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Service Quality Assessment and Optimization of Regional Medical Laboratory Center: A case study

HUANG Xiaoli

Doctor of Management

Supervisors:
PhD Felipa Sampayo, Assistant Professor,
ISCTE University Institute of Lisbon
PhD Wang Dong, Professor,
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Jury:

PhD Patrícia Andreia da Silva Filipe, Associate Professor,
Iscte - Instituto Universitário de Lisboa
PhD Isabel Maria Dias Proença, Associate Professor with Habilitation,
ISEG - Universidade de Lisboa
PhD Qian Yi, Full Professor,
Southern Medical University (China)
PhD Sofia Maria Lopes Portela, Assistant Professor,
Iscte – Instituto Universitário de Lisboa
PhD Felipa Dias de Mello Sampayo, Assistant Professor with Habilitation,
Iscte – Instituto Universitário de Lisboa

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Service Quality Assessment and Optimization of Regional Medical Laboratory Center: A Case Study

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Abstract

Regional medical laboratory centers are an emerging area of study with limited existing literature. This gap highlights the need to explore how these centers can improve and maintain high service quality. This study aims to address the questions of how to enhance service quality and evaluate the current state of service quality in regional medical laboratory centers. The research analyzes a case study to explore how regional medical laboratory centers leverage dynamic capabilities to meet stakeholder expectations over time. The study employs the service quality gap model and gathers first-hand data through questionnaire surveys to assess the service quality levels of these centers and propose countermeasures and suggestions. This study reveals that the laboratory center adopts different service models at different stages, all of which utilize three core competencies: perception, restructuring, and innovation. Initially, in the start-up phase, an epidemic oriented service model was established to deal with the impact of the COVID-19 epidemic. As it develops, it has shifted towards a market-oriented service model. Overall, the service quality of regional medical laboratory centers is relatively high and can basically meet customer needs. However, there is still a gap with customer service expectations, especially in the responsiveness dimension, where there is still room for improvement. The study concludes that while customers place high value on modern and intelligent medical equipment as well as accurate and professional testing reports, the performance of the centers in these areas still falls short of expectations.

Keywords: regional medical laboratory center, dynamic capability, service quality improvement, gap model of service quality
JEL: I11, L84

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Resumo

Os centros regionais de testes médicos são uma área de estudo emergente com literatura existente limitada. Esta lacuna destaca a necessidade de explorar como esses centros podem melhorar e manter uma alta qualidade de serviço. Este estudo tem como objetivo abordar as questões de como melhorar a qualidade do serviço e avaliar o estado atual da qualidade do serviço nos centros regionais de testes médicos. A pesquisa analisa um estudo de caso para explorar como os centros regionais de testes médicos utilizam capacidades dinâmicas para atender às expectativas das partes interessadas ao longo do tempo. O estudo emprega o Modelo de Lacunas da Qualidade de Serviço e recolhe dados através de inquéritos por questionário para avaliar os níveis de qualidade do serviço desses centros e propor medidas e sugestões. Este estudo revela que o centro de testes médicos adota diferentes modelos de serviço em diferentes estágios, todos utilizando três competências centrais: perceção, reestruturação e inovação. Inicialmente, na fase de arranque, foi estabelecido um modelo de serviço orientado para a epidemia para lidar com o impacto da epidemia de COVID-19. À medida que se desenvolve, tem-se deslocado para um modelo de serviço orientado para o mercado. No geral, a qualidade do serviço dos centros regionais de laboratórios médicos é relativamente elevada e consegue atender às necessidades dos clientes. No entanto, ainda há uma discrepância em relação às expectativas dos clientes, especialmente na dimensão de capacidade de resposta, onde ainda há espaço para melhorias. O estudo conclui que, embora os clientes valorizem os equipamentos médicos modernos e inteligentes, bem como relatórios de testes precisos e profissionais, o desempenho dos centros nessas áreas ainda não atende às expectativas.

Keywords: centro de laboratório médico regional, capacidade dinâmica, melhoria da qualidade de servi ço, modelo de lacunas da qualidade de servi ço
JEL: I11, L84

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摘　要

区域医学检测中心是一个新兴的研究领域，现有文献有限，这一差距凸显了探索区域医学检验中心如何提高和保持高服务质量的必要性。本研究旨在解决如何提高服务质量的问题，并评估区域医学检验中心的服务质量现状。该研究分析了一个案例研究，以探索区域医疗检测中心如何利用动态能力来满足利益相关者的期望。本研究采用服务质量差距模型，通过问卷调查收集第一手数据，评估这些中心的服务质量水平，并提出对策和建议。本研究表明，区域医学检验中心在不同阶段采用不同的服务模式，所有这些模式都利用了三种核心能力：感知、重组和创新。最初，在启动阶段，建立了以疫情为导向的服务模式，以应对新冠肺炎疫情的影响。随着它的发展，已经转向以市场为导向的服务模式。总体而言，区域医学检验中心的服务质量相对较高，基本能够满足客户需求，然而与客户服务期望仍有差距，特别是在响应能力方面，仍有改进的空间。该研究得出结论，尽管客户高度重视现代智能医疗设备以及准确专业的检测报告，但这些中心在这些领域的表现仍达不到预期。

关键词：区域医学检验中心，动态能力，服务质量优化，服务质量差距模型

JEL: I11, L84

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Chapter 1: Introduction

1.1 Research background and research questions

China is a populous country. According to the 2023 National Economic and Social Development Statistics Bulletin of the People's Republic of China released by the Chinese government in 2024, as of the end of 2023, the total population reached 1409.67 million people Therefore, the government has set the protection of the people's health as one of the prioritized strategic objectives, and has continued to improve the medical and healthcare system and policies, so as to enable the majority of the citizens to have access to high-quality and basic healthcare services. Since the implementation of the Healthy China strategy after the 19th National Congress of the CPC, safeguarding people's health has become one of the important goals of national development and has attracted a higher degree of attention. According to the requirements of the 19th CPC National Congress, a high-quality and efficient healthcare service system and a basic healthcare security system with Chinese characteristics should be comprehensively established to realize the public demands for comprehensive and full-cycle healthcare services. The Healthy China 2030 Plan explicitly proposes to "improve the level and quality of medical services, and provide the public with high-quality and efficient medical services", which indicates that China has elevated people's health to the level of a national strategy. In the report of the 20th CPC National Congress, it is emphasized to continue the promotion of the strategic task of Healthy China, expand the supply of high-quality medical resources and realize a balanced resource layout across regions in China, enhance people's well-being, and continuously improve people's quality of life. The quality of medical services exerts a direct impact on meeting the people's medical needs and enhancing their sense of gain. Against the above background, how to improve the quality of medical services is both a hot topic related to people's well-being and an important question that needs to be answered urgently.

Laboratory test and examination is a key link in diagnosis and treatment, and it is of great significance to enhance the level of laboratory medicine to improve the quality of medical services. Under the background of the new medical reform, although the basic healthcare system of China continues to improve, and the quality of medical services is also getting

continuous enhancement, China's primary healthcare institutions still face problems such as limited service items, lack of sophisticated lab equipment, unqualified service capacity, and insufficient technical personnel. Due to the different instruments and equipment used by the secondary and tertiary hospitals as well as the different testing standards adopted by them, the test results cannot be shared or mutually recognized, leading to a prominent phenomenon of duplication of testing. In the long run, it is not conducive to solving the problem of expensive and difficult access to medical services and has become a major bottleneck restricting the improvement of medical service quality in China.

In this context, the regional medical laboratory center came into being, and became an important link to promote the construction of medical association and the implementation of hierarchical diagnosis and treatment system. In recent years, with the aim to integrating the existing resources, the government has launched a series of favorable policies to speed up the development of regional medical laboratory centers. The goal of establishing regional medical laboratory centers is to perform an in-depth optimization and integration as well as reasonable allocation of the existing medical resources, achieve mutual recognition of testing results within the region, promote sharing of resources such as testing equipment and professional personnel, so as to achieve unified quality and standard of testing services, effectively reduce unnecessary duplication of testing, and enhance the service capacity and technical level of the grass-roots testing institutions.

Regional medical laboratory centers have played an important role in the prevention and control of the COVID-19 epidemic, and were highly recognized by the government and the society. In the post-epidemic period, the regional medical laboratory centers are facing a new round of development opportunities as follows. The application of intelligent testing technology promotes the development of regional medical laboratory centers to a higher level, and intelligent, information-based technology means are used to improve the accuracy of the testing, shorten the report cycle, and comprehensively improve the quality of testing services; the functions of the medical laboratory centers have been expanded and their scope of radiation has been extended, leading to the formation of a pan-centralized development model, which can better serve the majority of primary healthcare institutions and patients; the government-level support becomes more determined and strengthened, and relevant policy support systems are further refined and improved, aiming to encourage the construction of regional medical laboratory centers and enhance the service capacity; the accelerating promotion of inter-regional mutual recognition of medical test results has reduced the duplication of tests, improved the efficiency of healthcare resource usage, and promoted the integrated development

of cross-regional healthcare services; the rise of innovative technology-led new service models, such as “cloud testing” and “convenient testing” has created a new business model of the medical testing industry, so that the testing service becomes more convenient and efficient; with the development of science and technology, regional medical laboratory centers have started to try to use drone logistics and other advanced technological means to achieve rapid and safe transit of samples, opening a new era of medical laboratory logistics. In order to seize the opportunity for development, the regional medical laboratory centers urgently need to continuously innovate the service model, and incessantly improve the service quality and technical level, so as to meet the diversified and personalized healthcare needs of the public. However, as a newly emerging model, the service quality and service capacity of China’s regional medical laboratory centers still have a large gap compared with their foreign counterparts, and face constraints such as limitations on the scope of diagnosis and treatment, questionable quality control prior to the test, and low capacity of flexible testing.

It is worth noting that before and after the COVID-19, the development environment faced by the regional medical laboratory centers has changed dramatically. How do the regional medical laboratory centers adapt to this environmental change and continue to provide high-quality medical laboratory services? What is the current level of service quality of the regional medical laboratory centers? Can they meet customer expectations? In order to answer the above questions, we take the Lanwei (LW) regional medical laboratory center as the case study. Based on the service quality gap model and the theoretical foundations of the dynamic capabilities theory and the stakeholder theory, we study the evolution of the service capability of the regional medical laboratory center, develop a localized scale to test its service quality, quantitatively analyze the service quality of the regional medical laboratory center, and further propose countermeasures for service quality improvement.

1.2 Research significance

This research has both theoretical and practical significance.

In terms of the theoretical significance, since the regional medical laboratory center is still a new concept, there is not much Chinese research on it. Although the foreign research on third-party independent laboratory test institutions is pretty mature, there are still differences between third-party independent laboratory test institutions and regional medical laboratory centers, and there is also little foreign research specifically on regional medical laboratory centers. Healthcare service quality is one of the core monitoring indicators set out in the Healthy China

2030 Outline, and in order to ensure and improve the quality of healthcare services, it is crucial to adopt a scientific and rational evaluation system. The aim of this initiative is to promote the improvement and optimization of all links of healthcare services through rigorous evaluation methods, so that the public can have access to better, more efficient, and more appropriate healthcare services (Dong et al., 2011). Among the current research on regional medical laboratory centers, few scholars focus on evaluation of the service quality of regional medical laboratory centers and explore how regional medical laboratory centers can improve their service quality based on the dynamic capabilities theory. Therefore, with the LW regional medical laboratory center as the case study, we analyze the service quality of the regional medical laboratory center based on the service quality gap model as well as the dynamic capabilities theory and the stakeholder theory, and endeavor to construct a model for healthcare service quality improvement under the perspective of dynamic capabilities, which is a useful supplement to the existing research.

In terms of the practical significance, as China is entering an aging society, local governments have included health management of the elderly and the prevention and screening of common diseases in the basic public health services. Consequently, higher service quality requirements have been put forward for medical laboratory service. According to the population data released by the National Bureau of Statistics in 2024, based on the age structure of the population, the population aged 60 and above in China has increased from 202.43 million in 2013 to 28.04 million in 2023, accounting for 19.8% of the total population, up from 14.9%There are more than 180 million elderly people suffering from chronic diseases in China, and 75% of them suffer from two or more chronic diseases. In addition, about 40 million elderly people suffer from varying degrees of physical incapacitation or partial incapacitation . As the main healthcare institutions responsible for the management of chronic diseases in the aging society, primary healthcare institutions have become the main battlefield to deal with chronic diseases, but in actual operation, the supply capacity of primary healthcare institutions for in medical laboratory science is significantly insufficient. Medical service is a major livelihood undertaking to safeguard people’s health, and the provision of basic medical services for the majority of citizens is a concrete embodiment of the government’s functions. From the perspective of government management, assessing the level of service quality of regional medical laboratory centers and proposing recommendations for optimization, which can help government decision makers understand the service capacity of regional medical laboratory centers, and provide empirical evidence for the government to further optimize the system design of regional medical laboratory centers. From the perspective of the development of

regional medical laboratory centers, independent medical laboratories have been developing rapidly, and foreign third-party medical laboratory "giants" are eager to enter the Chinese market. It indicates that the Chinese regional medical laboratory centers will face strong rivals in a more open and competitive market, which will lead to the formation of a diversified and fiercely competitive market landscape. Evaluating the service quality of regional medical laboratory centers and proposing recommendations for optimization can help regional medical laboratory centers understand their own shortcomings in the supply of services, clarify the direction for their subsequent service quality improvement and implementation path, enhance their service capabilities, improve the core competitiveness to compete with foreign medical laboratory organizations, and achieve high-quality development. From the perspective of service recipients, assessing the service quality of regional medical laboratory centers and proposing recommendations for optimization is conducive to obtaining better medical laboratory services and alleviate cost pressures.

1.3 Definition of relevant concepts

1.3.1 Regional medical laboratory center

Regional medical laboratory center is a type of centralized medical laboratory set up in a specific region to provide a full range of clinical testing programs and related testing services for medical institutions at all levels within the region. Its core value lies in the fact that by constructing such a center in the region, it can realize the efficient sharing of testing resources, promote mutual recognition of test results among different medical institutions, ensure the standardization and consistency of test results, and thus enhance the overall effectiveness and level of medical services in the region (Chen et al., 2021). Regional medical laboratory center is a centralized service facility designed to provide a wide range of medical testing and pathology services to a variety of healthcare institutions within a specific geographic area, which may cover testing services only or both testing and pathology services. Such centers can be either independently operated third-party medical testing laboratories or a laboratory department affiliated with a hospital. The service is not limited to one healthcare facility, but includes all healthcare facilities in the radiated area, and the size of its service radius depends on the actual service capacity and carrying capacity of the center (Shen et al., 2019).

Most of the regional medical laboratory centers outside China are independent medical laboratories, which are service-oriented medical organizations with independent legal person

status, and most of them are run by private capital. In many developed countries, independent medical laboratories have been at a relatively mature stage, and their advantage lies in scale. By minimizing equipment vacancy and human resources waste, they achieve efficient and high-quality operation, and realize effective control of operating costs, so as to gain a price advantage. These independent medical laboratories can ensure that patients in primary medical institutions in a certain region can enjoy the medical laboratory testing services as good as those provided in large general hospitals, which is crucial to maintaining the sustainable development of primary hospitals and guaranteeing that patients can enjoy high-quality diagnosis and treatment services. Such specialized, commercialized and centralized regional testing mode has significantly improved the overall level of clinical testing and saved medical resources (Guo et al., 2018).

In Japan, Europe, and the United States, the market share of independent medical laboratories in the whole medical testing market accounts for 67%, 50% and 35%, respectively (Wang, 2018). Since the United States issued *Clinical Laboratory Improvement Amendments* in the 1980s, medical testing has been gradually standardized and legalized, and large-scale high-quality independent medical laboratories have been developing rapidly and gradually replaced the smaller ones. In western developed countries, third-party independent laboratory centers and imaging centers stand out by virtue of their efficient operation and management mode, relatively economic price advantage, standardized diagnostic technology, and excellent service quality. They are able to arrange patients' testing time more flexibly, which is especially convenient for some patients with special needs, ensuring a quick response to medical services and the satisfaction of personalized needs.

1.3.2 Service quality

There are many definitions of service quality proposed by different scholars. In this research, we adopt the definition given by the International Organization for Standardization (ISO), namely, service quality is the degree to which a set of intrinsic characteristics of the quality object meet the requirements. In particular, the customer-perceived service quality proposed by Gronroos in 1982 is the most representative concept and has the widest influence. Gronroos believes that the service quality is essentially a subjective perception of the customer, and it is defined as the comparison between customer's perceived service performance and customer expectation. The level of customer perceived service quality depends completely on the match between the perceived value and expected value.

The difference between service quality and quality of tangible products can be interpreted from three aspects. First, service quality is relatively more difficult for consumers to evaluate; second, customer perception of service quality depends on the difference between the customer expectations and the perceived performance; third, in the evaluation of service quality, customers usually consider not only the service results, but also the service process.

The connotation of service quality includes the following five aspects. First, service quality is the object of customer perception; second, improvement of service quality cannot leave the strong support of the effectiveness and systematicity of the internal management of the enterprise; third, service quality needs to take into account both subjective and objective factors, objective methods should be used to formulate and measure service quality, and the customer's subjective perception and cognition should be emphasized and used as a key consideration in service quality testing; fourth, the true face of service quality is often reflected in the moment of transactional interaction between the service provider and the customer; and fifth, service quality is actually demonstrated in real time during the process of service production and interaction.

To summarize, service quality is composed of subjective quality and objective quality. Objective quality is usually used to measure the level of service technology and service performance, while subjective quality reflects the subjective feelings of customers. Minimum customer service quality refers to the minimum level of service that is acceptable to the customer under the premise of customer satisfaction (Lei, 2007). Service quality is characterized by the integration of service outcome and service process, because the intangible nature of service is usually reflected in the service process, and the comparison between expected and actual effects of service quality are reflected in the service outcome (Parasuraman et al., 1985).

1.4 Research content and framework

Chapter 1 is the introduction, which explains the research background and significance of the study, and serves as a realistic basis for the proposition of the research questions. It is followed by a definition of the key concepts designed in this thesis. Next, the content and framework of the thesis is discussed to clarify the research topic of service quality assessment and optimization based on regional medical laboratory centers. This chapter also explains what kind of research methods are used in this research and what kind of technology roadmap is followed.

Chapter 2 is the literature review, which introduces the theoretical foundations of this thesis,

including the dynamic capabilities theory, stakeholder theory and gap model of service quality. Among them, the gap model of service quality is the basic theory for service quality assessment and optimization, the stakeholder theory is expected to help us identify the measurement objects of service quality of the regional medical laboratory center, and the dynamic capabilities theory is designed to help us propose the optimization strategy for the regional medical testing center. The related studies that are closely linked to this research are also introduced to help understand the current status of existing research, highlight the theoretical significance of the research, and also lay the foundation for the later discussion of the innovations of this research.

Chapter 3 is the practical exploration of the regional medical laboratory center. First, from the national level, the current development of the regional medical laboratory centers and the prominent issues are introduced, and the overview of the regional medical laboratory centers, the historical background of their emergence, the social expectations they shoulder and their development goals are presented. Then, the typical models developed in the development of the regional medical laboratory centers are analyzed. Finally, the constraints faced by the regional medical laboratory centers are analyzed. The above contents can further highlight the practical significance of this research.

Chapter 4 is the evolution of service capability of regional medical laboratory centers under the perspective of dynamic capabilities. Based on the dynamic capabilities theory, and through the analysis of the different development paths of the LW regional medical laboratory center in the epidemic period and the post epidemic period, we explore how the regional medical laboratory center can successfully adapt to the changes in the organizational operating environment and the adjustment of the development path through the dynamic capabilities, and develop different service models to meet the needs of different stakeholders in different stages of development.

Chapter 5 is an empirical study on the service quality assessment of regional medical laboratory centers, which includes two main parts: research design and results discussion. The research design mainly explains how to identify the core stakeholders through the stakeholder theory, determine the target audience for questionnaire distribution, modify the original SERVQUAL model measurement scale through brainstorming method, and develop a service quality scale suitable for this study. In the results discussion, we statistically analyze the research data through frequency and percentage statistics as well as sample t-tests, and analyze in which aspects there are still quality gaps in regional medical laboratory centers based on the gap model of service quality.

Chapter 6 is the study of service quality improvement for regional medical laboratory

centers. On the basis of Chapter 5, this chapter obtains primary data through field interviews, and together with other secondary data, the reasons for service quality gaps are analyzed using the gap model of service quality, and corresponding suggestions are proposed on how to improve service quality.

Chapter 7 summarizes the whole text and further explains the innovations and limitations of the research.

1.5 Research methods

1.5.1 Literature research method

Literature research method is a scientific research method, which mainly includes meticulous searching, prudent screening and systematic organization of various academic journals, professional books and other related literature. Through in-depth study and critical analysis of these documents, the researcher is able to extract scientific evidence from them, form a profound and accurate understanding of specific facts or phenomena, and thus construct a persuasive knowledge system. In this study, we search the Chinese databases such as CNKI, VIP scientific and technical journals, and Wanfang database with keywords of regional medical testing centers, service quality, dynamic capabilities, SERVQUAL model, etc. and uses Regional medical testing centers, service quality, dynamic capabilities, and SERVQUAL model. We also search Springer, EBSCO, Web of science and other English data databases. The Chinese and foreign literature on service quality of regional medical laboratory centers is collected to understand the theoretical and practical background of social responsibility report in public hospitals, grasp domestic and international academic frontiers, master the research methodology, and determine the theoretical framework and research innovations, so as to provide reference and research foundation for the subsequent research design.

