: The user verifies the list to be errorless and confirms that it can be submitted.

Examination of monthly plans by the General Affairs Department: The General Affairs Department is responsible for examining monthly plans of every department. After the examination, the supplies quota for the next month will be generated automatically.

2. Process of emergency application

Examination by the General Affairs Department: The General Affairs Department examines emergency applications of clinical departments on a regular basis. It can accept or deny the applications, but reasons must be given when applications are denied.

Inquiry of examination status by departments: Departments can have access to the status of emergency application through the self-service touch screen device.

3. Collection management

Outsourced delivery system conformation: Supplies applied according to the quota or emergency supplies that have been examined will be automatically imported to ERP as orders. According to the orders, the administrators will allocate supplies, print shipment list and package the supplies into cases. After the supplies are packaged, the warehouse administrator will send a “notification” in the supplies system to inform departments of collection.

Hospital inventory procurement confirmation: This applies to supplies purchased by the hospital itself. The hospital warehouse administrator can first print details of application and summarize data and then purchase supplies, put them in stock and package for delivery. After the supplies are packaged, the warehouse administrator will send a “notification” in the supplies system to inform departments of collection.

Collection confirmation: First, query should be conducted through computer or self-service devices. If the query result is “collected”, the user should take the

department magnetic card to the warehouse and check the consistency of the shipment list with the needed supplies. If the result is consistent, then the user should sign his name on the collection confirmation list and swipe the department card on the computer to confirm.

Statistics of statements and reports: Comprehensive inquiry with the parameters of departments, time periods, and types of supplies is provided by the system. The quantities of supplies are summarized and can be exported to a file compatible with Excel.

Appendix 3

Table Appendix 3-1 Survey Results of Traditional Management of Consumable medical supplies

No.	Content	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)	Level of Satisfaction with traditional management of consumable medical supplies
1	Traditional management has obvious drawbacks in hospitals.	0%	0%	0%	29%	71%	5.8%
2	Traditional management is not in line with the current medical reform.	0%	0%	0%	60%	40%	12%
3	Information application of traditional management is backward.	0%	0%	0%	39%	61%	7.8%
4	Traditional management is not professional.	0%	0%	0%	24%	76%	4.8%
5	Traditional management consists of too many processes and links, which do not comply with cost accounting.	0%	0%	0%	20%	80%	4%
6	The inventory cycle time of order management is too long under traditional management.	0%	0%	0%	12%	88%	2.4%
7	The implementation error rate of traditional management is high.	0%	0%	0%	21%	79%	4.2%
8	Traditional management traces back to management system recognition.	56%	23%	7%	13%	1%	36%

9	Superiors and subordinates have a harmonious relationship in traditional management.	80%	19%	1%	0%	0%	24.2%
10	Communication between colleagues from different departments is harmonious under traditional management.	66%	17%	0%	1%	0%	20.8 %(Have blank options)
11	Because of insufficient internal communication and coordination within a department, traditional management undermines efficiency.	1%	0%	0%	72%	27%	15.2%
12	Under traditional management, there are buck-passing and disputes over trifles among departments.	5%	0%	0%	23%	72%	8.6%
13	Coordination processes are too many and too long under traditional management.	1%	0%	1%	44%	54%	10%
14	Traditional management methods have constraints on hospital development.	1%	0%	4%	24%	71%	7.2%
15	Capital turnover efficiency is low under traditional management.	1%	0%	1%	19%	79%	5%
16	Warehousing cost is high under traditional management.	1%	0%	7%	21%	71%	7.8%
17	Logistics points are many and costs are high under traditional management.	0%	1%	1%	38%	60%	8.6%
18	Risk management and control is reasonable under traditional management.	51%	32%	7%	6%	0%	32% (Have blank options)

19	Traditional management does not meet the requirements of the medical reform.	0%	0%	40%	55%	5%	27%
20	Traditional management is not in line with China's finance support and development.	0%	0%	17%	68%	15%	20.4%
Level of Satisfaction with the traditional consumable medical supplies management					13.2%		
No.	Content	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)	Level of Satisfaction with the new management of consumable medical supplies
21	There is a clear mechanism for coping with adverse events under the new management.	1%	0%	0%	16%	83%	96.0%
22	The monitoring process is clear under the new management.	1%	0%	0%	9%	90%	97.4.0%
23	Level of automatic warehousing management is high under the new management.	1%	0%	0%	8%	91%	97.6.0%
24	Hospital labor cost is low under the new management.	1%	0%	1%	36%	62%	91.6.0%
25	Distribution rationality is high under the new management.	0%	1%	1%	57%	41%	87.6.0%
26	Job responsibilities and performance management are clear under the new management.	0%	0%	0%	26%	74%	94.8.0%
27	Service connection is normalized under the new management.	0%	0%	0%	28%	72%	94.4.0%

28	The warehousing cost is relatively zero under the new management.	0%	0%	0%	9%	91%	98.2.0%
29	The new management realizes real-time connection in management.	0%	0%	0%	9%	91%	98.2.0%
30	The new management reduces the number of logistics process nodes.	0%	0%	0%	19%	81%	96.2.0%
31	The new management requires low hospital finance cost.	0%	0%	2%	25%	73%	94.2.0%
32	The new management requires little coordination between departments and responsibilities are clear.	0%	0%	0%	58%	42%	88.4.0%
33	The new management fits the hospitals positioning of giving priority to technology development.	0%	0%	0%	68%	32%	36.4.0%
34	The new management lowers risks for hospital logistics and service management.	0%	0%	1%	19%	80%	95.8%
35	The new management is integrated platform management.	0%	0%	0%	2%	98%	98.0%
36	The new management reasonably applies e-commerce models.	1%	0%	0%	36%	63%	92.0%
37	The new management is in line with the requirements on development direction put forward by China's National Development and Reform Commission in 2014.	0%	0%	2%	77%	21%	83.8.0%

38	The new management is in line with the requirements on medical reform put forward by China's Ministry of Industry and Information Technology in 2014.	0%	0%	1%	44%	55%	90.8%
39	The new management is in line with the hospital development direction pointed by China's National Health and Family Planning Commission in 2014.	0%	0%	0%	21%	79%	95.8%
40	The new management is in line with the support to hospital development from the China's Ministry of Finance in 2014.	0%	0%	0%	44%	56%	91.2.0%
Level of Satisfaction with the new management of consumable medical supplies					93.5%		

Source: The author