1.5.2 Group discussion method

Group discussion method, also known as the brain storming method, is a method that encourages participants to speak freely, and generates sparks of creative thinking through the mutual collision of thinking. The brain storming method can be subdivided into two types, anti-brain storming and direct brain storming, according to the different ways of discussion. Direct brain storming is a strategy that relies on collective wisdom to maximize the activation of creative potential in the decision-making process of a team of experts, so as to generate a rich

variety of ideas and solutions. Anti-brain storming, on the other hand, examines and questions each of the ideas and proposals generated by direct brain storming, with an aim to exploring and verifying the possibilities and feasibility of realization. Twenty stakeholders of the regional medical laboratory center, including internal employees of the regional medical laboratory center, government officials, administrators of public hospitals, and doctors, as well as four professors of management, were invited to form a panel to fully discuss and modify the conceptual framework and indicator system of the service quality measurement scale of the regional medical laboratory center, and the indicators were screened one by one.

1.5.3 Questionnaire survey method

The questionnaire survey method is a means of investigation that indirectly collects research materials in written form. It is a method that indirectly obtains materials and information by sending a concise questionnaire to the interviewees and asking them to fill in the opinions and suggestions on the relevant issues. On the basis of literature research and brain storming, the Regional Medical Laboratory Center Service Quality Questionnaire is compiled to survey the core stakeholders: community health centers and public hospitals, and grasp the demands of the service recipients of the regional medical laboratory center for information about the hospital's social responsibility report. Descriptive statistical indicators such as frequency and percentage are used to analyze the overall level of service quality of the regional medical laboratory center, and at the same time through the statistical analysis of the sample t-test, we analyze whether there is a significant gap between the services provided by the regional medical laboratory center and the service recipients' expectations. Later, through the importance-performance analysis (IPA), we further clarify which dimensions have significant gaps, and what kind of initiatives should be taken to improve the quality of service.

1.5.4 Structured interview method

Structured interview, also known as standardized interview, is a technique in which the interview process is strictly controlled. In this form of interview, the selection of interviewees follows a consistent and rigorously standardized procedure, and the group of interviewees are often determined with the help of probability sampling. Each link in the implementation of the interviews is highly standardized, from the content of the questions, to the order in which they are asked, to the way in which the responses are recorded, and absolute consistency is guaranteed. In order to ensure this high degree of uniformity, the interviews usually rely on a

pre-designed, clearly structured questionnaire as a guiding tool. In other words, the investigator will question all respondents according to a standardized questionnaire with a fixed framework, and the way the answers are recorded follows the same standardized criteria. Based on the results of the questionnaire, we prepare the interview outline of regional medical laboratory center service quality gap causes and optimization analysis, conduct structured interviews respectively on the regional medical laboratory center service providers and recipients, and further grasp the reasons for the gap in the service quality of the regional medical laboratory center services, so as to provide support for the proposition of recommendations for optimization based on the dynamic capabilities theory.

1.5.5 Case study method

Case study is a research methodology widely used in various sub-disciplines of the social sciences, including management, economics, sociology and psychology. According to Yin et al. (2003), case study is a research approach based on the principles of positivism and aimed at exploring complex and transient phenomena in depth in a specific context. The value of case study is particularly prominent when the problematic phenomenon under study and the environmental context in which it occurs are difficult to be clearly defined. By collecting a wide range of information that is closely related to the research problem, it is able to unravel the mystery surrounding the phenomenon during the research process as if pulling the threads out of a cocoon, thus revealing the intrinsic nature of the problem. Based on the practical exploration of the LW regional medical laboratory center, we collect case data through field research and interviews as well as previous literature, establish a case study database, and explore the path to improve the service quality of the regional medical laboratory center from the perspective of dynamic capabilities.

1.6 Technology roadmap

We take the regional medical laboratory center in Liwan district as the blueprint for observation. Based on the systematic review of Chinese and foreign literature, we evaluate the service quality of the regional medical laboratory center based on the stakeholder theory and the service quality gap model, and at the same time put forward suggestions for optimization based on the dynamic capabilities theory. As shown in Figure 1.1, we design the research according to the logical idea of “proposing questions, analyzing questions, solving problems, and revealing conclusions”. In this process, literature research method, questionnaire survey method, case

study method, group discussion method, structured interview method and other research methods are comprehensively applied to evaluate the service quality of regional medical laboratory centers and propose suggestions for optimization.

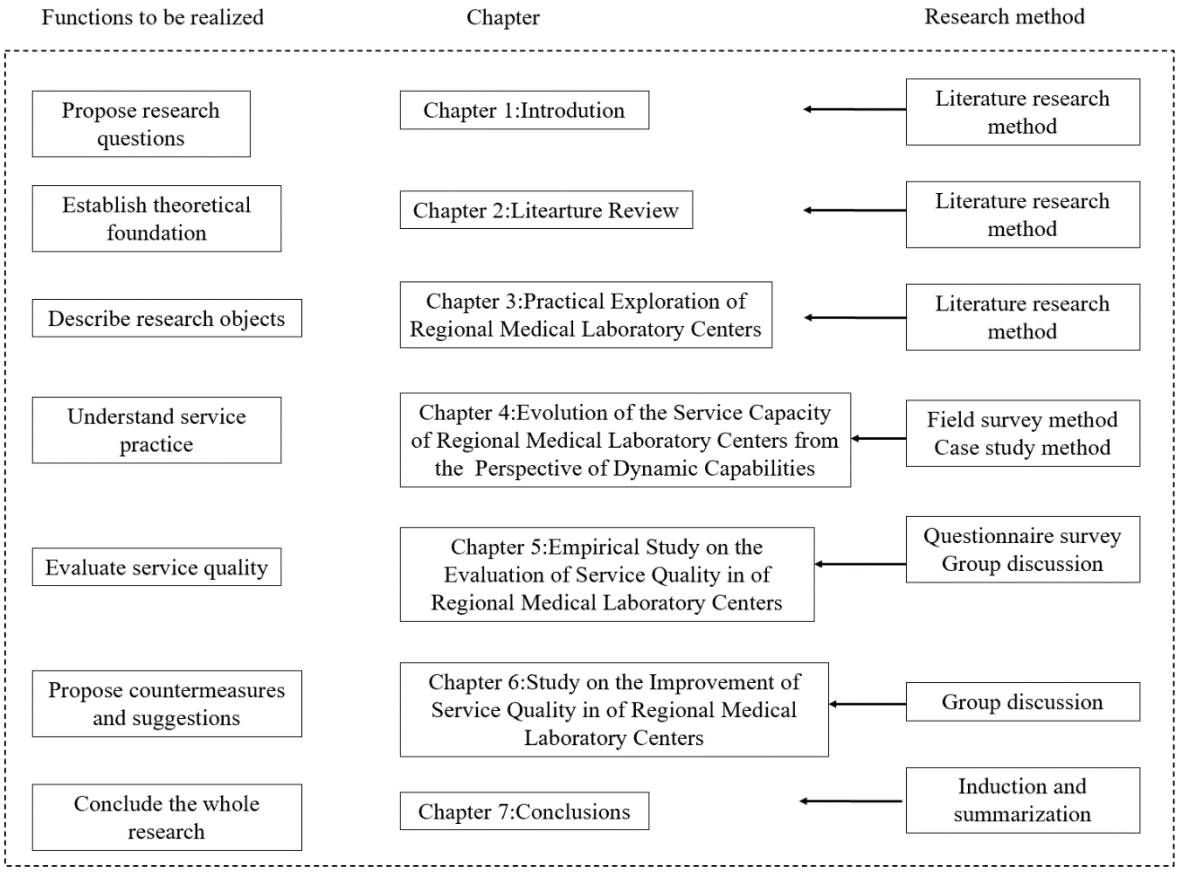

Figure 1.1 Technology roadmap

Chapter 2: Literature Review

2.1 Research on medical service quality

In 1990, the Institute of Medicine of the United States proposed that "the quality of medical services is the extent to which medical knowledge and technology can be utilized to increase the patient's desired outcomes and decrease the undesired outcomes in the course of medical services under existing conditions" (Lu et al., 2023), which is an important indicator to measure the level of development of health care services. The assessment of the healthcare service quality can be carried out in two dimensions: service process and service outcome, which can be further subdivided into functional quality and technical quality. Functional quality is mainly related to patients' satisfaction with the medical service itself, covering factors such as the smoothness of the medical service process, the professionalism of the attitude of the medical staff and the comfort of the medical environment. Technical quality, on the other hand, focuses on patients' perception and evaluation of the results of the application of medical technology, such as the accuracy of medical diagnosis, the effectiveness of the treatment program, and the professionalism of rehabilitation guidance. In short, the quality of healthcare services includes both the subjective feelings of patients brought by the service process and the objective evaluation of patients brought by the actual efficacy of medical technology (Parasuraman et al., 1988). There are increasingly diversified studies on service quality both at home and abroad, and the main research methods used are SERVQUAL model, rank-sum ratio method and composite index method, among which SERVQUAL model is more commonly used. Service quality gap model (SERVQUAL) is a model designed by the Western researchers to accurately assess service quality from a consumer perspective. Nowadays, this model has been widely promoted and applied in the healthcare field, and has become an effective tool to measure the quality of healthcare services (He et al., 2022).

Regarding the evaluation of medical service quality, there are mainly three perspectives in the existing research: first, the provider's perspective; second, the patient's perspective; and third, multiple perspectives of both the patient and the provider. Based on the integrated model of fuzzy AHP and fuzzy TOPSIS, Yucesan et al. (2020) collected sample data of 32 evaluators (including medical staff, hospital administrators, auxiliary staff and patients) in two public

hospitals and one private hospital in Turkey to evaluate the quality of healthcare services in Turkey. He et al. (2022) constructed an indicator system that integrates healthcare structure, process, and outcome based on a structure-process-outcome perspective to evaluate community hospital service quality. In addition, the study used SWOT analysis to identify the strengths, weaknesses, opportunities and threats of the service quality of community health centers . Zhen et al.(2023) constructed a comprehensive evaluation index system about the quality of healthcare services based on the structure-process-quality perspective.

2.1.1 Research on the evaluation of medical service quality based on SERVQUAL

One of the fundamental research issues in medical service quality is the conceptualization and measurement of service quality. Service quality is a multidimensional and multilevel construct. To be specific, the healthcare service quality model includes three dimensions, namely, healthcare service outcomes, healthcare service environment and healthcare service interactions, with a total of eight sub-dimensions (Sumaedi et al., 2016). There are not many studies on healthcare service quality using SERVQUAL model in China, and developing countries should try to develop their own medical service quality measurement model (Endeshaw, 2021).

Foreign research on healthcare service quality is more mature, most of which is empirical research based on the SERVQUAL model. For example, Snoj et al. (2002) carried out a longitudinal study on the service quality of the Slovenian mineral spring sanatoriums on the basis of the SERVQUAL model. Rahim et al. (2021) skillfully utilized user evaluation data from the official hospital website to construct a complete sentiment analysis and quality analysis system based on the SERVQUAL model. This system is able to automatically identify and extract the emotions and service-level information in patients' evaluations, and effectively reduce the potential bias of patients' subjective emotions on the survey results by collecting, analyzing, and evaluating patients' feedback data in detail, thus creating more abundant and diversified ways to assess the quality of healthcare services.

The core dimensions of healthcare service quality are usually found in all models used by previous researchers. We found that these core dimensions are slightly different in developed and developing countries, as SERVQUAL are usually used as the basic models to generate new dimensions or add more contextual dimensions. In empirical studies on healthcare service quality, it is also found that SERVQUAL model is insufficient in comprehensive measurement of technical and functional dimensions and a more comprehensive measure of healthcare service quality should be used in future studies.

2.1.2 Research on factors influencing the quality of medical services

With the increasing prominence of the service nature of healthcare, research on the factors influencing the quality of healthcare services has been on the rise. Danilov (2021) studied 500 questionnaires on the satisfaction with healthcare service quality using the five dimensions of the SERVQUAL model and confirmed the negative correlation between the expectations of healthcare services and the perceived quality standards of healthcare services and the average perceived quality of healthcare services. It is emphasized that the satisfaction with healthcare services can be effectively enhanced by improving physical conditions and meeting patient needs (Danilov, 2021). Amporfro et al. (2021) investigated women's satisfaction with the provision of health care services, and found that education and religious independence were significantly related to service reliability, overall satisfaction, and responsiveness; and cost was related to responsiveness and feasibility. The study focused on the fact that age, region, healthcare worker friendliness, and healthcare accessibility were all independently associated with reliability, responsiveness, tangibility, and overall service satisfaction at the multivariate level. In Pakistan, Javed and Ilyas (2018) assessed the quality of healthcare services in public and private hospitals through 456 patients and found that patient satisfaction was strongly associated with empathy in public hospitals and responsiveness in private hospitals. The study analyzed the objective status of different healthcare sectors and identified the key factors affecting the quality of services, which offers the development direction for hospital policy makers in a targeted manner.

Based on data from 21 member states of the European Union, Bleich (2009) analyzed the core factors affecting satisfaction with the healthcare service quality from the patient's perspective. The results showed that more external factors had a significant impact on patient satisfaction than the healthcare service itself, and these factors included but were not limited to the ease of transportation, the environmental conditions of the healthcare institutions, and the completeness of the healthcare facilities. Through an in-depth analysis of a large amount of data from 18 European countries, it is concluded that the convenience of patient access to healthcare exerts the most significant impact on their satisfaction (Kroneman et al., 2006). Polluste (2004) analyzed the reform of the primary healthcare system in Romania through a questionnaire survey. The study shows that after the introduction of the family doctor system, the residents' satisfaction with healthcare services has been significantly increased.

It can be found that a large number of related studies mainly rely on the SERVQUAL model. From the perspectives of hospital administrators, medical staff and patients, the researchers

carry out an all-round comprehensive assessment of the quality of healthcare services, and on this basis, they explore the factors that have a significant impact on the quality of services, with the aim of achieving continuous improvement and optimization of service quality.

2.1.3 Research on optimization of the quality of medical services

At present, there are still a lot of problems in the field of healthcare service quality in China, such as heavy economic burden of treatment, unsatisfactory implementation of hierarchical diagnosis and treatment, prevalent excessive diagnosis and treatment, and untimely response to patients' complaints, which has restricted the enhancement of medical service level to a great extent. The content of patient satisfaction surveys is generalized and outdated, which seriously affects the improvement of the management quality of the hospital. The SERVQUAL model is a scientific method to evaluate the quality of healthcare services, which is characterized by multidimensionality, objectivity, and comprehensiveness. Combined with the detailed survey results, the SERVQUAL model can clarify the key links and key points of improvement for the healthcare services, which can provide managers with more targeted and more precise practical guidance. A large number of research results have confirmed that the SERVQUAL model plays an important role in assessing the quality of healthcare services, which can go through the surface of the service status, dig deep into the root causes of service quality gaps, and put forward targeted improvement measures and recommendations. In Iran, Mohammadi-Sardo (2019) designed a 24-entry questionnaire based on the SERVQUAL model, and identified tangibility as an important factor influencing patient satisfaction with emergency department healthcare services through a survey of 373 patients. This is a short-term study limited to a single center, and therefore the generalizability and validity of its conclusions need to be fully considered and interpreted in the specific local social and cultural contexts. Mason (2022) investigated 440 telemedicine patients and designed a questionnaire with 4 dimensions based on the SERVQUAL model. The results showed that patient-centered care proved to be the most important dimension in determining the quality of telemedicine care and the study further verified the benefits of telemedicine for the health of patients. During the COVID-19 epidemic, Uddin et al. (2022) developed a new scale based on the SERVQUAL model including dimensions of assistance, facilities and layout, trust, empathy, agility, and knowledge to conduct an exploratory and confirmatory factor analysis of data from 206 patients to measure healthcare service quality during the COVID-19 epidemic and patients' expectations of hospital service quality. Therefore, in the practical application of SERVQUAL in the medical field, the

SERVQUAL should be flexibly adapted to a variety of changes, and the researchers should take into full consideration of factors such as the development trend of informatization technology, the characteristics of certain key diseases, the relevant factors of the medical and healthcare system, the uniqueness of the medical industry, the diversified demands of the patients, and the specific contents of the medical services, so as to modify and refine the scale in a timely manner. In addition, the reliability and validity of the modified scale can be verified in combination with the use of professional assessment tools such as the Delphi method, which can enhance its scientificity and practicality. This is particularly important and should not be ignored in the evaluation and improvement of the healthcare service quality by hospital administrators.

Rahim et al. (2021) utilized the SERVQUAL scale and logistic regression analysis to carry out an in-depth discussion on the patients' comments posted on online platforms as well as the quality of hospital care. The results showed that all service dimensions, except for tangibles and assurance, reflected patients' dissatisfaction with hospital care services. This finding suggests that healthcare organizations can continuously improve service quality by monitoring and evaluating patient feedback in real time. Ko and Chou (2020) constructed an electronic healthcare service quality assessment tool based on the SERVQUAL model specifically for the elderly. This well-designed questionnaire not only reveals service quality deficiencies at multiple levels in a profound manner, but is also ideally suited for application in the comparative assessment of service quality before and after the introduction of new technologies in nursing homes in the context of an aging society. Traditional patient satisfaction surveys, such as satisfaction surveys after discharge and satisfaction surveys during hospitalization, often affect the effective implementation of improvement measures due to time delays and geographical limitations, as the analysis results cannot be updated in real time. In contrast, relying on modern information technology, through real-time monitoring and in-depth mining of data related to healthcare services, healthcare organizations are able to respond quickly, such as making timely adjustments to the healthcare environment settings, and strengthening the training of healthcare personnel. In addition, the implementation of online consultation services through Internet hospitals can optimize the allocation of medical resources, and the use of information technology to provide treatment reminders and real-time information services can reduce patient waiting time. These practices are designed to achieve the goal of instant feedback, instant resolution and instant improvement of patients' opinions.

2.2 Theoretical foundation of service quality evaluation

2.2.1 Gap model of service quality

In the 1980s, three American scholars, Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (PZB for short), proposed the components of service quality and the SERVQUAL model based on the theory of Total Quality Management (TQM) (Parasuraman et al., 1985; Parasuraman et al., 1988). SERVQUAL is the abbreviation of Service Quality, and the SERVQUAL theoretical model is a commonly recognized tool to measure service quality in the academia, and it is now widely applied and accepted in many industries such as tourism, education, finance and hospitality. The core idea of the SERVQUAL model is that the quality of service actually depends on the degree of difference between the level of service actually perceived by users and the level of service they expect to receive, and is therefore also figuratively known as the Expectation-Perception model. In this model, users' service expectations play a prerequisite role in the provision of quality services, and the key to providing quality services lies in exceeding users' expectation thresholds. The SERVQUAL model divides service quality into five core dimensions, which are: tangibles (referring to the physical attributes of the service environment), reliability (stability and consistency of the service), responsiveness (service speed and proactivity), assurance (fulfillment of service promises and establishment of trust), and empathy (service personnel's attention and care to users' personalized needs). Each of these dimensions is subdivided into various questions, and these dimensions are elaborated and quantitatively assessed through a questionnaire composed of 22 specific questions as shown in Table 2.1. The calculation process is: service quality (Q) = customer perception (P) - customer expectation (E), and the SERVQUAL theoretical model is shown as per Figure 2.1.

Table 2.1 Perceived and expected quality of service evaluation scale

Interval of difference between perception and expectation	Evaluation of service quality
Difference < 0 (P-E < 0)	It proves that there is a large gap between the customer's expectations and the perceived performance, and the perceived performance is lower than the expected performance. The dimension corresponding to this indicator should be improved, indicating that the customer shows dissatisfaction with the current service quality.
Difference between 0 and 1 (0 < P-E < 1)	It proves that the difference between the customer's expectations and perceived performance is small, indicating that customers are relatively satisfied with the current service quality.
Difference > 1 (P-E > 1)	It proves that the perceived performance is higher than the expected performance, and service quality has reached a relatively high level, indicating that customers are very satisfied with the current service quality.

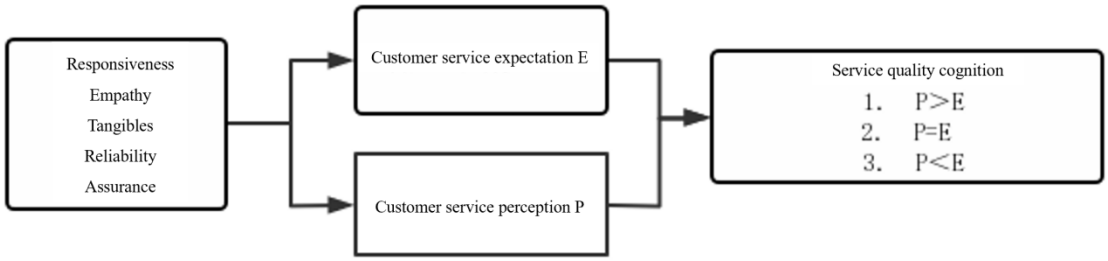

Figure 2.1 SERVQUAL model

Internationally, the five dimensions of the SERVQUAL model are as follows.

1. Tangibles: this dimension evaluates the actual facilities, equipment, service personnel and promotional materials of the service providers.

2. Reliability: this dimension evaluates fulfillment of the customer's commitment of the service providers.

3. Responsiveness: this dimension evaluates the initiative and enthusiasm of the service providers to offer convenient and efficient service.

4. Assurance: this dimension evaluates the appearance, language and behavior of the service providers.

5. Empathy: this dimension evaluates the customer service provider's ability to understand the customer's needs and provide personalized and customized service.

This theoretical model is one of the most widely used models in academia and management to study the improvement of service quality, which helps researchers to comprehensively understand and analyze the root causes of service quality problems. In addition, it puts forward corresponding suggestions to improve service quality according to the dimensions of the service quality gap model. Service quality gap refers to the deviation of the service provider in the process of providing services from the original proposed service standards, and there are five aspects of this deviation, which are customer gap, perception gap, delivery gap, communication gap and standard gap. The customer gap is the core of the service gap model, and in order to make up for the customer gap, it is necessary to make up for the four aspects of perception gap, transmission gap, communication gap and standard gap. The service gap model is shown as per Figure 2.2, with a dotted line dividing the model into upper and lower parts. The upper part is consumer-related and the lower part is service provider-related.

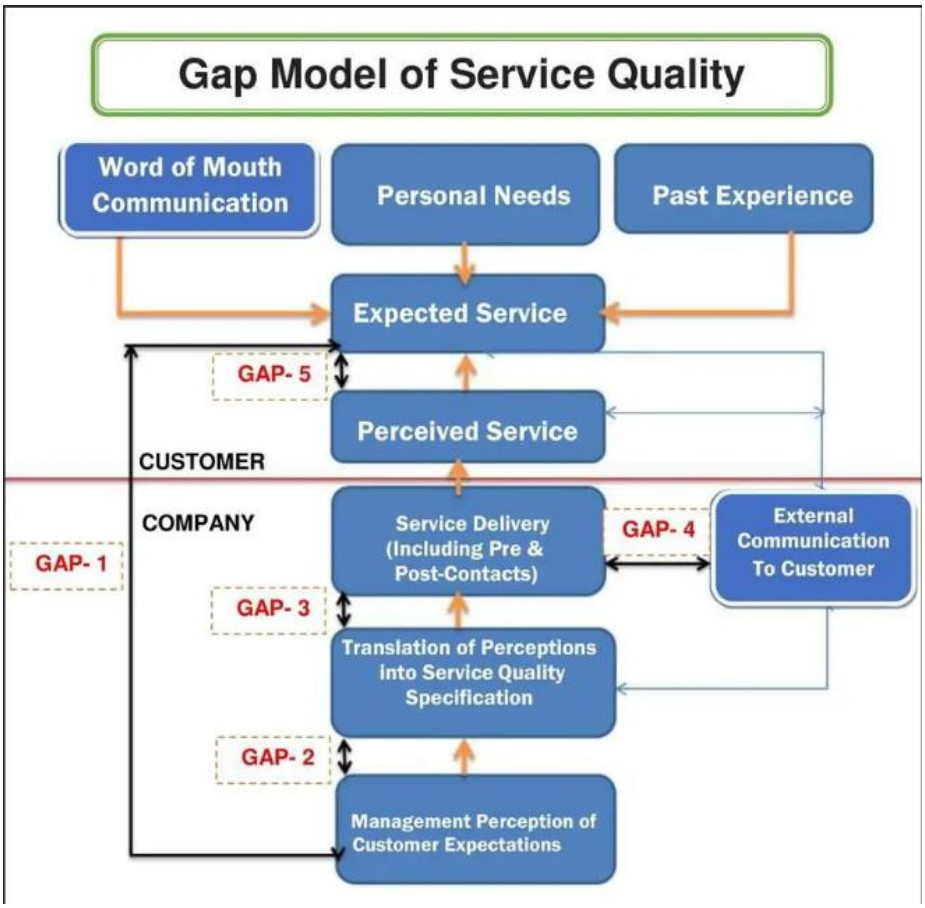

Figure 2.2 Gap model of service quality

(1) Customer gap

The customer gap is at the center of the service quality gap model. It is defined as the difference between the customer's expectations of the service and their perception of the service, and the reason for this gap is caused by the other four gaps, so it is necessary to bridge these four gaps in order to ultimately bridge the customer gap. Customer expectation generally refers to the self-perception evaluation of a thing that may happen or should happen in the future. Usually, the user's expectation of the service basically comes from the service provider's related factors (product price, service distribution channels, and service commitment), and the customer's previous consumption experience, consumption habits, personal needs and word-of-mouth evaluation will also affect the service expectations to a certain extent. The customer perception is usually referred to as the actual perception of the customer in the process of consumption after receiving the actual service, as well as the comprehensive feeling of consumption after receiving the service. If the customer's perception is equivalent to or even exceed the expectation, the customer is considered to be satisfied with the service; if the perception is lower than the expectation, the customer is considered to be not very satisfied with the service quality, and this dissatisfaction is thus manifested as the customer gap.

(2) Perception gap

Perception gap usually refers to the difference between service provider's understanding of the customer expectation and the customer's expectation for the service. The main reasons for the perception gap are as follows. 1. Inadequate marketing research (including insufficient market research, lack of comprehensive analysis of information on demand, and failure to take service quality as the basis for research); 2. Inadequate communication with the management (lack of communication between managers and employees, lack of communication between managers and customers, and bloated organizational hierarchies that impede or change the service information related to the customers); 3. Inadequate remedial measures to deal with service emergencies (lack of timely remedial measures for service problems, lack of effective resolution mechanisms for remedial measures, and lack of incentives for employees to listen to customer complaints); 4. Inadequate attention to the service relationship (more attention to segmentation of the market for customers and transaction over maintenance of customer relationships, and more attention to new customers over maintenance of customer relationships).

(3) Standard gap

The standard gap usually refers to the discrepancy between the service provider's understanding of customer expectations and the development of customer-driven service design and the standards proposed by the service provider when studying customers. Customer-oriented service standards are usually different from the traditional service standards set by most service providers. The customer-oriented service standards should be easily identified and evaluated by customers, and they should be set according to the customer's service requirements. The service provider should mainly consider the customer's service expectations and service standards rather than merely focus on factors of production such as the productivity and/or production efficiency. There are many reasons for the gap in service standards. First, service concept is not comprehensive enough (lack of systematic considerations in the development of new services, ambiguous standards in service design, lack of an effective combination of service design and service orientation, lack of order in service plan management, human errors in the service plan, and insufficient planning process); second, there lack customer-oriented standards (service providers lack the necessary attention and understanding of customer service needs, customer-oriented service standards are not clear enough, and the management organization lacks a clear directional goal); third, service scenarios and tangible demonstration is mismatched (customer expectation of the service is not effectively transformed into a practical scenario, and service-related occasions cannot be set up to meet the needs of the customers and employees).

(4) Communication gap

The communication gap usually refers to the difference between the promises made by a company to its customers and the services actually provided by the company. Companies will use a variety of marketing and publicity channels to let consumers know the service in advance, and the most common means include media advertising, and marketing personnel. In the process of publicity, promises may increase the customer's expectations, because the customer will take the publicized promises as the standard to evaluate of the quality of corporate service standards. Therefore, if the service provided by the company is different from the promises in the publicity, there will be customer gap. In addition, a part of the relatively hidden external communication factors will also affect the customer's evaluation of service quality. The key factors affecting the communication gap are as follows. 1. Insufficient integration of marketing and publicity (service providers are accustomed to treating external communication as an independent part, there lacks interaction between marketing in the communication of service-related programs, and implementation of internal marketing programs is undesirable). 2. Insufficient management of customer expectations (companies are accustomed to using a single marketing channel for ineffective communication management, and there lacks adequate and effective education for customer expectations). 3. Over-commitment (over-commitment in promotion and service personnel marketing in order to achieve the purpose or over-commitment in the tangible demonstration). 4. Inadequate communication between departments (inadequate communication between the marketing and planning departments, inadequate communication between the advertising and planning departments, and discrepancies between subsidiaries of various branch offices and the head office). 5. Unreasonable pricing (sales price is higher than the expected price, and sales price is higher than the perceived value).

(5) Delivery gap

The delivery gap usually refers to the inconsistency between the service standards set by the enterprise and the actual implementation of the work by the service personnel. Even if the enterprise sets high service standards and upholds the right service philosophy to serve customers, there is no guarantee that the final service results will be satisfactory. Service standards need to be supported by factors such as the appropriate service staff, information systems and technology, as well as continuous attention and enhancement to make them more efficient. The key reasons for the delivery gap are as follows. 1. Lack of relevant human resources policies (inefficient or ineffective recruitment, role positioning ambiguity or conflict, unreasonable arrangements of the enterprise staff and work technology, unreasonable performance appraisal system, and insufficient team spirit). 2. Mismatch between supply and

demand (lack of relevant measures in time to balance the relationship between supply and demand, unscientific customer portfolio, and over-reliance on the price equilibrium relationship. 3. Customers' ignorance of their own responsibilities (customers are easy to ignore their own obligations, and customers are prone to exert negative impact on each other). 4. Contradictions between service intermediaries (unreasonable match between the goal and performance, contradiction between the cost and the return, difficulty in controlling the quality and uniformity, and difficultly in striking a balance between authorization and process control).

2.2.2 IPA model

In 1977, James and Martilla (1977) proposed the importance-performance analysis (IPA) model, which is an analytical method to measure service quality satisfaction through the comparison between the importance of the service expected by the customer and the actual perceived service performance. The model consists of two core dimensions: importance and performance, with performance represented by the horizontal axis and importance by the vertical axis. The mean value of performance and importance is set as the origin of coordinates to form four quadrants representing different meanings, which is shown as per Figure 2.3. By projecting the measured service quality index data into the corresponding quadrants, we can intuitively categorize service quality, clearly identify the strengths and weaknesses of resource allocation in quality management, and guide quality improvement in a more targeted manner.

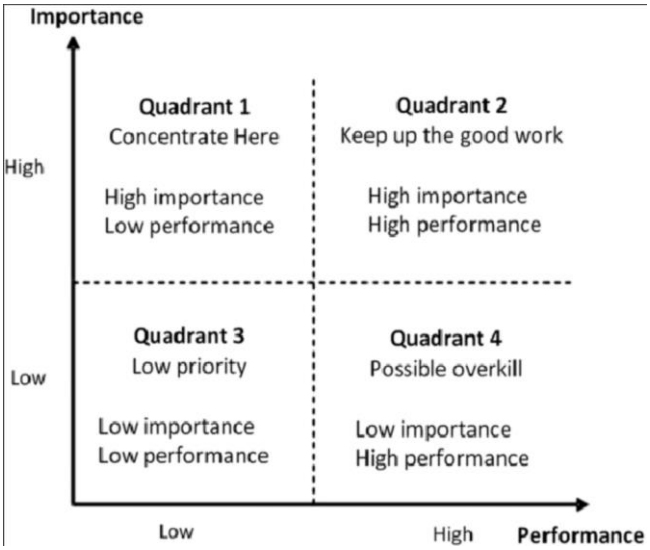

Figure 2.3 IPA quadrant analysis

2.3 The stakeholder theory

2.3.1 Definition of stakeholder

Around 1963, the theoretical framework of stakeholders emerged in Britain and the United States, when a scholar at the Stanford Research Institute first proposed this concept. Later, this theory witnessed rapid development, and now it has become an important theory in the field of organizational ethics and strategic management, and has been widely used in organizational decision-making and practice. However, there are still controversies and discussions among scholars about the definition of stakeholders, power relations and balance of interests. There is still no universally-recognized definition of the concept of stakeholders in the academia.

In 1984, Freeman first proposed the concept of stakeholder in *Strategic Management: An Analytical Approach to Stakeholder Management*, which breaks the traditional enterprise theory of "shareholder first". Freeman believes that stakeholders are any individuals or groups of people who are able to influence the achievement of the organizational goals, or who are affected by the achievement of the organizational goals. In addition to the shareholders, there are other groups of people who can influence the achievement of the organizational goals and can be influenced by the process in which the organization achieve its goals. They may include the organization's employees, suppliers, customers, social organizations, the government, and environmental protection organizations. They interact with the organization, and are a part of the organization's external environment. They have their own interests, which may be in conflict with the organizational goals. The organizational behavior exerts an impact on the stakeholders, and at the same time the behavior of the stakeholders also exerts an impact on the organization. The organization needs to treat all stakeholders equally and should not merely consider the interests of the shareholders (Freeman, 2004). In this research, we define the stakeholders of regional medical laboratory centers in a broad sense.

In the future, scholars should further study and apply the stakeholder theory, and integrate and it with other theories in order to improve the level of organizational social responsibility and sustainable development.

2.3.2 Classification of stakeholders

With the deepening of research, researchers have subdivided stakeholders from different dimensions, which has deepened the understanding of stakeholders, and provided a basis for the management of stakeholder classification. Although there are different views on the

segmentation of stakeholders, the classification of stakeholders mainly adopts the multi-dimensional scaling method and the Mitchell score-based approach. Both the two methods are based on the different characteristics of stakeholders. It is also possible to integrate different classification methods, take different dimensions into consideration, choose the suitable method according to the actual situation, and then adopt corresponding management strategies to identify and assess the interests and impacts of stakeholders in a more comprehensive manner.

1. Multi-dimensional scaling

Multi-dimensional scaling (MDS) is a commonly used method for stakeholder categorization, which can help organizations better understand different types of stakeholders and develop more targeted management strategies for different types of stakeholders, and has been widely used in stakeholder management in organizations.

Freeman is one of the pioneers in the field of CSR. To better understand and manage these stakeholders, Freeman pioneered the use of MDS to classify stakeholders. MDS provides a relatively clear and complete hierarchy of categories that help to gain a better understanding of their needs and interests. Freeman proposed three dimensions: power, interests, and attitudes. In the dimension of power, stakeholders are classified based on their degree of control and influence over enterprises: employees and management who have direct control and influence over the decisions and operations of enterprises; shareholders and investors who obtain equity through the investment that have certain control and influence over the decisions and operations of enterprises; governments and regulatory agencies that regulate and control enterprises through laws and policies; and social organizations and the public that exert pressure on enterprises through public opinion and social influence. In the dimension of interests, stakeholders are classified according to their concerns about enterprises: financial stakeholders are concerned about the financial performance and return on investment (ROI) of enterprises; social stakeholders are concerned about the impact of the enterprise on society and the environment, such as employee welfare, environmental protection and public welfare; and product stakeholders are concerned about the quality and safety of enterprises' products and services. While in the dimension of attitudes, stakeholders are classified according to their attitudes towards enterprises: supporters who support the decisions and behavior of enterprises; and neutrals who are neutral towards that of enterprises; opponents who oppose that of enterprises.

Frederick (1998), one of the important scholars in the field of CSR, also used MDS to propose four dimensions to classify stakeholders to better understand and manage their interests and demands. In the dimension of interests, stakeholders are classified according to their

concerns about the enterprise, including economic stakeholders concerned with the financial performance and ROI of enterprises; legal stakeholders concerned with enterprises' compliance with laws and regulations; career stakeholders concerned with the career opportunities and working conditions that enterprises provide to employees; and social stakeholders concerned with the impact of the enterprise on society and the environment, such as employee welfare, environmental protection, and public welfare. In the dimension of influence, stakeholders are classified according to their degree of control and influence over the enterprise, including internal stakeholders, composed of employees, management and shareholders within the enterprise, who have direct control and influence over the decisions and operation of the enterprise, as well as external stakeholders, composed of shareholders, customers, suppliers, social organizations and the public outside the enterprise, who have a certain degree of control and influence over that of the enterprise. In the dimension of the degree of concern, according to their degree of concern for the enterprise, stakeholders can be divided into the following categories: important stakeholders who have a significant impact on the decisions and behavior of the enterprise and are critical to the long-term development of the enterprise; ordinary stakeholders who have some influence on that of the enterprise but are not critical stakeholders; and secondary stakeholders who have less impact on that of the enterprise, but still require attention and management. In the dimension of priority, according to their priorities in the daily operation of the enterprise, stakeholders are classified as key stakeholders that are crucial to the daily operation of the enterprise and require priority attention and management; important stakeholders who have a certain impact on that of the enterprise and require attention and management; and ordinary stakeholders who have less impact on that of the business, but still need attention.

Charkham (1992) proposed to classify stakeholders based on the existence of a transactional contractual relationship between the stakeholder group and the organization. He classified stakeholders into two categories: community stakeholders and contractual stakeholders. Community stakeholders encompass a wider range of non-contractual associates such as the local community, all consumers, pressure groups, the media, regulators, and government departments; while the contractual stakeholders mainly encompass those who have assigned formal agreements with the organization, such as employees, shareholders, distributors, customers, lenders, and suppliers. He proposed three dimensions to classify stakeholders. In the dimension of power, according to their power and influence in the decision-making process, stakeholders can be divided into strong stakeholders who have high power and influence in the process and can directly or indirectly affect the decisions and behavior of the

enterprise; and weak stakeholders who have low power and influence in the process and are unable to directly or indirectly affect that of the enterprise. In the dimension of attitudes, based on their attitudes and positions towards the enterprise, stakeholders can be divided into supporters who support the decisions and behavior of the enterprise and are willing to provide assistance and resources; opponents who oppose that of the enterprise and may take action against the enterprise; and neutrals who holds a neutral attitude towards that of the enterprise, neither supporting nor opposing the enterprise. In the dimension of interests, based on their concerns about the enterprise, stakeholders can be divided into economic stakeholders who focus on the financial performance and ROI of the enterprise; social stakeholders who are concerned about the impact of the enterprise on society and the environment, such as in employee welfare, environmental protection, and public welfare; and individual stakeholders who pay attention to the impact of the enterprise on personal interests, such as employment opportunities, compensation, and benefits.

2. Mitchell score-based approach

In the late 1990s, the American scholars Mitchell and Wood (1997) proposed a new score-based approach to define stakeholders, which helps organizations to better understand and meet the needs and interests of stakeholders.

The method mainly includes the following three dimensions. 1) In the dimension of the power and interests of stakeholders who can affect the enterprise, stakeholders are divided into the following four categories. Unimportant and non-urgent stakeholders, who have very limited influence and interests in the enterprise and usually do not require special attention and treatment. Important and non-urgent stakeholders, who have great influence and interests in the enterprise, but do not require immediate action to meet their needs. Unimportant and urgent stakeholders, who have very limited influence and interests, but need to take immediate action to address their needs to prevent the problem from getting worse. And important and urgent stakeholders who are very important to the influence and interests of the enterprise, and need to take immediate action to meet their needs.

2) In the dimension of the degree of connection of stakeholders who connect and interact with the enterprise, stakeholders have the following three categories: stakeholders with low connection, who have very few connections with enterprises, with almost no interaction; stakeholders with moderate connection, who have many but not very close connections with the enterprise, and only need regular communication; stakeholders with high connection, who are very closely connected to the enterprise and need frequent communication to ensure that the interests of both parties are satisfied.

3) In the dimension of the positions and attitudes of stakeholders towards the enterprise, stakeholders can be divided into the following two categories. Stakeholders with a positive stance, who hold a positive attitude towards the enterprise and usually support the decisions and behavior of the enterprise. Such stakeholders usually have a good cooperative relationship with the enterprise and have a positive contribution to the development and success of the enterprise. They may be shareholders, employees, suppliers, customers, and government agencies. Stakeholders with a negative stance, who hold a negative attitude towards the enterprise and usually do not support the decisions and behavior of the enterprise. They may be dissatisfied with or critical of the decisions, behavior, products or services of the enterprise. They may also be competitors of the enterprise, environmental protection organizations, consumer advocates, labor organizations, and political organizations. It should be noted that the positions and attitudes of stakeholders are not static, because they may change with time, circumstances and the behavior of the enterprise. Therefore, enterprises need to timely understand and analyze the changes in the positions and attitudes of stakeholders, and take targeted measures to safeguard the interests of stakeholders and the development of enterprises.

Mitchell and Wood suggested dividing stakeholders into three attributes, legitimacy, power and urgency. They comprehensively scored and analyzed these attributes, and then determined whether an individual or group is a stakeholder of the enterprise and what type of stakeholder it belongs to according to the evaluation score obtained. Then the enterprise knows how to handle and respond to the interests and needs of stakeholders.

The attribute of legitimacy refers to whether the needs and interests of stakeholders are legitimate, that is, whether they conform to legal, moral, social and cultural norms. For stakeholders with high legitimacy, enterprises need to meet their needs and interests as much as possible to avoid legal and moral condemnation and criticism or those of public opinion. Meanwhile, the stakeholders with high legitimacy may also be the potential partners and co-creators of value for the enterprise.

The attribute of power refers to whether stakeholders have the ability, opportunity and corresponding means to influence the decisions and behavior of the enterprise. For high-power stakeholders, the enterprise needs to seriously consider their needs and interests, and try to meet their requirements to avoid their adverse impact on the enterprise. In addition, high-power stakeholders may also become the important community of shared interests for the enterprise, working together to create value.

The attribute of urgency refers to whether the needs and interests of stakeholders are urgent, which can immediately attract the attention of the management. For stakeholders with high

urgency, enterprises need to take immediate measures to meet their needs and interests to avoid serious consequences. For example, issues of consumer safety and health and environmental protection have high urgency. Comprehensive scoring and analysis of these three attributes can help enterprises better understand and evaluate the needs and interests of stakeholders, so that decision-makers can make more effective strategies and decisions for stakeholder management, and achieve the goal of common development of enterprises and society. In the meantime, for stakeholders with high scores in different attributes, enterprises need to strengthen communication and cooperation with them to establish long-term partnerships and trust, and jointly create more value.

Mitchell proposes a comprehensive approach to score and analyze potential stakeholders, emphasizing that any entity to be considered as the stakeholder of an organization needs to possess at least one of the following three attributes: legitimacy, power or urgency. A true stakeholder should have a legal and enduring interest in the organization, be able to quickly draw the attention of the organization's management personnel (as well as the regulators and the public), and have the ability to exert significant influence on the organization's operational decision-making and strategic management processes, so as to materially affect the company's operational performance. Depending on the attributes of the stakeholders, an organization's stakeholders can be subdivided into definitive stakeholders, expectant stakeholders and latent stakeholders.

Definitive stakeholders are those who are clearly identified as having high legitimacy, high power and high urgency in the operation and decisions of the enterprise. Enterprises can better understand and balance the rights and interests and influences among different stakeholders to better manage risks and enhance CSR. They are usually viewed as the key stakeholders of the enterprise, and the management of the organization must always pay attention to and respond to their needs and interest demands and try to improve their satisfaction for the survival and development of the organization. Typical definitive stakeholders include clients, employees, and shareholders.

Expectant stakeholders are those who have potential influence on the behaviors and decisions of the enterprise. They possess two of the above three attributes, but they still have some degree of impact on the interests, reputation, and sustainability of the enterprise. Media and commentators can affect the reputation of enterprises through their reports and comments, so enterprises need to actively communicate and cooperate with them, respond to their concerns in a timely manner, and take measures to maintain their reputation. Industry associations and organizations can affect the business and image of enterprises, so enterprises need to actively

participate in their activities, establish good relationships with them, and participate in the formulation of industry standards and norms. Potential customers and suppliers are important sources of future business development for enterprises, so enterprises need to actively understand their needs and expectations, establish good relationships, and provide them with quality products and services. Social and environmental groups supervise and evaluate CSR and environmental impact, so enterprises need to actively respond to their concerns to achieve social responsibility and sustainable development.

Latent stakeholders are those individuals or organizations that have no obvious interest at present, but are likely to have an interest in the enterprise in the future. They have two of the above three attributes. Unlike definitive stakeholders and expectant stakeholders, they may be people or groups affected by organizational activities, but are not recognized or included in the category of stakeholders by the organization for some reasons, including an insufficient understanding of relevant parties, cognitive biases, and poor communication. The government and regulatory agencies supervise and review the operation and behavior of enterprises to ensure their legitimacy and fair competition. As a result, enterprises need to actively understand the decisions and policies of government agencies, maintain good communication and cooperation with them, and timely adjust the business and behavior to adapt to changes in government policies. Competitors may have an impact on the market position and competitiveness of enterprises in the future. Consequently, enterprises need to actively understand the business and behavior of competitors and take timely measures to protect their market share and competitive advantage. Investors and shareholders may influence the investment and performance of enterprises in the future, so enterprises need to actively convey the right message to them to enhance their trust and recognition so as to attract more investment and capital. The society and the public are concerned about the social responsibility, environmental impact and public interests of enterprises. Thus, enterprises need to actively respond to their concerns to achieve social responsibility and sustainable development.

The dynamic nature of the stakeholder classification model proposed by Mitchell implies that any individual or group may shift from one category to another as attributes are added or removed at different stages of organizational development. As Mitchell himself emphasizes, the model provides us with two key insights. First, whether a group has legitimacy is not the only reason for the management to determine whether or not they belong to the stakeholders, nor is it the only attribute that confirms identity. When defining stakeholders, the management also need to consider those who have some kind of power in a given organizational context, as well as groups that have urgent needs to be met. Second, the identity of stakeholders is not a “fixed

property" (Jia & Chen, 2002).

As in Figure 2.4, the proposal of Mitchell score-based approach has greatly enhanced the practicality and operability of stakeholder classification, and quantified the results of the stakeholder classification in the form of different scores. This method marks a breakthrough in the academic research on stakeholder definition, shifting the stakeholder research that was originally stuck in theoretical discourse to the level of empirical analysis. It has not only strongly promoted the popularization of the stakeholder theory in practical application, but also gradually become one of the most commonly used tools to define and classify stakeholders.

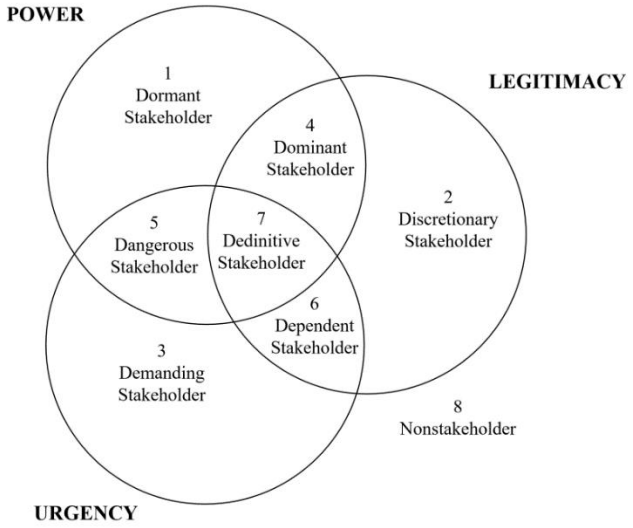

Figure 2.4 Definitions of stakeholders based on Mitchell score-based approach

Source: Mitchell (1997)

Latent stakeholders: 1, 2, 3

Expectant stakeholders: 4, 5, 6

Definitive stakeholders, namely, core stakeholders: 7

3. Other classification methods

Bryson's Typology, is a method to classify stakeholders according to their roles and power in decision-making, which divides stakeholders into four types: dominant power stakeholders, cooperative stakeholders, collaborative stakeholders and discretionary stakeholders.

Dominant power stakeholders have strong influence and control in decision-making. They usually possess a high degree of resources and power and have a significant impact on decision-making, such as the government, senior management, and major shareholders. Cooperative stakeholders usually have a close partnership with the organization and work together to achieve decision objectives. They usually have some resources and power, but do not have a decisive influence on decision-making, such as employees and partners. Collaborative

stakeholders are usually the public or other organizations. They do not have a close cooperative relationship with the organization, but have a certain influence on the decision-making and implementation of the organization, such as clients, media, and non-governmental organizations. Discretionary stakeholders do not have a direct influence on the decision-making and implementation of the organization, but their interests are affected by the decisions, such as the public, environmental organizations and charities. Through classification, organizations can better understand the characteristics and influence of stakeholders, and adopt corresponding communication and management strategies for different types of them. Besides, stakeholders can also better understand their positions and influence in the decision-making process, so as to better participate in and influence decision-making.

Matthew's Typology refers to the classification of stakeholders in terms of their influence and interest in the enterprise. This classification method divides stakeholders into four categories. Those who have a great influence on the enterprise and have a significant influence on the interests of the enterprise, such as shareholders, employees, customers and suppliers, are called motivative stakeholders. Those who cooperate or interact with the enterprise, such as business partners, competitors, and government agencies, have a certain influence on the success or failure of the enterprise, but are not as influential as motivative stakeholders, are called cooperative stakeholders. Those who have a small influence on and infrequent interaction with the enterprise, such as media, social public, and environmental protection organizations, who have less impact on the success or failure of the enterprise, but who the enterprise needs to maintain a good relationship for the corporate image and reputation, are called retainable stakeholders. Those with minimal influence on the enterprise, such as some political and cultural groups, and specific interest groups, who have no substantial impact on the success or failure of the enterprise, and whose needs and interests enterprises do not need to consider, are called non-critical stakeholders.

Miles' Typology, proposed by Mitchell in 1997, is a method of classifying stakeholders according to three dimensions of interests, power and legitimacy, and it is one of the most popular classification methods in Stakeholder Theory. Stakeholders refer to those who have a certain influence on the operation and interests of the enterprise, such as customers, suppliers, competitors, and financial institutions. They have a significant influence on the decisions and operation of the enterprise, but are not as influential as power stakeholders. Power stakeholders are those who can influence the operation and decisions of the enterprise, such as government agencies, shareholders, executives, and labor unions. They influence the decisions and operation of the enterprise through their own power, and are one of the most important

stakeholders of the enterprise. Social responsibility stakeholders are those who have expectations and requirements for CSR and moral obligations, such as environmental protection organizations, consumer rights organizations, and the public. They have a certain impact on the decisions and operation of enterprises, but mainly consider from the perspective of CSR and moral obligations. The advantage of Miles' Typology is that it can clearly indicate the degree of influence and interest of stakeholders on enterprises, which helps enterprises to better identify, understand and deal with different types of stakeholders. And the classification method also helps enterprises to be more objective and effective in the balance of interests.

In this research, we use the Mitchell score-based approach to identify the stakeholders and their types in regional medical laboratory centers through questionnaires and expert interviews.

2.3.3 Application of the stakeholder theory in medical service

When first proposed, the stakeholder theory mainly focused on CSR. During this period, the stakeholder theory was mainly applied to public service, manufacturing and financial services industries. After the 1980s, it gradually expanded to various industries, including retail, energy and environmental protection. In the 1990s, it began to consider factors such as the cultural differences, laws and regulations, and social responsibilities in various countries and regions to formulate strategies and policies in line with the interests of local stakeholders. Since the 2000s, the stakeholder theory has gradually become a basic concept of enterprise management. Emerging technology industries have also begun to apply the stakeholder theory, focusing on issues such as users, the public, and privacy protection. Nowadays the stakeholder theory has been widely used to analyze the behavioral performance, roles, and impacts of health institutions or individuals in health policy formulation and implementation, and has become an indispensable theoretical tool and research perspective in the healthcare field.

Liu (2018) used Mitchell score-based approach to identify stakeholders of public hospitals and developed corresponding management strategies based on the characteristics and needs of different stakeholders. This thesis firstly classified the stakeholders of public hospitals, including government regulators, patients and their families, medical staff, medical insurance institutions, suppliers, partners, and the public. Then, the author analyzed the characteristics and needs of each stakeholder to determine their importance and influence in the governance of public hospitals. After identifying stakeholders, the author used Mitchell score-based approach to evaluate the weight of stakeholders. This method scored stakeholders based on their power, urgency and legitimacy. Specifically, the authors used a 5-point system, where 5

points indicates that the stakeholder has the highest weight and influence, and 1 point indicates the lowest. Finally, according to the weight and influence of stakeholders, the author put forward the corresponding classified management strategies. For example, for government regulators, the important stakeholder, the author proposed to establish a sound internal management system and policies and regulations compliance mechanism, and strengthen government communication. For patients and their families, the important stakeholder, the author put forward strategies to improve service quality and doctor-patient communication and strengthen medical security.

In establishing the European Network for Health Technology Assessment (EUnetHTA), Nielsen et al. (2009) emphasized the importance of stakeholder participation in the process of health technology assessment and opinion formulation, and provided guidelines and tools for stakeholder participation. First, they defined the stakeholders that may be affected by the evaluation and opinion, including patients, physicians, insurance companies, and medical device manufacturers. Through promotional activities, they introduced the assessment system to stakeholders and told them how to participate. They recruited stakeholders in a variety of ways, such as organizing symposium and sending invitations to groups. Then they used various tools such as online surveys, expert opinions, and case studies to provide opportunities for stakeholders to participate.

Plaza-Úbeda et al. (2010) proposed a method to measure stakeholder integration, which applied the basic principles of Stakeholder Theory to measure the three dimensions of stakeholder integration: knowledge, interaction, and adaptational behavior. They also integrated the evaluation results of the above three dimensions and compared the degree of integration between different stakeholders in order to further develop improvement strategies.

Wisell et al. (2016) applied the Stakeholder Theory to analyze the influence of the pharmacy ownership liberalization reform in Sweden on the expectations and perceptions of stakeholders. Sweden implemented the pharmacy ownership liberalization reform in 2009, which aroused the attention and reaction of multiple stakeholders in the health care system. By conducting in-depth interviews with multiple stakeholders, the authors understood stakeholders' expectations and perceptions of the reform. For example, the government hoped to improve the quality and efficiency of health care services through the reform, the owner of the pharmacy wanted more market shares and profits, while doctors and patients desired better services and choices. The authors discussed the conflicts and coordination among stakeholders, and balanced the interests of all parties. As the pharmacy ownership liberalization reform has different impacts on different stakeholders, corresponding policies and measures should be taken to

resolve conflicts and improve overall benefits.

Malfait et al. (2017) held that the needs and interests of stakeholders are indispensable for the hospital's decision processes of policies. Hospitals provide sufficient and accurate information to facilitate stakeholders' understanding of the content and impact of policies, thereby enabling them to make wise decisions. Through various forms of participation, including holding meetings, and setting up committees or working groups, different stakeholders can participate in the decision processes of policies. Hospitals provide relevant training and education to stakeholders, so that they can understand relevant policies, regulations and standards, and open multiple communication channels, such as face-to-face communication, telephone, and e-mail, to make stakeholders give feedback and suggestions to the hospital in time. Incorporating the opinions and suggestions of stakeholders into the decision processes can help hospitals formulate better policies and have better effects. Tambo et al. (2015) applied Stakeholder Theory to explore the views of healthcare stakeholders on patient payment policy in six Central and Eastern European countries (Hungary, Poland, Romania, Serbia, Slovakia and Ukraine). They collected the views and opinions of stakeholders on the cost, quality and accessibility of healthcare services, and pointed out some challenges and difficulties in the process of healthcare policy formulation, such as the opacity and information asymmetry in the process of policy formulation, and how to balance the interests and demands of different stakeholders. They emphasized that in the process of healthcare policy formulation, it is necessary to disclose as much information as possible, improve the transparency of policy formulation, and strengthen communication and cooperation with various parties to formulate more equitable and sustainable patient payment policies.

In recent years, Chinese scholars have applied the stakeholder analysis method to the research in the field of health. Luo and Jiang (2011) systematically sorted out the application progress of Stakeholder Theory and its analytical methods in the field of health, and proposed that the research methods of stakeholders in the medical industry could be divided into the following six steps. (1) Regarding the definition of stakeholders, we often refer to the definition proposed by Freeman, namely, stakeholders include all individuals or groups that can have an impact on or be affected by the achievement of the organization's objectives. (2) A preliminary description of stakeholders is performed, including their responsibilities and their roles in the organization. (3) The Mitchell's score-based approach is used, and experts are asked to assess the stakeholders in terms of urgency, power and legitimacy. The stakeholders are categorized according to the scoring results to identify the core stakeholders. (4) Characteristics of core (key) stakeholders are depicted in terms of multiple dimensions such as resource control, power

exercise, positional orientation, and expertise. (5) Based on the research objectives and needs, the researchers apply the results of stakeholder analysis to design corresponding response strategies. (6) Evaluate the rationality and effectiveness of the proposed strategies. If necessary, the impact of the implementation of these strategies on key stakeholders should be analyzed.

2.4 Dynamic capabilities

2.4.1 Definition of dynamic capabilities

In order to compensate for the inadequacy of the static nature of the resource-based view in explaining the competitive advantage of firms in the changing environments, Teece and Pisano attempted to introduce the concept of dynamic capabilities: competitiveness, or a subset of capabilities, that facilitates a firm's process of creating a new product or service and is able to respond to a changing market environment. Later, Teece et al. (1997) modified the concept of dynamic capabilities: the ability of firms to integrate, build and reconfigure internal and external resources to gain competitive advantage in a rapidly changing environment. This theory suggests that, against the backdrop of the accelerating pace of globalization, those firms that stand out in the global marketplace are not solely based on the accumulation of tangible technological resources, but rather on their ability to respond quickly to changes in market demand and promote product innovation in a flexible and efficient manner. The theory became popular in the field of strategic management as soon as it was proposed, and since then, scholars have developed dynamic capabilities based on different theoretical perspectives. From the perspective of evolutionary economics, Eisenhardt and Martin (2000) proposed that dynamic capabilities are the unique abilities of firms to use and manage resources, or in particular, the abilities to effectively integrate, reorganize, acquire and release resources to adapt to, and even shape, changes in the market environment. These abilities are also reflected in how firms respond to the various opportunities and challenges that arise during the market life cycle, such as the stages of incubation of new markets, market fragmentation, competition intensification, evolution and decline, as well as the formation and adjustment of organizational structures and strategic routines during these processes. Based on the organizational learning theory, Zollo and Winter (2002) argue that dynamic capabilities are a mode of collective learning activity and are resulted from three aspects, namely, the process of accumulating tacit knowledge, knowledge externalization, and effective implementation of knowledge encoding activities. It is through the construction and development of such dynamic capabilities that firms are able to

systematically create and redefine their business management practices, which in turn stimulate internal innovation potential and thus enhance the organization's competitive position in the marketplace. From the perspective of the resource-based view, Winter (2003) suggests that dynamic capabilities are the ability to expand, modify or create ordinary capabilities. From the perspective of the behavioral theory, Helfat and Peteraf (2009) suggest that dynamic capabilities are the ability of an organization to purposefully create, expand, and modify its resource base. In this study, we adopt the definition of dynamic capabilities by Teece et al. (1997), which is also a widely used definition in the existing literature.

2.4.2 Dimension of dynamic capabilities

Dynamic capabilities differ greatly in the division of dimensions, and based on different theoretical perspectives, scholars have proposed different dimensions. First, based on the assumptions of evolutionary economics, Teece et al. (1997) proposed a classical definition of dynamic capabilities and elaborated the coordination, learning and reconfiguration processes of dynamic capabilities. Subsequently, Teece (2007) proposed three dimensions of sensing, utilization, and reconfiguration capabilities from a procedural-framework perspective, and the process perspective contributes to the operationalization of dynamic capabilities and the understanding of how they affect practical change. In addition to the opportunity-related dynamic capabilities dimension, Eisenhardt and Martin (2000) proposed that dynamic capabilities include resource integration, reconfiguration, acquisition, and release capabilities, and subsequent scholars have conducted more in-depth research around these dimensions based on the resource perspective. For example, Wang (2007) argued that dynamic capabilities are essentially the continuous resource integration, reconfiguration and updating within the firm, and he identified three constituent elements, namely, innovative capability, adaptive capability and absorptive capability. Dong et al. (2011) classified dynamic capabilities into five dimensions, namely, resource integration capability, resource reallocation capability, learning capability, adaptive capability and innovative capability. In addition, the knowledge perspective, as a special but important extension of the resource perspective, has also contributed to the dimensionalization of dynamic capabilities. Wang (2007) categorized dynamic capabilities into three dimensions based on the knowledge perspective, including adaptive, absorptive and innovative capabilities. With the opportunity and resource perspective becoming the mainstream of entrepreneurship research, the classification of dimensions of dynamic capabilities under the opportunity-resource integration perspective has received increasing

attention, including opportunity capability, resource capability, and relationship capability (Zeng et al., 2013). Currently, with the emergence of digital foundations such as artificial intelligence, block-chain, cloud computing, and big data, the speed of enterprise change has been accelerated, and the instability, complexity, and uncertainty of the environment has been increasing (Cheng & Zhong, 2019). Helfat and Raubitschek (2018) discussed three dynamic capabilities required for digital platform firms to create and capture value: the ability to innovate, the ability to scan and sense the environment, and the ability to integrate ecosystem, which are critical for platform leaders.

Jiang et al. (2020) summarized four perspectives of the dimensions of the dynamic capabilities by scholars.

(1) The perspective of internal processes of enterprises. The dynamic capabilities are classified as coordination, integration, learning, and reconfiguration capabilities (Eisenhardt & Martin, 2000; Teece et al., 1997). This theoretical perspective focuses on how enterprises, when faced with internal and external resource and capability bases, can update and strengthen their intrinsic core competitiveness through effective integration, rational allocation, and flexible reorganization and adjustment of these resources and capabilities in a timely manner in response to changes in the external environment. The enhancement of such capabilities helps enterprises to continuously launch high-quality products and services that meet the market demands, create greater added value for customers, and thus ensure that they maintain a leading position in the competition. It is also worth noting that enterprises that have built competitive advantages generally have excellent resource integration capabilities, which is reflected not only in being able to optimize the mix of resources at their disposal, but also in driving strategic transformation and upgrading through resource integration.

(2) The perspective of environment. Teece (2007) divides dynamic capabilities into three aspects: environmental sensing, environmental adaptation, and environmental reshaping capability. He believes that the dynamic capabilities of enterprises are essentially the ability to actively adapt to changes in the external environment, and emphasizes that enterprises are not merely passively adapting to environmental changes, but are capable of influencing and transforming their environments through a series of proactive behaviors.

(3) The perspective of organizational learning and knowledge management. Dynamic capabilities are divided into external knowledge acquisition, knowledge internalization, knowledge innovation capacity (Camisón & Forés, 2010). Scholars have pointed out that the process of knowledge acquisition by enterprises is essentially a process of continuous development and evolution of their dynamic capabilities. Through the continuous learning and

accumulation of external knowledge, enterprises can continuously enhance their ability to anticipate future environmental changes, and, in turn, effectively adjust and reconfigure their resources accordingly to adapt to and conquer the changing external environment (Zollo & Winter, 2002). In addition, the enterprise not only enhances its own dynamic abilities in this process, but also establishes a unique knowledge reserve and knowledge chain through continuous accumulation and deepening of knowledge, which is difficult to be copied by competitors, and thus wins a significant competitive advantage for the enterprise.

(4) The perspective of enterprise life cycle. Enterprises in different life cycles will also show different characteristics in the construction and evolution of their capability systems. From the perspective of the five core dimensions of strategic isolation mechanism, resource integration capability, learning capability, environmental adaptability and organizational change capability, enterprises first need to identify and target key and valuable rare resources in the external environment, and optimize internal resource allocation and strengthen collaboration among resources by acquiring and integrating these resources, so as to enhance their adaptability to changes in the external environment. This process will prompt enterprises to continuously adjust their internal management mechanisms and enhance their dynamic capabilities, so that they can evolve continuously with changes in the external environment (Dong et al., 2011).

Although scholars have carried out fruitful research on the division of dynamic capability dimensions, there is no uniform opinion on the specific division of dimensions so far, and it is necessary for researchers to choose specific dimensions according to theoretical perspectives, research objects, and data types.

2.4.3 Measurement of the dynamic capabilities

At first, research on dynamic capabilities is mainly dependent on theoretical deduction, so it is criticized by scholars for the lack of empirical research. Therefore, scholars have carried out fruitful research on measurement of dynamic capabilities. Since the concept of dynamic capabilities is relatively abstract, scholars at home and abroad mainly use questionnaire for measurements (Jiao & Cui, 2008). However, the cross-sectional data represented by questionnaires actually cannot reflect the evolutionary nature of dynamic capabilities. With the deepening of research, the understanding of the connotation of dynamic capabilities has deepened, and scholars have also tried to measure dynamic capabilities by integration of questionnaire survey and secondary panel data or secondary data only.

Jiao and Cui (2008) summarized the research of related scholars on the operationalization of dynamic capabilities, and the measurement methods used are mainly as follows.

(1) Measurement based on the components of dynamic capabilities. Scholars mainly measure dynamic capabilities from this aspect. Li and Wang (2004) believe that the differences in the performance of enterprises in the same industry are related to the three core attributes of dynamic capabilities, namely, the timing of resource allocation, the cost control of resource allocation, and the learning and imitation capability of resource allocation. The differences in these three attributes of dynamic capabilities between enterprises give rise to differences in their corporate performance, but such differences are not permanent and do not have long-term stability. He et al. (2006) reviewed the manifestations of dynamic capabilities from several aspects of enterprises. First, enterprises should have market potential in the market competition, which is mainly reflected in the quality advantage, cost advantage, and the extended advantage of technological innovation, or a combination of these advantages. Second, organizational learning should not only be limited to the accumulation and transformation of internal knowledge, for example, there should be an incentive mechanism to stimulate the efficiency of learning within the enterprise, a sound training system and employee education system, but also involve communication with other organizations, as well as imitation and learning activities. Third, organizational change emphasizes the spirit of innovation and entrepreneurship within the enterprises, which requires the enterprises to maintain sufficient organizational flexibility in the face of fast-changing market competition, and this strategic flexibility not only relies on the strategic responsiveness of the entrepreneur individually, but also requires that the enterprise's organizational structure can quickly adapt to the entrepreneur's strategic decisions and make corresponding adjustments. In addition, the strategic isolation mechanism is also an important factor, emphasizing that enterprises should have the self-protection ability to prevent the loss of core competence and protect their competitive advantages. Therefore, it is suggested that the dynamic capabilities of enterprises can be measured from the following six dimensions: customer value orientation, core technology and its support system, organizational structure and support system, institutional guarantee mechanism, renewal drive of innovation capability and strategic isolation mechanism.

(2) Measurement based on the characteristics of dynamic capabilities. Teece et al. (1997), after revisiting the resource-based theory of the firm, propose a measurement approach based on characteristics of dynamic capabilities. They assess the rarity of capabilities by comparing the differences in capability levels across firms; and the inimitability of capabilities is measured by examining the persistence of such differences. In other words, if a firm shows a significant

and persistent advantage over its competitors in a particular capability, it can be considered to have a high degree of rarity and inimitability in terms of the dynamic capabilities. The strategic significance of any particular capability ultimately depends on its impact on a firm's competitive position or on its role in determining factors such as long-term survival, sales, profitability and market share of the firm. In turbulent environments, firms that systematically review their knowledge of organizational "architecture" may outperform their competitors, and they take "architecture", "integration", or "combination" capabilities as the source of sustained competitive advantage. Lei (2007) measured the dynamic capabilities of enterprises through the integration, reconfiguration, learning and transformation capabilities and the impact of the dynamic capabilities on corporate performance. The resource integration, reconfiguration and learning are meaningful only when corporate resources are abundant. To be specific, dynamic capabilities are the ability of a firm to integrate and coordinate internal and external resources, acquire and internalize new knowledge from other organizations, and transform and reconfigure its initiating resource base into new processes or practices. For technology-based firms, dynamic capabilities or the ability to adapt to rapid environmental change are particularly important for survival.

(3) Measurement based on various business activities of an enterprise. Sher and Lee (2004), in their study of how endogenous and exogenous knowledge can be managed through the effective use of information technology in order to enhance dynamic capabilities, assessed organizational learning from a number of dimensions. These dimensions include: the effectiveness of corporate learning of new knowledge, the precision and quality of corporate decision-making, the ability of internal communication and coordination, the speed and sensitivity of response to external changes, the ability to integrate resources and innovate in the process of new product development, the ability to accumulate and pass on knowledge, the efficiency in the use of resources, and the ability to maintain and deepen customer relationships. By considering these aspects, they attempt to comprehensively understand and quantify how IT applications can facilitate organizational learning and thus enhance dynamic capabilities. Research on strategic management is also paying more attention to the theoretical and empirical convergence of knowledge management from the perspective of dynamic capabilities. Knowledge is usually contained in the business process management function, and the business functions contain the knowledge of the products, markets, and customers for sales purposes, lessons learned from project or product development, knowledge around information system implementation, and the competitive intelligence of the strategy and planning functions, as well as the "learning history". Effective and efficient knowledge flows within an organization are

critical to building and maintaining dynamic capabilities, and knowledge management is a major source of quality improvement and business excellence.

With the increasing business opportunities and intensifying global competition, there is a need for proactive knowledge management tools, new competencies, and the ability to update and reconfigure existing competencies. The scenario process builds an interactive and structured social environment for organizational communication. First, different numbers of individuals from different organizations form a knowledge network for a given task in order to create and share new knowledge; second, the participants of the scenario process continue to express tacit knowledge, and then construct the scenario, which is the integration of new knowledge; the last stage of the scenario process is the realization of the created scenarios, which allows the created explicit knowledge can be internalized during the scenario process and new competencies are developed through learning by doing. These created new knowledge is transferred and disseminated to the organization of the network, and create additional value for the network through sharing and learning by doing. The internalization of scenarios makes it possible to rethink organizational processes, and collaborative learning brings diversity of ideas into closer knowledge sharing (Bergman et al., 2004). Based on the knowledge management perspective in their empirical model, Cepeda and Vera (2007) capture the knowledge management processes behind dynamic capabilities development and utilization, examine their impact on operational competence, and measure the dynamic capabilities through knowledge reconfiguration capabilities. Their research illustrates that the knowledge evolution can be subdivided into four key links: innovative evolution, internal screening, replicative diffusion, and solidified transmission, which correspondingly map onto four commonly shared insights for a multilevel understanding of dynamic capabilities. First, the essence of any capability is the organizational procedures and routines constructed on the basis of knowledge; second, the starting conditions of dynamic capabilities include the initial setting of the enterprise's original combination of resources and established operating habits; third, the mechanism of dynamic capabilities is reflected in the in-depth transformation of the enterprise's internal knowledge resources and operating traditions; and fourth, the results of dynamic capabilities are manifested in the formation of a completely new pattern of resource allocation and the improved configuration of working habits.

2.4.4 Application of the dynamic capabilities in healthcare service

The dynamic capabilities theory has been widely studied and applied in management, involving many aspects such as corporate strategy, organizational structure, innovation management, knowledge management, and resource allocation, and has become an important theoretical basis for the formulation of corporate strategy.

With the continuous deepening of the research on dynamic capabilities, more foreign scholars have have begun to apply this theoretical framework to the research on capability development in the healthcare industry. As early as 1969, Kerr and Trantow (1969) clarified the starting point and end point of healthcare capacity building from a purpose-oriented perspective, and they argue that the key to the capacity of healthcare services lies in the effective response to community health needs. In contrast, Fraser and Greenhalgh (2001) defined capability from a potential growth perspective as a state of being able to adapt to changes in the environment, create new knowledge, and continually improve effectiveness, ensuring that healthcare organizations are able to keep up with the times and provide high quality healthcare services that match the demands in a rapidly changing environment. In addition, Epstein and Hundert (2002) defined the concept of professional competence from the perspective of professionalism of healthcare professionals, the core resource of healthcare services, namely, the habitual and judicious use of communication skills, professional knowledge, technical skills, clinical judgment, and appropriate emotions and values that healthcare professionals should possess. Together, these form the basis of their daily work in serving the well-being of individuals and communities.

Although the above views are all about the concept of dynamic capabilities, the current mainstream research in academia focuses more on the relationship between dynamic capabilities and competitiveness enhancement, performance evaluation, healthcare service quality, and economic benefits in the healthcare field, while there are relatively few specific empirical studies on how regional medical laboratory centers can use dynamic capabilities to optimize the quality of their services.

2.5 Chapter summary

In this chapter, we summarize and introduce the relevant studies as well as theories involved in this study, aiming to clarify the direction of innovation and lay a theoretical foundation for subsequent research. We first review relevant studies on healthcare service quality and find that

most of them use the Gap Model of Service Quality as an analytical tool, and use the SERVQUAL model developed by the Parasuraman, A., Zeithaml, V. A., & Berry, L. L. team as the assessment tool. It is believed that service quality problems are caused by a series of gaps in the different stages of service delivery, including cognition gap, standard gap, delivery gap, communication gaps, and perception gap. The Gap Model of Service Quality analyzes the causes of quality problems by measuring the gap between service expectations and service perceptions, and continuously bridges the gap between service quality provision and customers' actual needs, thus providing a reference for continuous quality improvement. Although the SERVQUAL model and the Gap Model of Service Quality have been widely used in existing research on service quality in the healthcare field, we have not found any research that has developed a service quality measurement scale for the regional medical laboratory centers.

In addition, this chapter introduces the stakeholder theory and the dynamic capabilities theory. The former is the mainstream research perspective in the field of corporate social responsibility, and the latter is an emerging research direction in the field of strategic management. With the continuous improvement of the theoretical system, the research objects and application boundary of the two are expanding, and the relevant application research in the field of health care is gradually increasing. However, we have not found any research on the application of the two theories in the study of regional medical laboratory centers.

Chapter 3: Practical Exploration of Regional Medical Laboratory Centers

3.1 Overview of the development of regional medical laboratory centers in China

The healthcare service industry is the part of the medical and healthcare industry that directly faces the general public, and is a direct representation of a country's medical level. China's healthcare service market continues to grow at a high rate. In terms of the total revenue generated by various types of medical institutions, the total size of the medical service market in China increased from RMB 3,698 billion *yuan* in 2017 to RMB 5,207 billion *yuan* in 2021, with a compound growth rate of 8.9%. Medical testing and pathological diagnosis is a core segment of the industry, and its development plays a crucial role in meeting the demand for equal access to high-quality medical services for residents. Internationally speaking, regional medical laboratory centers are mostly independent medical laboratories. They are service-oriented medical institutions with independent legal personality and market-oriented operation, and most of them are privately-run (Chen et al., 2021). In the United States, Germany, Australia, Japan and other developed countries, independent medical laboratories have become core components of regional medical laboratory services. In China, the development of regional medical laboratory centers also started from the model of independent medical laboratories. Many healthcare institutions in China, especially small community hospitals and private hospitals, tend to send test specimens to independent medical laboratories for testing, which not only meets the clinical needs, but also saves manpower, material and financial resources.

With the rapid development of in-vitro diagnosis industry and national policy support, China's regional medical laboratory centers are experiencing a period of rapid development, and are gradually becoming an important support for the implementation of the hierarchical diagnosis and treatment policy. By continuously improving the quality and efficiency of testing services, regional medical laboratory centers are playing an increasingly important role in optimizing the allocation of medical resources and promoting equalization of medical services. On the whole, the development of China's regional medical laboratory center shows the following characteristics.

Good market prospect and great potential. Data of 2018 shows that the market share of independent medical laboratories reached 38% in the US, and the clinical testing volume of the two major independent medical laboratories, Quest and Labcorp, accounted for 24% of the overall testing volume across America. The market share of independent medical laboratories in the Europe reached 53%, and this figure was 60% in Germany. The market share of independent medical laboratories in Australia reached as high as 80%.

Compared with developed countries, the overall penetration of the third-party testing industry in China is currently low, with a percentage of only about 5%. It is not only because of the large proportion of secondary and tertiary public hospitals and the small volume of private medical services, but also due to the impact of the current medical service charging policy that obstructs incentives for outsourcing of testing services. By the end of 2018, the numbers of medical imaging diagnostic centers, medical testing laboratories, pathological diagnosis centers, and hemodialysis centers nationwide were 633, 1,495, 318, and 559, respectively, up by 48.2%, 73.4%, 40.7%, and 104% compared with the end of 2017. In the future, thanks to the implementation of hierarchical diagnosis and treatment and medical insurance fee control, the testing volume of the secondary and primary hospitals will increase. However, due to the constraints of capacity and pressure of cost control, hospitals will be more motivated to outsource the tasks to third-party testing centers. In addition, with the full implementation of the policy of DRGs and the development and growth of private hospitals, the penetration rate of third-party medical testing market will be further increased.

Multi-party participation and rapid development. In recent years, under the support of national policy, the number of third-party testing centers has witnessed rapid growth, and there had been 1,275 testing centers by the first half of 2018. In the upstream of the In Vitro Diagnostic Products (IVD) industry chain, manufacturers, distributors, as well as organizations with resources related to the pharmaceutical industry and other industry investors have been involved in the industry. However, given that the industry has initially formed a relatively solid competitive landscape and has high barriers to entry, involving key technological barriers, a pool of professionals, advanced management systems, and adequate financial support, it is expected that organizations new to the industry will face a severe test of development in the new economic environment.

At present, the third-party regional laboratory center market presents a diversified and differentiated competitive situation, with various types of participants competing to enter, which has promoted the development and prosperity of the entire industry. In terms of ownership, there are private third-party medical laboratories, led by KingMed Diagnostics and

Dian Diagnostics, as well as testing centers that rely on public hospitals, such as the Shenzhen Luohu District Medical Laboratory Center. In terms of disciplinary, there are comprehensive test centers (such as KingMed Diagnostics), as well as specialized test centers (such as the Beijing Genomics Institute). In terms of business operation, there are chained test centers, as well as independent laboratories. In terms of the capital market, there are listed group companies as well as unlisted companies. In terms of future development potential, leading organizations, mainly listed companies, have large market share and obvious comprehensive advantages, and will continue to lead the development of the industry.

The development of the industry has initially taken on the situation of "The strong keep getting stronger, while the weak keep getting weaker", but there is still a large gap compared with foreign counterparts. China's foreign medical testing services can be traced back to the Yangzhou Medical Laboratory Center in the 1980s, but the first independent medical laboratory was the KingMed Medical Laboratory Center established in 1994 in Guangzhou, which marks the start of China's independent medical laboratory. At present, among China's regional medical laboratory centers, third-party medical laboratories are still the main force. According to statistics, there are more than 1,300 independent medical laboratories in China currently. Independent medical laboratories with strong competitiveness have begun to explore cross-regional and chained business model, and some of them have been successfully listed in the stock market.

In the Chinese market, the four leading organizations have a relatively large market share, occupying about 70% of the outsourcing market, demonstrating obvious advantages in economy of scale. However, compared with mature foreign counterparts, the Chinese medical testing centers are still in the early stages of development, especially in terms of laboratory size and the number of test items. For example, the foreign testing company Quest offers more than 3500 test items, the independent medical laboratories occupy a market share of 67% in Japan, of which BML independent medical laboratory has more than 40 branches and offers more than 4000 testing items, while the laboratories in China usually offer about 2,600 testing items (Guo et al., 2018).

3.2 Policy support

At present, there is an obvious imbalance in the geographic distribution of China's medical and healthcare resources, with a large number of high-quality medical resources concentrated in tertiary general hospitals, while primary healthcare organizations are often faced with the

problem of insufficient high-quality medical resources, and are therefore unable to adequately meet the medical needs of the general public. The limited technical level of the medical staff in the primary healthcare institutions lowers the residents' trust in them as well as the initial consultation rate, which also indirectly leads to the failure to effectively utilize the many medical resources of primary health care institutions, and even the idleness and waste of resources. As China is entering a new era, the main contradiction in society has undergone profound changes. In the face of the new normal, new characteristics and new requirements of economic development, the contradiction between the existing healthcare service system and the people's growing demands for multi-level and all-around healthcare is becoming increasingly apparent. How to appropriately solve the problem of "unbalanced and insufficient" development of medical resources, seek a harmonious balance between equity and efficiency, and find a collaborative path between the government-led and market-oriented mechanisms, so as to promote the optimization and upgrading of the structure of medical and healthcare resource allocation, improve the convenience, fairness, and accessibility of healthcare services, and enable every citizen to enjoy healthcare services with better quality in a more equitable manner, so as to enhance the people's sense of security, happiness and fulfillment in their lives, these issues have triggered extensive attention and in-depth discussions among the government, academia and all sectors of society.

In order to further deepen the reform of the medical and health system, improve the service efficiency of medical resources, promote the sinking of high-quality medical resources, and give full play to the government's role of macro-control and market allocation of resources, in recent years, the Chinese government has issued a series of guiding policies at various levels which encourage to fully utilize social resources, establish regional medical laboratory centers, optimize the allocation of medical resources such as regional inspection and testing, promote the high-level homogeneity of regional inspection and testing services, and realize the overall improvement of regional medical service capabilities, thereby ensuring the quality and safety of medical care, and providing residents with better quality, more convenient medical and health services. Relevant major policies are as follows:

China's General Office of the State Council (2012) encouraged to explore and establish centralized laboratory centers in *the Opinions on the Comprehensive Reform Pilots of County-level Public Hospitals*.

The General Office of the State Council (2013) pointed out that "it is necessary to rigorously promote and support the development of third-party medical service institutions, and guide and develop professional medical laboratory centers and imaging centers" in *Opinions of*

the State Council on Promoting the Development of Health Service Industry.

The General Office of the State Council (2015) once again clarified that "it is necessary to explore the establishment of independent regional medical laboratory institutions, pathological diagnosis institutions, medical imaging institutions, disinfection supply institutions and blood purification institutions, thus achieving regional resource sharing" in *Implementing Opinions of the General Office of the State Council on the Full Implementation of the Comprehensive Reform of County-level Public Hospitals* and *Guiding Opinions of the General Office of the State Council on Boosting the Construction of a Tiered Diagnosis and Treatment System.*

The State Council (2016) pointed out to guide and develop professional medical laboratory centers, medical imaging centers and pathological diagnosis centers in *Outline of the Plan for "Healthy China 2030"*.

In the same year, in order to facilitate the implementation of relevant policies issued by the State Council, China's National Health Commission (2016) issued *Notice on the Basic Standards and Management Regulations for Medical Inspection Laboratory (Trial)*, pointing out that "medical imaging diagnosis centers and medical laboratories can be independent medical institutions, and applicants who plan to open a group or chain medical imaging diagnosis center or medical laboratory center can be given priority for approval".

The General Office of the State Council (2017) issued *Guiding Opinions on Promoting the Construction and Development of Medical Alliances*, making it clear that medical alliances can set up medical testing centers to provide member institutions with integrated medical services.

In *Notification on Further Reforming and Perfecting the Examination and Approval of Medical Institutions and Physicians*, the National Administration of TCM (2018a) indicated that under the premise of ensuring the quality and safety of medical care, medical institutions may entrust independent medical laboratories, pathological diagnosis centers, or other eligible medical institutions to provide services such as medical testing and pathological diagnosis, with the entrust agreement as the registration record for corresponding diagnosis or treatment items.

In *Notification on the "Five Initiatives" to Promote Information Convenience*, the Office of Guangdong Provincial Health Commission (2019) pointed out that public health administrative departments at or above the prefecture level should establish medical testing, medical imaging, and pathological quality control centers as soon as possible, strengthen medical quality control, and medical groups and alliances should formulate and implement work processes and systems for the mutual recognition and sharing of such information as medical testing, medical imaging, and pathological examinations".

In terms of how to further improve the utilization rate of medical resources, reduce medical

costs for the public, and ensure the quality and safety of medical care, the National Health Commission (2022) formulated *Notice on Issuing the Management Regulations of the Mutual Recognition of Inspection and Testing Results among Medical Institutions*, pointing out that medical institutions should carry out mutual recognition of inspection and testing results in accordance with the principle of "taking the guarantee of quality and safety as the bottom line, quality control as the premise, reducing the burden on patients as the guidance, meeting the needs of diagnosis and treatment as the foundation, and judgment of the consulting physician as the standard".

3.3 Needs of the times

The emergence of the regional medical laboratory center is the reality of the reform and development of China's medical services, with its special practical background and the needs of the times, and it is a useful supplement to and improvement of China's primary healthcare services.

The high-quality medical resources in China are insufficient in quantity, unreasonable in resource allocation structure and uneven in geographic distribution. According to the 2021 China's healthcare development statistical bulletin, the number of visits to primary medical institutions accounted for 50.2% of the total number of visits to medical institutions in China. However, most high-quality healthcare resources are concentrated in grade A tertiary hospitals in large and medium-sized cities. With the continuous growth of Chinese residents' demand for high-quality medical services, primary medical institutions are facing great challenges in meeting the diversified diagnosis and treatment needs and health management demands of the public. Therefore, optimizing the distribution of medical resources and upgrading the capacity of primary healthcare services have become important tasks in the reform of China's medical system.

The service capacity of primary medical institutions in China cannot meet the public demands. First of all, the hardware resources of primary medical institutions are limited. The room of development for clinical laboratory department in primary medical institutions is limited. The simple equipment and few testing items lead to low service quality and capacity. Medical institutions at all levels have great demands for new testing items to provide accurate, fast, and high-quality medical testing services. Second, primary healthcare institutions fail to form an effective homogenized, synchronized, and consistent management. The primary healthcare institutions are backward in application of information technology and digital

technology, the testing information cannot be shared within the region, there is no unified quality control standards, and timeliness and uniformity of test reports cannot be guaranteed. Finally, the clinical service capacity of primary healthcare institutions is very limited. Clinical laboratory departments in primary healthcare institutions lack awareness to support the clinical services, the new testing technologies and methods emerge one after another, clinical promotion and training is generally insufficient, and clinicians fail to form a clear understanding of the new technologies or new testing items. Therefore, the testing quality cannot be effectively controlled, resulting in clinical risk.

At present, the primary healthcare institutions generally face problems such as failure to meet clinical needs, backward equipment, lack of quality management system, lack of laboratory information system, and inadequate professional quality of the testing personnel. In addition, the medical testing instruments and methodology of the primary healthcare institutions are different, and the quality control standards are different, so it is difficult to achieve mutual recognition of test results, and repeated testing cannot be avoided.

Multiple factors have led to the shortage of health professionals. Unreasonable staff structure among regional medical institutions has led to inefficiency and shortage of personnel in primary hospitals. Community health centers have a large number of contracted personnel, all of whom are dispatched through the purchase of services by a third party, with low wages and high mobility, which is not conducive to business development and talent cultivation, and also leads to internal instability because of different pay for the same post due to differences in status. The lack of flexibility in adjusting the recruitment requirements has led to a long-term shortage of professional and technical personnel, as well as frustration of the sense of belonging and enthusiasm for the contracted employees, which has seriously impeded the long-term development of community health centers. There is insufficient room for the growth of talents, with few job posts for those with intermediate and senior professional titles. The mechanism for personnel training is imperfect, and the technical and management level is yet to be improved. Medical staff in district healthcare institutions cannot be exchanged to community health service centers due to different natures of public institutions and different ways of financial subsidies, so the community health service centers are limited in recruitment and training of reserve talents.

Regional medical laboratory centers play a key role in this context by integrating and optimizing the existing medical testing resources, and constructing a unified testing technology system, information management system, and strict quality control standards, aiming to achieve the standardization of testing services and mutual recognition of results among different

medical institutions, thus effectively enhancing the overall diagnosis and treatment level of primary medical institutions and strongly promoting the implementation of hierarchical diagnosis and treatment system in China (Chen et al., 2021).

3.4 Typical models

Regional medical laboratory centers are established based on the allocation of medical resources and testing needs of the local areas, with a variety of development models. The common core of the development is the laboratory construction and management, test samples and test information transmission mode. In the regional medical laboratory center, generally the institutions with sufficient and advanced testing equipment are treated as the regional medical testing center laboratory, such as regional "leading" hospitals or third-party independent medical testing laboratories. The rest of the medical institutions in the regional medical laboratory center transport the test samples through the cold chain to the regional medical testing center laboratory, the test reports will be transmitted back to the medical institutions through the network after the tests are completed.

Development of China's regional medical laboratory centers are mainly based on the following models: (1) Regional medical laboratory center established on the basis of the laboratory departments of large general hospitals in the region, such as the Shanghai Songjiang model. This model makes full use of the technical and resource advantages of large hospitals' laboratory departments, expanding them into testing service centers that serve a larger region; (2) Regional medical laboratory center with independent legal person status established in the region, such as Jiangsu Changshu model and Shenzhen Luohu model. These centers operate independently and provide medical testing services through a centralized and specialized approach; (3) Regional medical laboratory center built through direct participation of independent medical laboratories in medical alliances, such as KingMed Diagnostics, Dian Diagnostics, Adicon, Daan Gene, and Shanghai Topgen Biopharm Topgen. Through cooperation with medical institutions at all levels, they provide efficient and high-quality testing services; (4) Regional medical laboratory center jointly built by independent medical laboratories and regional leading hospitals or professional organizations, such as Guangdong Qingyuan model and Hunan Zhuzhou model. This model leverages the complementary strengths of both parties to achieve resource sharing and synergistic development; (5) Regional medical laboratory centers jointly built by in vitro diagnostics companies and regional leading hospitals, such as Autobio, MedicalSystem Biotechnology, and Hybribio. This model improves the overall service level and efficiency by integrating the R&D, manufacturing and testing

services of in vitro diagnostic products; (6) Regional medical laboratory centers jointly built by professional construction companies for regional medical laboratory center and regional leading hospitals, such as Xrun Medical (Henan Lingbao model and Hubei Jingshan model). This model combines the advanced management experience of specialized companies and the rich clinical resources of hospitals to create a high-quality regional medical testing service platform (Chen et al., 2021).

(1) Shanghai Songjiang model: Shanghai Songjiang District Regional Clinical Laboratory Center was established in November 2011 under the overall planning of the Health Bureau. The operation mode of the center is unique. Through collaboration with the Health Bureau platform, 18 community healthcare institutions in the district send the test specimens other than the three routine items to the center through cooperation with professional private logistics companies for centralized testing. The testing center has eight specialized testing units, including an emergency room, a clinical testing room, a biochemical and immunological room, a cellular room, a PCR room, a bacterial room, a tuberculosis testing room, and an infectious disease testing room. The center mainly relies on the strong technical support from the Department of Laboratory Medicine of Songjiang District Central Hospital, and is responsible for the testing and inspection tasks of community healthcare centers (other than the three major routine testing items) and some secondary hospitals in the region. In the process of operation, the testing center adopts a centralized testing mode and closely relies on information technology means to realize the functions of automated collection, transmission, processing and storage of specimen information and testing information among different medical units, as well as the two-way identification and interactive work of testing instruments, thus improving the testing efficiency and service quality.

(2) Shenzhen Luohu model: the Luohu Hospital Group Medical Laboratory Center is in charge of the medical laboratory of the Shenzhen Luohu Hospital Group as well as the Luohu Port Medical Laboratory of Shenzhen Luohu Hospital Group, covering an area of more than 8,000 square meters. Luohu Hospital Group Medical Laboratory Center consists of 5 hospitals and 43 community health centers, and the daily testing and transportation tasks are complicated. Among them, Luohu District People's Hospital, Luohu District Maternal and Child Health Hospital, and Luohu District Hospital of Traditional Chinese Medicine have a large number of test samples and test tube preparations that need to be transported to the Medical Laboratory Center of Luohu Hospital Group for testing. Luohu Hospital Group Medical Laboratory Center offers a wide range of tests covering clinical hematology, clinical fluid, clinical immunology, clinical biochemistry, clinical microbiology, clinical molecular biology and clinical

cytogenetics, totaling more than 1,000 items. As a large-scale, comprehensive and modern regional medical testing center, the center is not only committed to providing comprehensive clinical testing services, but also plays an important role in transformation and application of scientific research, and teaching results. It is worth mentioning that the center is one of the first laboratories authorized to carry out COVID-19 nucleic acid testing in Shenzhen, and its total volume of nucleic acid tests among public medical institutions in Guangdong is among the highest, of which the highest testing volume in a single day exceeded 1 million, showing a very high level of testing capacity and emergency response.

(3) KingMed model: Guangzhou Conghua District Health Bureau actively promotes the development of Conghua Medical Laboratory Alliance and views the Conghua KingMed Medical Laboratory Center as a regional medical testing center hub. The Conghua Medical Laboratory Alliance is established with the Conghua KingMed Laboratory Center as the core, and 3 grade A secondary hospitals, 4 community health service centers and 8 township health centers as the members. This initiative aims to make full use of the existing medical testing and diagnostic resources in Conghua, achieve vertical integration of resources in public healthcare institutions at the city and district levels, and gradually achieve the sharing of testing resources within the alliance, thereby enhancing the testing and diagnostic level and efficiency of the entire region, and better serving the inter-hospital collaborative services such as hierarchical diagnosis and treatment and referral appointments. In addition, the Health Bureau has also established a cooperation mechanism for inspection and diagnosis between medical institutions in the region and third-party independent medical laboratories (such as KingMed) through the introduction of a commissioned testing model. In this way, residents in the region can make appointments or receive medical testing services of the same level as those of high-level hospitals at primary healthcare institutions, which strongly promotes the implementation of the hierarchical diagnosis and treatment policy and facilitates the mutual recognition of the testing results.

(4) “West China Model” (West China Laboratory Discipline Alliance): West China Laboratory Discipline Alliance is a cross-regional collaborative organization initiated by West China Medical Alliance and established by the Department of Laboratory Medicine of West China Hospital. The alliance adheres to the principle of “open and dynamic” cooperation, and builds an alliance operation system featuring “resource integration and result sharing” with extensive coverage through integration of “online” remote collaboration and “on-site” field interaction. At present, the alliance has absorbed more than 300 medical institutions from Sichuan, Chongqing, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Guangxi, Xinjiang and Tibet

in 10 provinces and municipalities. A cross-regional and cross-level network of the West China Laboratory Medicine Alliance has been established, aiming to improve the overall level of medical technology, and promote academic exchanges and common development among disciplines.

(5) Ma'anshan model: The Clinical Laboratory Center of Ma'anshan Municipal Medical Group is a product of the integration and formation of the Laboratory Departments of the Group's medical branches, which include the Municipal People's Hospital, the Maternal and Child Health Hospital, the Municipal Hospital of Traditional Chinese Medicine and the Municipal Hospital of Infectious Diseases. The Ma'anshan Regional Clinical Laboratory Center relies on the regional collaborative medical platform for clinical testing centers set up by the Group to build its digital service network. The center consists of six professional departments, including clinical examination room, biochemistry room, immunity room, bacteriology room, PCR room and tuberculosis testing room, and they are fully responsible for all the clinical testing tasks of all the medical branches in the Group and shoulder the tasks of scientific research and teaching. In addition, the center's service radiation is not only limited to the group, but also covers the medical institutions in the whole city and the surrounding areas. It provides a full range of clinical testing services and technical support, which effectively promotes the sharing of medical resources and cooperation within the region, and improves the overall quality and efficiency of medical services.

(6) Xrun medical model: Founded in May 2017, Shanghai Xrun is a professional regional medical testing center construction company, and its main business is to provide regional medical testing center construction program for the medical community, medical consortium or medical group and other regional leading hospitals. Its services include construction programs of regional medical testing information platform, regional biological samples logistics system, regional test operation management system, and the central lab platform supply chain. Shanghai Xrun has assisted in the construction of three regional medical testing centers, including Hubei Jingshan model, Yunnan Anning model and Henan Lingbao model.

The development of clinical medical laboratory centers in China is in the initial and developmental stage, and the construction and application of such centers in many regions are not yet mature enough. Most of the existing successful clinical testing centers are operated under a service model combining government guidance and private capital participation. These regional clinical medical testing centers are generally equipped with specialized departments such as emergency rooms, biochemistry and immunology rooms, cellular rooms, PCR laboratories, bacteriology rooms, tuberculosis laboratories, and infectious disease laboratories,

so as to provide comprehensive testing services. On the basis of information technology and project transformation as a strong support, the regional clinical medical laboratory centers actively promote the standardized integration and construction of health service centers in the region, and effectively realize the optimal allocation of health resources. In this way, the laboratory centers can better reduce the ineffective consumption and waste of medical resources, improve the overall effectiveness of medical services, and provide patients with more convenient and efficient medical services. In addition, it also brings a synergistic effect to the medical institutions within the region, which is conducive to promoting the implementation of the hierarchical diagnosis and treatment system and the balanced development of the healthcare industry (He et al., 2020).

3.5 Construction goal

The construction of regional medical laboratory centers is aimed at integrating or introducing high-quality testing resources, enhancing the level of regional medical testing, optimizing the allocation of medical resources, improving efficiency, reducing costs, improving the testing level in the grassroots level, facilitating the hierarchical diagnosis and treatment, establishing a database platform, and accelerating the clinical application of high-tech testing items.

(1) Integrate or introduce high-quality testing resources to enhance the level of regional medical testing

In the planning and construction of the regional medical laboratory centers, they focus on a comprehensive and scientific integration in the distribution of testing resources within the region. Based on the existing medical resources in the region and its future development plan, the center will sort out, optimize and supplement the key resources of medical institutions at all levels such as testing items, testing equipment and testing personnel, and strive to maximize the utilization of regional medical resource endowment, so as to prevent unnecessary overlap and waste of resources. Through such integration and planning, the regional medical laboratory centers aim to achieve efficiency, specialization and standardization of testing services in the region. It can not only enhance the quality and efficiency of testing, but also reduce healthcare costs through resource sharing and optimal allocation, promote the overall level of healthcare services in the region, and help to achieve hierarchical diagnosis and treatment and fair distribution of healthcare resources. In the implementation of hierarchical diagnosis and treatment and development of regional medical capacity, the regional medical laboratory center has professional talents, advanced equipment, comprehensive testing items, and strong laboratory management capabilities, which can promote the sinking of high-quality medical

resources to the grassroots level. In addition to providing accurate, fast and high-quality medical testing services, it can further promote the realization of the unified test quality standards within the region, thereby enhancing the regional medical testing service level, promoting the level of clinical diagnosis and treatment in the region, and effectively alleviating the problem of difficult and expensive access to medical services (Shen et al., 2019).

Regional medical laboratory centers play an important role in optimizing the allocation of medical resources, which can help build an information-based collaborative network between medical laboratories at all levels to achieve immediate sharing and interaction of information. By gathering and sharing the excellent expert team resources of regional medical testing centers, the overall testing technology standard and service effectiveness in the region can be rapidly improved. It is necessary to build an information network covering the laboratories of medical institutions in the region, establish a regional testing center synergistic platform, connect the existing medical laboratory testing instruments in each community health institution to the platform, and centralize the tests with higher costs and poorer timeliness, so that the testing costs can be effectively reduced and the cycle of the test report can be greatly improved. Ultimately, the sharing of testing data and testing instruments throughout the region can be realized.

(2) Optimize the allocation of medical resources, improve efficiency and reduce costs

The implementation of uniform quality standards and operational norms in a particular region can lead to mutual recognition and exchange of test results between different medical institutions in the region, thus effectively avoiding patients being forced to repeat the same test items due to referrals and other reasons. It not only saves the patient's medical costs, but also reduces the burden on the health insurance fund, thereby reducing the pressure on individual medical expenditure and government health insurance spending. The key to achieving this goal lies in the establishment of a unified quality management system, which in turn needs to ensure the standardization and homogenization of testing equipment, reagents, laboratory information systems and the operation of testing personnel within the region.

Through centralized procurement and uniform distribution of testing equipment and reagents, regional medical laboratory centers have greatly reduced their operating costs. In addition, the integration and optimization of testing resources in the region helps avoid redundant acquisition of testing instruments and duplication of settings. Generally speaking, a large-scale regional medical laboratory center can include multiple medical laboratories, and under the premise of ensuring the basic needs of social public services, they pay close attention to the actual clinical diagnosis and treatment needs of medical institutions at all levels in the

region, and with the help of modern information technology, they can build up a modernized clinical laboratory network system covering diversified testing items, highlighting the professional advantages and realizing intelligent management (Shen et al., 2019).

(3) Prioritize resources to the grassroots level, improve the level of grassroots testing, and facilitate implementation of hierarchical diagnosis and treatment

In China, the service capacity of community health service centers is generally insufficient, the testing and diagnostic equipment is generally outdated, and the technical personnel are also in short supply. In order to improve this situation, the regional laboratory centers are established to cover all laboratories within the region. The integrated management and implementation of unified test quality standards and operating procedures can ensure that the testing quality of the grassroots laboratories and regional medical laboratory centers are consistent. Through access to the regional laboratory information system, primary medical institutions can share all the test items of the regional medical laboratory center, so that patients do not need to go to a higher level of hospitals, and can enjoy comprehensive, advanced, and high-standard medical testing services in the community healthcare institutions. Through the strengthening of grassroots testing capacity, we can gradually improve the overall level of medical care, promote the prioritized allocation of high-quality medical resources to the grassroots level, and effectively support the implementation of the hierarchical diagnosis and treatment system. The overall improvement of the testing level within the region can bring multiple benefits as follows.

For patients, if the test results between medical institutions in the region can realize mutual recognition, which means that patients can retrieve and print their test results in any tertiary hospital within the regional medical laboratory center system, even if they receive tests in a community medical institution. The unified management and sharing of test results data greatly helps the residents in their demands for referral between different levels of healthcare institutions. In addition to ensuring that patients can enjoy the convenience and consistency in receiving continuous treatment, it also helps effectively avoid the additional medical costs associated with repeated testing. Furthermore, in terms of testing items for which primary medical institutions temporarily do not have the testing capacity, the collected clinical specimens can be sent to the central laboratory for testing, and patients can view the test reports in real time through mobile devices, which significantly improves the medical experience.

In promoting the sinking of high-quality medical resources to the grassroots level, when the doctors of tertiary hospitals offer treatment in the grass-roots clinics, thanks to the complete facilities and equipment of the regional medical laboratory centers and the quality management system, they can accurately prescribe the test items in line with the actual needs of the patients,

which not only facilitates the patients, but also provides the doctors with a fast, accurate evidence-based medical basis, so that the effectiveness of the high-quality healthcare resources can be maximized.

From the macro healthcare system and long-term development point of view, the sinking of high-quality testing resources to the community level means that patients can enjoy testing services equivalent to the level of services offered in tertiary hospitals in their neighborhoods, which has undoubtedly greatly enhanced the convenience of medical care, and effectively alleviated the pressure on the tertiary hospitals. With the improvement of the medical technology in community health centers, although the average cost of patients receiving treatment in the community did not increase, the average gross profit of community health centers has increased, thus promoting the healthy development and optimization and upgrading of the entire health care service system (Liu et al., 2012). As a result, the outpatient pressure of tertiary medical institutions has been alleviated. This is of great significance in promoting the long-term and healthy development of China's medical and healthcare industry and safeguarding and improving people's livelihood.

(4) Establish a database platform to accelerate the clinical application of high-tech testing items

With the continuous progress of science and technology, cutting-edge testing technologies, such as genetic testing and special protein testing, have emerged and have been playing a crucial role in the diagnosis, treatment and prevention of diseases, especially in the field of personalized diagnosis and treatment of genetic and metabolic disorders and tumors. However, limited by the number of clinical cases, investment in medical equipment and professional and technical personnel, even large medical institutions often found it difficult to fully carry out or widely apply such high-end testing programs. The emergence of regional medical laboratory centers is a good solution to this problem. With its large-scale specimen testing and processing capabilities, regional medical laboratory centers can cover the patient samples of many different hospitals in the region, and have the ability to build up an advanced testing platform and a large-capacity information database correspondingly. With the basis of the database and the advantages of the team of professional laboratory experts, the regional medical laboratory centers can establish close cooperation mechanisms with universities and medical institutions at all levels, which can ensure the continued and stable development of high-tech projects, and promote the extensive application of high-end testing programs in clinical practice.

This will not only help solve the diagnosis and treatment of difficult diseases, enhance the academic level of the discipline and promote the overall development of the discipline, but also

strongly improve the level of clinical diagnosis and treatment services at all levels of hospitals, so that more patients can enjoy the latest and most advanced testing technology services in their neighborhoods, which effectively promotes the equity and accessibility of the regional medical services (He et al., 2020).

3.6 Problems and challenges

Although regional medical laboratory centers have entered a period of rapid development, and the government has also introduced a number of favorable policies to encourage the establishment and development of regional medical centers, as an emerging thing, regional medical laboratory centers still face many problems and challenges, which restricts the full play of the service potential, and reduces the quality of the services provided by the regional medical laboratory centers in the current stage (Shen et al., 2019).

There are increasing risks such as the conflict of business operation benefits between regional medical laboratory centers and medical institutions. The establishment of regional medical laboratory centers is conducive to the integration of medical resources, but it also means that the testing business of each medical institution is subject to a certain degree of impact, which is not only reflected in the staff positions, but also in the hospital's own business income. The establishment of regional medical laboratory centers means that the hospital laboratory needs to be separated from the hospital to become an independent legal entity, and it means that the financial income and expenditure of the laboratory department must be separated with that of the hospital. Laboratory departments occupy a pivotal position in the financial revenue of hospitals, and their income is critical to maintenance of hospital operation. The loss of this part of income is likely to cause financial strain of the hospital and may affect the normal operation of the hospital. In particular, as hospitals are public institutions whose funding is in the form of balance allocation, they are responsible for their own profits or losses. If they lose the laboratory revenue, and the government does not give corresponding financial subsidies to the hospitals, they will face serious financial distress. In this case, without relevant supporting policies, the hospitals are not willing to allow the laboratories to be independent and become an independent legal entity. Unless there is a corresponding compensation mechanism or laboratory department can still create revenue for the hospital even after independence, otherwise, hospitals will not easily give up the management and control of the laboratory departments. Therefore, the premise of smooth operation is the decentralization of regional medical institutions, and it is also necessary for relevant departments to introduce relevant supporting policies to solve the collaborative relationship and reasonable distribution of

benefits between regional medical institutions and regional medical laboratory center (He et al., 2020).

Communication problems between regional medical laboratory centers and hospitals are a major challenge in medical testing services. Effective communication and collaboration is a key aspect of ensuring the quality of testing. Especially when there are problems with test quality or when patients complain about the quality of service, close information exchange and definition of responsibilities must be carried out between the laboratory department and the clinical departments. However, after the establishment of an independent regional medical laboratory center, as it is no longer directly under a hospital, it is possible to form a pattern of independent operation, resulting in the phenomenon of poor information flow and weakened willingness to communicate between the laboratory centers and each hospital.

On the one hand, the regional medical laboratory centers may not be willing to invest excessive resources to strengthen the daily communication with the hospitals due to operational independence. As a result, clinicians may be unable to get timely feedback on test results, problems in the testing process may not be resolved in a timely manner, and there lacks professional participation of testing personnel in the interpretation of test results and discussion of difficult cases. On the other hand, the physical distance between the laboratory centers and the hospitals may also hinder face-to-face communication and coordination meetings, lectures and other activities. For example, the staff of the testing center may not be convenient to participate in the on-site consultation or difficult case discussion of the clinical departments, and it is also not convenient to carry out the training on testing-related training on the clinicians, including the latest information on testing technology, guidance of clinical application of testing programs, as well as standardized training on specimen collection and transportation.

Therefore, in order to overcome these problems, it is necessary to establish and improve the long-term communication mechanism between regional medical laboratory centers and hospitals, share testing information through the technology platform, regularly organize joint meetings and training courses to ensure seamless integration between testing services and clinical diagnosis and treatment, so that the laboratory centers and hospitals can work together to improve the quality of medical services and patient satisfaction. In addition, we also need policy support and guidance to promote the in-depth integration and cooperation between regional medical laboratory centers and medical institutions (Ma et al., 2017).

There lacks standardized unified management mode. Regional medical laboratory centers started late in China, with backward development quality and lack of standardized management mode and access standards. Phenomena such as product homogenization and low-price

competition still exist to a certain extent. The development of small and medium-sized organizations is constrained to a certain extent by the market dominance and brand effect of leading organizations, and the impact of newcomer forces on the original market layout should also be noted under the new policy environment such as “Internet +” (Li, 2021).

The difficulty of pre-test sample quality control has increased. Before the test specimens of each medical institution are sent to the regional medical laboratory center, they need to go through a number of newly added processes such as collection, pre-treatment, transportation and storage, and the accuracy of the results will be affected to a certain extent. The quality control in each link has become one of the important factors in the implementation of mutual recognition of medical testing. If the quality control of each link is not adequately safeguarded, factors such as increasing links and contaminated specimen will lead to an increase in the error rate and reduction of the accuracy of the test results. In addition, apart from providing technical support for laboratory testing for large medical institutions in the surrounding area, regional medical laboratory centers also need to focus on serving the primary medical institutions, especially those grassroots healthcare institutions in remote areas with inconvenient transportation. These institutions often face the problem of small specimen volume and long transportation time. The limited number of specimens transported at one time and the long distance not only increase the difficulty of transportation, but also significantly raise the transportation cost. More importantly, the long-time specimen transportation may cause the test results to suffer from non-negligible influences, which may lead to declining accuracy of the test results, and may even damage the authority of the test results and reduce public trust.

Because of its high dependence on advanced technology and capital, the medical testing industry needs to reach a certain scale before giving full play to the economies of scale, and it has strict and high requirements on capital investment and professional talents. Non-chain, small-scale independent testing centers are often difficult to attract sufficient talent and medical resources due to insufficient size and lack of economies of scale, which limits their progress in product innovation, technological upgrading and ability to provide comprehensive clinical services. Laboratory centers established under the guidance of leading hospitals have a solid foundation in terms of expertise, but they may encounter bottlenecks in terms of service drive and the breadth and depth of regional operations when their functions extend from serving only their own hospitals internally to serving a number of medical institutions in the surrounding area. The laboratory centers focusing on a particular specialty area may have strong professional testing capabilities in a particular area, but due to the relatively narrow coverage of the specialty, they may be unable to provide comprehensive clinical testing services and cannot meet the

diverse clinical needs. Therefore, in the construction and development of regional medical laboratory centers, it is necessary to not only focus on economies of scale and resource integration, but also take into account the balanced development of specialty expertise and comprehensive service capabilities. In terms of the core competitive elements of talent, whether the laboratory centers can attract reserve of outstanding professionals and build a talent echelon is also an important factor affecting its ability to sustain healthy development.

3.7 Chapter summary

This chapter first explores the current development of regional medical laboratory centers from a macro point of view, and then further focuses on the research object of this study - LW Regional Medical Laboratory Center, to introduce its overall situation, so that readers have an intuitive cognition of the regional medical laboratory center, which is an emerging thing with Chinese characteristics. In the background of insufficient supply of testing services in grassroots healthcare institutions in China and unreasonable structure of testing resources, the government attempts to establish regional medical laboratory centers to integrate high-quality testing resources, optimize medical resource allocation, improve efficiency, improve the level of grassroots testing, facilitate the hierarchical diagnosis and treatment, and accelerate the clinical application of the high-tech testing items. On the whole, China's regional medical laboratory centers are entering a period of rapid development. Thanks to the strong support of national policy, the regional medical laboratory centers have presented good market expectations and great potential. The market presents a trend of "The strong keep getting stronger, while the weak keep getting weaker", but there is still a large gap between the regional medical laboratory centers in China and their foreign counterparts. The regional medical laboratory centers in China at this stage are also facing a number of problems and challenges such as lack of standardized unified management model, existence of uncontrollable factors in sample turnover efficiency, increasing difficulty of pre-test sample quality control, increasing risk of conflict of interests between regional medical laboratory centers and healthcare institutions, product homogenization, and low-price competition, and the level of service quality is still constrained.

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Chapter 4: Evolution of the Service Capacity of Regional Medical Laboratory Centers from the Perspective of Dynamic Capabilities

4.1 Research design

The case study method is used to deconstruct and analyze how the LW Regional Medical Laboratory Center improves its service quality through the development of dynamic capabilities, and there are several reasons for it. First, the issue of how the regional medical laboratory center improves its service quality through the development of dynamic capabilities is a typical qualitative research question, and the case study method is the most suitable to answer the question. The case study method presents unique advantages in exploring complex, qualitative research questions such as “why is it so”, “why does it happen” and “how to realize the goal”, and it can provide a detailed, three-dimensional description and analysis of the research topic. Second, case study has a natural advantage in presenting the characteristics of the development and evolution process of things, which can profoundly explore and demonstrate the dynamics and completeness of the change process. The purpose of this research is to explore how regional medical laboratory centers improve their service quality from the perspective of dynamic capabilities, and unravel the intrinsic link between dynamic capability improvement and service quality enhancement. However, unfortunately, there has been inadequate exploration of this relationship in the existing literature. Therefore, the case study method is chosen for exploratory analysis, which can reveal the micro-operating mechanism of this process with the help of extensive and detailed case materials and data, so as to get a more in-depth understanding and knowledge of this research topic.

4.1.1 Selection of the case

In this study, we choose LW Regional Medical Laboratory Center as the case to study how regional medical laboratory centers can improve service quality through the development of dynamic capabilities. The case is selected for the following considerations. First, the principle of representativeness. As an industry leader, LW Regional Medical Laboratory Center occupies a leading position in the medical testing industry and has been actively promoting its own service-oriented transformation strategy. It has achieved a high market growth rate and return

on assets through superior service innovation and sustained market acumen, which makes it a typical example of the service transformation development model in its industry. The in-depth study of LW Regional Medical Laboratory Center, especially the analysis of its service quality improvement strategy and practical experience, will undoubtedly offer significant implications and reference for other regional medical laboratory centers of the same type. Second, the principle of data availability. The author has been working in LW Regional Medical Laboratory Center for a long time, and have access to a large amount of internal information about the case.

4.1.2 Data collection

This study has adopted diversified means to collect data, mainly including: semi-structured interview, field investigation, and collation and generalization of secondary data.

(1) Field observation and semi-structured interview. The author conducted field investigation and in-depth interviews in the LW Regional Medical Laboratory Center in September 2023. First, the author went to the actual operating environment of LW Regional Medical Laboratory Center to investigate its testing process, equipment configuration, personnel operation standard, and customer service process, which is a way to visualize and record its specific measures and actual effects in service quality improvement. Second, by designing a set of targeted semi-structured interview outlines, in-depth conversations were held with relevant directors, staff, representatives of cooperating medical institutions and beneficiary patients of the LW Regional Medical Laboratory Center, so as to obtain first-hand information on their experiences, strategies, challenges and solutions in the process of service quality improvement. The interviews and discussions lasted two to three hours.

(2) Secondary data collection. By reviewing the annual reports, development strategy plans, quality management documents, research results releases, media reports and other relevant information of LW Regional Medical Laboratory Center over the years, combined with external literature such as industry reports, policies and regulations, and academic articles, we gained a comprehensive understanding of the center’s history of development, the background, process, and influencing factors of service quality improvement. This multi-level and multi-source information collection method not only allows for cross-validation of the information obtained from the semi-structured interviews to ensure the reliability of the data, but also effectively controls and calibrates possible recall bias or subjective misunderstandings. By combining actual field observations with historical records and objective data from secondary sources, a research strategy of triangulated validation was developed, which is essential to enhance the

authenticity and credibility of the findings of this study. This approach ensures a more comprehensive and accurate analysis of the service quality improvement mechanism of the LW Regional Medical Laboratory Center, thus providing more instructive practical experience and theoretical basis for other regional medical laboratory centers.

(3) Establishment of a case database to enhance research reliability. During the establishment of the case database, we collected a series of extensive and detailed information, covering handwritten summaries of case interviews, detailed interview records, various forms of audio and video materials, as well as various types of written documents obtained in the field investigation. Before conducting each in-depth interview, we would get an in-depth understanding of the basic situation of the case company from relevant official websites and other information channels, and the information includes the competitive situation of the industry in which it is located, the characteristics of its products, the characteristics of its customer composition and demand, and the content and characteristics of its service business, so as to determine the core focus of the interviews. During the interview, with the consent of the interviewee, we recorded the entire interview process to ensure the complete recording of information. After the interview, all data entry would be completed within 24 hours and the interview recordings were transcribed to texts. Meanwhile, for certain key data, we double-checked and confirmed with the interviewees to ensure the accuracy of the data. All collected data were systematically filed into the database to form a complete case database resource for subsequent in-depth analysis and research.

(4) Structured analysis of case data is carried out to establish a chain of evidence. During the research, the principal task is to ensure the authenticity and objectivity of the collected data, so that the researcher will not be constrained by the pre-set theoretical framework and produce a misinterpretation of the actual situation. In order to ensure the traceability of the data, each piece of data in the case database is recorded in detail with information such as its source, collection process, time and place. In the process of data summarization, if contradictions or inconsistencies are found in data from different sources, this study follows the principle of subordinating second-hand data to first-hand data, and takes the initiative to re-communicate and verify the disputed or ambiguous data with the relevant interviewees or contacts of the case companies, so as to amend, supplement and improve the data accordingly. Through the strict implementation of the above data processing norms, this study was able to build a solid foundation consisting of multiple chains of evidence, which ensures that the in-depth analysis of the mechanism of service quality improvement in the LW Regional Medical Laboratory Center has solid empirical support and rigorous scientificity.

4.2 Overview of the case

4.2.1 Background of establishment

LW Regional Medical Laboratory Center is located in Liwan district of Guangzhou, Guangdong Province, and its establishment is based on the fact that there are huge demands for primary healthcare testing services in Liwan district, but the service capacity of primary healthcare institutions is insufficient. Liwan district is the downtown area of Guangzhou, and a core functional area of an important metropolis in China. According to the seventh national census, the permanent population is 1,238,300, of which 169,200 are aged 65 and above. There are five secondary and tertiary public hospitals in the district, with a total business revenue of 834 million yuan, and a cumulative laboratory revenue of 87.433 million yuan, accounting for 10.5% of the total revenue. Among the five hospitals, the revenue of the laboratory department of the stomatological hospital is only 62,600 yuan. There are 19 community health service centers in the district, and their basic data are as follows. The total business revenue is 263 million yuan, and the average business revenue is 23.86 million yuan. The cumulative laboratory revenue is 7.1182 million yuan, and the average revenue is 634,200 yuan. The average percentage of laboratory revenue is 2.7%, which is significantly low. However, the comprehensive cost of the laboratory department accounts for 159% of its revenue, which means it cannot make ends meet. In terms of pathological examination, only the Central Hospital and the People's Hospital have pathology departments, and the business carried out is limited to cytopathology and routine histopathology. The cumulative revenue from pathology business in the whole district in 2019 was 3.8282 million yuan, of which 3.56 million yuan is contributed by the Central Hospital, and the rest 5 hospitals only contribute 265,200 yuan, indicating that their pathological capability is extremely weak.

In addition, medical institutions in Liwan district also have outstanding problems as follows. The personnel structure among regional medical institutions is unreasonable, resulting in low efficiency and shortage of personnel in primary hospitals. The performance distribution of personnel in secondary hospitals and community medical institutions is unreasonable, and there lacks a sound and effective performance appraisal mechanism, failing to adhering to the principle of more pay for more work and generous pay for outstanding work. The test results are not uniform, and cannot be mutually recognized. Quality of private healthcare institutions is uneven, and the level of medical technology is relatively low.There lacks training on new testing technologies as well as clinical promotion of new programs. For example, the laboratory

department of the People's Hospital severely lacks awareness to support clinical services, so that the clinical department carries out POCT by itself, and the quality cannot be effectively controlled, resulting in clinical risk. The limited space of the laboratory department exerts a great limitation on its development, as the needs for the increase of clinical laboratory items cannot be met. The clinicians do not have clear understanding of the new technology and new items, and they need more academic training and communication platforms.

In order to further deepen the reform of the medical and health system in Liwan District, improve the service efficiency of medical resources in the district, and promote the sinking of high-quality medical resources, in accordance with *Law of the People's Republic of China on the Promotion of Basic Medical Care*, *Hygiene and Health, Guangdong Provincial Implementation Plan for Promoting the Development of Socially-run Medical Services*, and *Circular on Issuing the Implementation Plan of Guangzhou to Support Social Capital to Provide Multi-level and Diverse Medical Services to Promote the Development of Socially-run Medical Services*, Liwan District firmly implements the *Work Plan for Promoting the Integrated Innovation and Development of Regional Inspection and Testing Services in Liwan District*, and gives full play to the government's role in macro-control and the market's role in resource allocation. The Liwan district government works together with Shanghai Labway Clinical Laboratory to establish a regional medical laboratory center, aiming to optimize the allocation of medical resources such as regional laboratory, realize the overall improvement of regional medical service capabilities, ensure medical quality and safety, and provide residents with better and more convenient medical and health services. By introducing advanced service concepts and giving full play to the advantages of intensification, scale and specialization, District Liwan is exploring the regional medical inspection model to comprehensively improve the inspection service capabilities of medical institutions in District Liwan, thereby promoting the rapid development of the health service industry, building and developing professional regional medical laboratory centers with advanced international science and technology and quality management system. With the help of the confirmation of such core service concepts as precision medicine center, public health center, and scientific research training center, District Liwan is expected to systematically improve its core values in the development of key disciplines, the level of precision medicine, and the service capacity for scientific research and public health response, thus deepening the medical reform in the region eventually.

4.2.2 Development history

LW Regional Medical Laboratory Center is a holding subsidiary of Shanghai Labway Clinical Laboratory Co., Ltd. Located in Liwan district of GZ and founded in 2021, it is a high-tech service enterprise with medical testing and pathologic diagnosis services as the core business. In line with the direction of national medical reform, the establishment of LW Regional Medical Laboratory Center facilitates the medical reform within the region, and is designed to enhance the service effectiveness of the medical resources within the region and promote the sinking of high-quality medical resources to the grassroots level. With the platform advantages of the medical laboratory center and pathology diagnostic center, LW Regional Medical Laboratory Center adopts a business model that integrates third-party medical diagnostic services and in vitro diagnostic product sales, aiming at empowering the medical technology departments such as laboratory department, pathology department and central laboratory within hospitals, through which it can effectively help these medical technology laboratories reduce daily operation costs, avoid operation risks and improve the medical service quality and technology.

Ever since its establishment, Shanghai Labway Clinical Laboratory has been focusing on the field of testing services. Through unremitting efforts and innovation, Labway has become a group integrating medical testing service, testing product sales and health management. At present, the business of the head office covers more than ten provinces and municipalities, with more than ten regional medical testing and pathologic diagnosis centers, forming a branded, large-scale and standardized laboratory network. With a total of more than 1,000 employees, it has a team of experts consisting of national excellent testing and pathology talents and a team of senior management talents from Hong Kong and Taiwan. In the field of medical testing and pathologic diagnosis, Labway has successively passed the ISO15189 international standard accreditation and the CAP and CMA certification.The 2022 annual report data show that the business revenue in the current period was 4.199 billion yuan, an increase of 136.14% over the same period of the previous year. The net profits belonging to shareholders of the listed company reached 617 million yuan, an increase of 202.85% over the same period of the previous year. Labway believes that through years of development, it has become a leading company in the field of medical testing and pathologic diagnosis, and completed the transformation from a “regional laboratory center” to a five-in-one regional platform featuring “test + pathology + public health + precision + training”.

4.2.3 Infrastructure

In accordance with the requirements of the international specialized quality certification system (ISO15189), as for the overall equipment configuration, LW Regional Medical Laboratory Center takes the "large-scale laboratory center configuration + differentiated terminal configuration mode" as shown in Figure 4.1. The regional laboratory center is equipped with comprehensive testing platforms covering blood clinical examination, biochemical immunity, physical and chemical molecules, microbiology, and molecular biology, and undertakes the intensive testing services of the medical institutions within the region. According to the different service targets faced in the terminals, different instruments are equipped at different terminals.

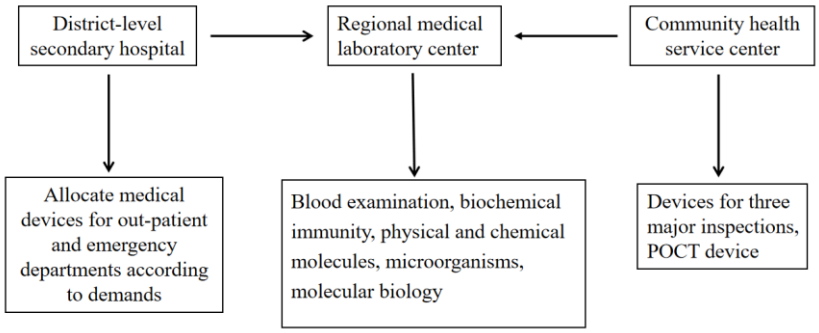

Figure 4.1 Comparison of testing service capability in different modes

(1) Laboratory

The LW Regional Medical Laboratory Center has a modern medical testing laboratory covering over 4,000 square meters. With a comprehensive and specialized testing platform, the laboratory has established a quality management system featuring suitability, adequacy and effectiveness. In addition, the LW Regional Medical Laboratory Center actively participates in the International Organization for Standardization (ISO) 15189 accreditation, which is of great significance in promoting the mutual recognition of test results in the international arena, and thus strongly promotes the scientific, normalized and standardized management of medical laboratories as well as its internationalization.

The central laboratories are staffed by professional laboratory and pathology analysts, and a team of experts in medical laboratory quality management and control have been formed to ensure the professionalism and accuracy of laboratory operation. These laboratories are equipped with a range of world-leading high-tech equipment, such as internationally renowned second-generation sequencers for gene sequencing, flow cytometers for cell sorting and analysis, fully-automated lines integrating biochemical and immunological tests, and hemocytometer lines for efficient blood cell counting and sorting. In addition, the laboratories are equipped with fully automated staining machines to optimize the staining process of tissue

sections, a state-of-the-art immunohistochemistry instrument for complex protein localization and quantitative analysis, and a telepathology diagnostic system, which supports telemedicine services and improves the efficiency and accuracy of pathology diagnosis. The presence of these top-notch facilities and professional team greatly enhances the overall technical strength and service level of the laboratory.

(2) Regional information system

The construction of the regional information system covers such components as the testing data center platform, data interaction platform, regional quality supervision platform and big data statistical analysis platform. The system is capable of comprehensively collecting, storing, exchanging, profoundly analyzing and effectively managing the test data generated by all medical and health service institutions in the region, and providing centralized test report release and resource sharing services for medical institutions at all levels, as well as real-time monitoring and accurate assessment of the quality of testing services, with the aim of guaranteeing the high efficiency and low error rate of the system operation.

Through this system, the testing information within the region can achieve seamless connection and smooth exchange, thus providing solid technical support for the extensive sharing and mutual recognition of test results. The ultimate goal is to enhance the effectiveness of medical services with the help of information technology, strengthen the quality of medical services, promote the rational use of medical resources, and lay the foundation for the integration and standardization of tests within the region.

(3) Regional logistics system

LW Regional Medical Laboratory Center establishes its own high-quality logistics team, and all the test samples are transported using a specially made transportation box. The pre-analytical conditions (such as temperature and time) are strictly controlled, which effectively guarantees the quality and safety of the samples. In addition, LW Regional Medical Laboratory Center establishes a standardized regional logistics system featuring professionalism, safety and timeliness. Strict monitoring and real-time supervision are carried out on all aspects affecting test results, such as people, machines, materials, methods, environment and measurement. International advanced quality control software is used to carry out real-time monitoring of internal quality control of each platform, and the laboratory's internal quality control situation is included in the international comparison database to ensure that the internal quality control is in line with the standard. It also participates in the capability validation program or external quality assessment of Ministry of Health and the clinical laboratory centers to ensure the accuracy of test results.

4.2.4 Service delivery capability

With an advanced laboratory quality management system, LW Regional Medical Laboratory Center strictly follows the relevant standards at home and abroad, and has a number of technical personnel with senior and intermediate professional titles. It is also the doctor's workstation for the laboratory department of Guangdong Provincial People's Hospital. It offers a full range of medical testing services to 5 secondary and tertiary public hospitals as well as 19 community health service centers in Liwan.

LW Regional Medical Laboratory Center is a comprehensive medical testing institution with complete facilities and advanced technology, which consists of several specialized departments, including Clinical Laboratory, Biochemistry, Immunology, Microbiology, Molecular Biology and Diagnostic Pathology, and is able to comprehensively cover the needs from basic to high-end medical testing. It is equipped with abundant hardware facilities, including advanced testing equipment of international and domestic first-tier brands, such as automated pre-processing to biochemistry, luminescence detection of Roche's integrated production line technology, the fully automated hematology analysis line and urinalysis workstations of Sysmex, as well as Beckman Coulter's biochemistry analyzers, Antobio's luminescence analyzers, and YHLO's luminescence analyzers and other state-of-the-art equipment. It can provide more than 1,000 kinds of precise testing services.

In addition to independently completing various testing tasks, LW Regional Medical Laboratory Center also actively responds to market demands, and provides customized laboratory solutions for small and medium-sized medical institutions and various specialized hospitals, including but not limited to laboratory department design and planning, operation and management, and routine maintenance services. It places special emphasis on enhancing the localized rapid testing capabilities of routine blood, urine and blood coagulation tests to ensure the timeliness and accuracy of test results. Based on different technical principles, testing methods and their specific applications in clinical practice, the medical diagnostic business of LW Regional Medical Laboratory Center is subdivided into seven main areas: pathological diagnosis, molecular biology testing, biochemical testing, immunological testing, microbiological testing, basic clinical testing (including clinical body fluids and blood testing), and physical and chemical testing.

4.3 Case analysis

4.3.1 Start-up stage (2021-2022)

LW Regional Medical Laboratory Center was established in 2021 when the COVID-19 epidemic was raging and the transmissibility of Delta and Omicron variants was intensifying. The management perceived the vast demand of the general public for the epidemic testing. In response to the status quo of few testing items and low testing level in the primary healthcare institutions in Liwan District, the management made the strategic decision of suspending the other testing business to fully satisfy the demands for nucleic acid testing in Liwan District. During the reporting period, the company completed a total of nearly 30 million nucleic acid tests. In order to implement the strategic decision of the decision makers that nucleic acid testing service should become the leading business, LW Regional Medical Laboratory Center has taken the following measures.

(1) Readjust the organizational structure and establish a centralized organization

In order to respond to the growing demands for nucleic acid testing, LW Regional Medical Laboratory Center has fine-tuned and improved its organizational structure by setting up a central laboratory and four laboratory departments, namely, Laboratory Department 1, Laboratory Department 2, Laboratory Department 3 and Laboratory Department 4, which are responsible for the clinical laboratory work of 5 hospitals and 19 community health centers in the region. In this organizational structure, the director of the center plays the role of the core coordinator, and holds the highest level of resource deployment authority and personnel command power to ensure that human resources can be quickly distributed and mobilized from the central laboratory and each laboratory departments in case of emergency .

In order to cope with the challenges of large-scale nucleic acid testing, the center has built up a number of professional teams, including the specimen collection and transportation team, nucleic acid extraction and testing team, sterilization team, logistics team and information statistics team, making sure that there are sufficient personnel support and effective operation mechanism in each link. A clear division of responsibilities and hierarchical management has been established between all levels of management, with each task being assigned to a specific person to ensure the smooth execution of work and traceability of results.

Despite the relative complexity of the organizational composition of the LW Regional Medical Laboratory Center, the effective integration of its management system enables all staff related to nucleic acid testing to work together under the unified command of the Center, thus

ensuring that the entire testing process from specimen reception to result release can operate in a high-speed, orderly and accurate manner. It fully reflects the advantages of resource integration and the effectiveness of professional management.

(2) Reconstruct the service process and establish a standardized nucleic acid test service system

In order to meet the demand for large-scale nucleic acid testing, the LW Regional Medical Laboratory Center has established a complete set of standardized nucleic acid testing system, covering laboratory standardization, sample collection and transportation, nucleic acid extraction and amplification, quality management system and biosafety protection. The center implements a flexible staff scheduling system to ensure that transportation, pre-processing, technical services, information management, nucleic acid testing, logistics and storage and transportation can operate around the clock.

In the sample collection stage, the Center utilizes a mobile sample collection system developed by PDA, which can efficiently enter the information of thousands of people per hour, and can work normally even in an environment with poor network signals. In the sample receiving and testing stage, the Center adopts the Laboratory Information Management System (LIS) for nucleic acid testing to ensure efficient and accurate sample registration, verification and receipt, report review and issuance. The report sending is synchronized and uploaded to the WeChat official accounts of the laboratory department, hospital and provincial and municipal health administrative departments to update the epidemic data in a timely manner. In the daily management, the Center adopts intelligent laboratory management platform to monitor the resource dynamics in real time to achieve accurate resource allocation and efficient decision-making.

In the face of the prevention and control requirements of "making nucleic acid testing available for those who ask to be tested", the Center integrates the nucleic acid testing function into the WeChat official account, which makes it convenient for patients to complete the process of registering, placing orders, and checking the reports online, and significantly improves the experience of medical treatment.

In order to ensure the quality of nucleic acid sampling, the Center has adopted a unified and standardized mobile sampling method. It participated in the compilation of the Guideline on Mixed Sampling Operation of Nucleic Acid Testing for COVID-19 in GZ and promoted the standard operations through video. The Center established a professional logistics team through bidding to take charge of nucleic acid sampling at 75 sampling sites within the whole district during peak hours, formulated strict operation procedures and trained relevant personnel to

ensure the quality of each link of sampling, preservation, transportation, reception and transferring.

The laboratory focuses on optimizing the nucleic acid extraction process by selecting high-efficiency and high-purity extraction methods and reagents to reduce the false-negative rate. Real-time fluorescence RT-PCR method is adopted to strictly control the analysis and interpretation of the test results. The Center implements rigorous comparative validation procedures for key testing elements such as nucleic acid extractors, operators and testing systems. The Center has received full scores in two external quality assessment activities for nucleic acid testing organized by the National Health Commission, and passed the ISO15189 on-site accreditation in March 2021, marking that its nucleic acid testing system and capabilities have reached international standards.

In terms of biosafety management and protection, the Center has maintained the record of "zero infection" since the outbreak of COVID-19, and has innovated the training mode. WeChat mini programs and remote video conferencing have been used to carry out the training and assessment of nosocomial infections, laboratory biosafety, and biosafety of the sampling process. The Center has also summarized its experience into the video of On-site Training for Sampling Sites of COVID-19 Nucleic Acid Testing for Large-scale Population, which was disseminated through WeChat to improve the training efficiency.

In terms of medical waste treatment, the Center has set up a special prevention, control and disinfection treatment group with reference to the relevant regulations of the National Health Commission to implement effective and standardized disinfection treatment of medical waste generated by large-scale testing. For out-of-hospital sampling sites, the Center adopts the approach of designated personnel, transportation monitoring and centralized disposal, and utilizes mobile APP for electronic and informatized management of waste to ensure full-process traceability and effectively reduce handover errors, which guarantees the safe and orderly disposal of medical waste under large-scale testing, and provides strong support for the safe and smooth testing.

(3) Develop new service tools to respond to the demands of epidemic prevention and control and nucleic acid testing

At the beginning of the COVID-19 epidemic, the LW Regional Medical Laboratory Center acted decisively and quickly deployed resources to build a large-scale, multi-functional nucleic acid testing laboratory system. The Center carried out urgent renovation and expansion of the original routine molecular diagnostic PCR laboratory, and completed the heavy task of testing more than 150,000 samples in only two weeks. It also took on the task of training PCR

technicians in grassroots hospitals, which demonstrates a strong coping ability and efficient execution ability. In order to meet the requirements of the epidemic prevention and control policy, the Center has built three high-standard nucleic acid testing laboratories and one antibody testing laboratory, and is equipped with sufficient modern testing equipment, including five rapid nucleic acid testing analyzers, 29 fully automated nucleic acid amplifiers and 19 96-channel nucleic acid extractors. It has greatly improved the efficiency of nucleic acid testing and dramatically increased the proportion of test reports issued within five hours from less than 50% to 98%, which plays a crucial role in the battle to fight against the epidemic.

In addition to laboratory construction and equipment upgrading, the Center also attaches great importance to the quality control of nucleic acid test kits. As many kits were quickly marketed under the emergency approval process at the beginning of the epidemic, there may be problems such as unstable performance and large batch-to-batch variation. Therefore, after purchasing kits approved by the State Drug Administration, the Center will also carry out strict performance verification, including verification of parameters such as detection limit, reproducibility and compliance rate, to ensure accurate and reliable test results. Based on the performance evaluation module of ISO15189 standardized intelligent management platform, the center systematically evaluated the consistency and detection ability of 7 Chinese nucleic acid test kits and 3 fully automated chemiluminescence immunoassay kits. In addition, the Center actively creates a scientific research atmosphere, builds a scientific research platform, and encourages the employees to carry out in-depth research on the problems arising in the testing process, with an aim to improving the scientific research quality and problem-solving ability of all the staff. Through practical exploration and research accumulation, the Center has summarized a series of valuable practical experience, such as emphasizing that internal quality control needs to cover weak-positive, negative and blank control, and suggesting the use of more than two reagents to review samples suspected to be weak-positive. It is also found that the sensitivity of the combined screening of IgM and IgG in the reagent of SARS-CoV-2 antibody is better than that of the single-indicator test. These measures not only ensure the accuracy of test results, but also lay a solid foundation for normalized epidemic prevention and control and large-scale testing.

The rapid development of new-generation information technology, such as the Internet, big data and cloud computing, has played an important role in tackling the challenges of epidemic prevention and control. In the context of COVID-19, the company independently developed the COVID-19 screening information management platform, and realized whole-process information automation management and supervision. It assisted the Guangzhou Municipal

Government in deploying and upgrading the COVID-19 screening system, and now the COVID-19 screening information management platform can undertake the information screening task of a city with millions of residents. In the sample receiving and testing process, considering the challenges that large-scale nucleic acid testing may bring to the daily operation, the LW Regional Medical Laboratory Center has developed a Laboratory Information Management System (LIS), which can effectively handle the key steps of sample registration, acceptance, report examination and release, significantly reducing the work pressure and risk of error due to the influx of large numbers of samples. In the daily operation and maintenance of nucleic acid testing, the Center adopts a standardized intelligent laboratory management platform developed independently, which can monitor and record changes in laboratory human resources, material reserves and financial status in real time. With the epidemic prevention and control entering a new phase, the Center has directly embedded the functions of nucleic acid test appointment, order placing and report inquiry into the WeChat official account, so that the majority of patients do not need to be physically present, but only need to use their cell phones to easily complete the whole process of operation from registration, order placing to report reading.

In the important link of sample transportation, the LW Regional Medical Laboratory Center has specially designed special sample transportation boxes with a capacity of 100 to 150 samples per box to ensure that the samples are properly protected on the way from the collection site to the laboratory. The collected samples strictly adhere to the relevant laws and regulations, and are encapsulated in special SARS-CoV-2 specimen transport boxes with unique identification labels to ensure safety and accuracy. The Center adopts an intelligent logistics service system with temperature monitoring, GPS positioning and other functions, which enables the staff to monitor the temperature change, real-time location, historical temperature curve and vehicle track in the specimen transport box in real time. When the temperature is out of the preset safety range, the system can automatically issue an early warning, thus realizing effective monitoring and instant interaction during the transportation process, and ensuring that the quality of the samples will not be affected before sending them for testing. In order to cope with the influx of a large number of samples and prevent cross-contamination, the LW Regional Medical Laboratory Center has deliberately set up the specimen receiving area in a separate area outside the nucleic acid testing laboratory, and established detailed standard operating procedures for specimen acceptance and rejection. In the receiving of specimens, professionally trained staff will carefully verify the status of the specimen, confirm the status of the specimen transport box, the source of information and the transport route through the special marking,

and disinfect the exterior of the specimen, as well as record the source in detail. Given that the samples have been pre-connected to digital information at the collection stage, the staff can quickly and accurately enter the sample information into the laboratory information system by scanning the pre-printed bar code on the sample preservation tubes, which greatly enhances the efficiency and accuracy of sample reception and information processing.

4.3.2 Development stage (2023 till now)

With the abolition of universal nucleic acid testing by the end of 2022, LW Regional Medical Laboratory Center had to change its original development strategy which is dominated by nucleic acid testing services. Decision makers of the LW Regional Medical Laboratory Center decision makers determine their own development strategy and service path by accurately perceiving the development trend of China's third-party medical testing services. They believe that, as a result of aging population, growing health awareness, and implementation of hierarchical medical system, third-party medical testing market in China will enter a period of rapid growth. In response to the growth of the market, the LW Regional Medical Laboratory Center is committed to becoming an effective complementary company to the public healthcare institutions, providing integrated medical diagnostic solutions with a flexible business model of "product agency + third-party services" and building a comprehensive professional medical service system. With newer, faster, easier and cheaper as the standard of service, LW Reginal Medical Laboratory Center intends to build a replicable and integrated regional center to adapt to the diversity and complexity of the medical testing industry in China. To this end, LW Regional Medical Laboratory Center has taken measures as follows.

(1) Reconstruct the organizational structure, and implement flat management

The Center implements flat management of the organizational structure, and builds a grid-based customer service management model. In order to keep abreast of changes in market trends and rapidly respond to customer needs, after the COVID-19 epidemic, LW Regional Medical Laboratory Center re-adjusted its own organizational structure.

Flat management requires decentralization of the leadership, which is based on information transparency and information sharing. The Center highly integrates the laboratory information system, quality control system, financial centralized management system, supply chain centralized management system, collaborative management system, enterprise knowledge base, and enterprise data center, and at the same time introduces the EAM asset management system and document cloud data management system, which initially realizes integrated information

collaboration. In addition, it has also optimized and upgraded the financial management system, OA system, e-HR system and other information systems, which greatly improves the standardization of process management, automation of collaborative office, and intelligentization of business data, so that the management and employees at all levels can fully communicate and share information with each other.

The Center implements the construction of multi-functional team, and supplements it with grid-based management. Through years of practice, LW Regional Medical Laboratory Center has set up a group of professional staff including engineering technology, information technology, testing technology, supply chain management, and project management. The Center has formed a complete set of standard system from the perspectives of laboratory process optimization, decoration and renovation design, equipment selection and installation, testing item design, supporting purchases catalog design, information system program design, technician staffing program, discipline development program, and quality control and technology system construction. On this basis, an operational management system based on technical quality and service quality has been formed to provide a full range of specialized medical services for cooperative clients in the region.

(2) Continuously expand service boundaries and service ecology, and realize the deep integration of the industrial chain and value chain

The providers of medical diagnostic service include three main categories: hospital laboratory/pathology departments, independent clinical laboratory (ICL), and other types of medical diagnostic service providers, including nursing homes, medical examination centers, research institutes, and other nontraditional medical institutions. In recent years, the independent medical testing market has shown strong growth momentum and fierce competition pattern. On one hand, large-scale comprehensive ICLs have dominated the market share with their one-stop and all-around diagnostic service capabilities; on the other hand, a number of specialty-specific ICLs focusing on specific fields or diseases have also risen to prominence, forming an industry ecology of diversified and specialized development. This competitive situation has prompted companies to provide more personalized services with better quality to meet the increasingly diversified market demand. After analyzing the development trend of the industry and the company's core competitiveness, the company decided to rely on the continuous expansion of its own resources and the continuous extension of external cooperation to strengthen the service ecosystem in order to focus on the three major links of research and development, production and marketing.

LW Regional Medical Laboratory Center continuously strengthens its own service

capabilities to become a partner of domestic enterprises and multinational companies in China by providing comprehensive solutions for their research and development of innovative medicines, launch of IVD products in the Chinese market, and the introduction of high-quality foreign diagnostic products in China. The LW Regional Medical Laboratory Center has maintained close cooperation with internationally renowned pathology equipment suppliers such as Leica and DAKO, and it has integrated the leading pathology quality control system in China, which enables it to provide customized solutions for the construction of pathology departments of medical institutions at different levels. In the field of biochemical tests, immunoassays and routine clinical tests, the Center has been acting as a long-term agent of Roche and Sysmex, the products of which enjoy a high degree of industry recognition and market share. The Center always adhere to the promotion and application of cutting-edge medical testing technology as the core, keep pace with the progress of medical technology, and effectively meet the needs of medical institutions at all levels for technological innovation. As a core distributor of global renowned manufacturers, the company continues to deepen the cooperation with these strategic partners, actively explore new modes of cooperation, and vigorously expand the business of integrated service platform for in vitro diagnostic products, striving to create greater value in the field of medical testing services.

The rich and diversified customer resources accumulated by the Center have constructed a strong supply chain alliance, giving it stronger bargaining power in its dialogue with suppliers. Therefore, it can select high-quality cooperation partners or suppliers in a more strategic manner, and continuously introduce advanced testing and diagnostic technologies and products to better meet the specific needs of different customer groups. In addition, the Center has also established a perfect supply chain management center, which follows the standards of chain operation, and implements a centralized purchasing system, and unified brand selection, purchasing channel and inventory management processes. Through the establishment and application of standard cost models, the Center carries out an in-depth analysis of various factors affecting cost changes to achieve delicacy management of the laboratory testing business, which in turn can gradually cut internal transaction costs, and improve overall operational efficiency and economic benefits.

(3) Build a comprehensive service system with rich content and reasonable structure

Specialized technical services: The LW Regional Medical Laboratory Center has established an independent studio for medical testing technology experts, focusing on research and development related to clinical medical testing. The Center brings together professionals from the fields of life sciences, medical testing, diagnostic pathology and clinical medicine, who not only have long-term industrial background and excellent management experience, but

also rely on the company's continuous investment in medical diagnostic standardization and continuous optimization of the core technical team. The Center has become a leader in providing a full range of professional technical services. In response to the specific needs of different levels of customers in the region, the Center, with its experienced team of consultants, is able to provide a series of tailor-made services to meet the customer needs, including but not limited to quality management solutions, medical consulting services, special technology platform building programs and the application of newly introduced technologies. The Center can also share its own advanced technology platform and improve the standard of medical testing technology together with its customers. In addition, the Center actively establishes close cooperation with grade A tertiary hospitals and medical schools to integrate resources from all sides, invites top medical experts to offer professional lectures and guidance to the customers, and helps customers carry out the construction of distinctive specialties. In this way, the Center continues to deliver the latest industry information, cutting-edge technology and practical professional knowledge, which has promoted the continuous development and progress of the medical testing industry in the region.

Comprehensive operational services: the Center has improved a set of delicacy operation and management mode. Through efficient operation and management output, the Center can implement the services in a standardized manner, including regional testing and diagnostic informatization service, professional specimen logistics service, regional laboratory supply chain service, quality management service, medical technology talent reserve, training and sharing service, scientific research platform construction and sharing service, and public health service. The company's mature operation and management model and services can be applied not only to the operation of regional medical technology centers, but also the co-construction and cooperation of a single customer.

(4) Build an industry-leading service management system relying on the advantages of the integrated management system

Standardized quality management. Given that healthcare is related to people's lives and health, it requires strong professionalism and rigorousness. In addition, the relevant national norms are increasingly standardized and clarified. From the four perspectives of pre-analysis, during-analysis, post-analysis and continuous improvement, the Center has introduced ISO15189 Medical Laboratory Quality and Competence Accreditation Guidelines, and has been accredited with the ISO15189 qualification. Meanwhile, in terms of pathological diagnosis, the Center relies on the ISO15189 accreditation guidelines to establish a strict quality management system for pathological diagnosis.

Establishment of an all-round and three-dimensional medical testing technology platform system. At the level of routine testing, the Center has a variety of testing platforms covering blood and body fluids, biochemistry and luminescence, immunoassay, microbiology, pathology, and molecular testing. The Center adopts a variety of cutting-edge technologies, including electrochemiluminescence, PCR, flow cytometric analysis, high-performance liquid chromatography and liquid-mass spectrometry. The center has also realized automated assembly line operation on some platforms, which ensures that while guaranteeing the quality of testing, the testing efficiency has been greatly improved and the cost has been effectively saved. It is especially worth mentioning that the Center provides platforms such as blood and body fluids and point of care testing (POCT) to customers who cooperate with the Center, and ensures the Turn-Around-Time (TAT) of emergency test results under the unified quality management framework.

In the field of special testing, the Center has built chromosome karyotyping platform, sequencing platform, FISH in situ hybridization platform, flow cytometry platform, biochip platform, and mass spectrometry platform. With molecular biology and molecular pathology technology as the core, the Center has made great efforts to expand the testing programs for complex diseases such as tumors, hereditary and metabolic diseases, and hematological disorders. The organic combination of general and special tests enables the LW Regional Medical Laboratory Center to meet the diversified testing needs of various medical institutions and provide timely and accurate test results and diagnosis and treatment basis for the clinical diagnosis of various diseases. As a first-class medical testing service provider, the Center continuously optimizes the existing technology platforms and promotes the continuous optimization of quality, efficiency and cost control through technological innovation; on the other hand, the Center pays close attention to and actively introduces international advanced new products and technologies, and realizes the clinical transformation of new technologies or projects through the in-depth integration with the upstream suppliers. It continuously expands the scope of testing programs, improves the testing capacity, and enhances the market competitiveness and flexibility.

Modernized information management. Medical testing service is a highly professional and rigorous industry, and its information management is in strict accordance with the national standards of *Classified Protection of Information Security Technology/Information System Security*. The Center has continuously invested in the laboratory information system and developed a laboratory information management system applicable to the operation of regional centers. Through the “cloud” technology, real-time sharing of data resources to the various types

of medical institutions served by the Center can be realized. Specifically, the system includes laboratory LIS, WEBLIS, physical examination system, self-service printing system, regional platform testing service system, and remote pathology diagnosis system. In terms of internal operation, the company vigorously promotes application of information technology, integrates several key systems such as quality control system, laboratory information system, supply chain centralized management system, financial centralized management system, enterprise data center, internal knowledge database and collaborative office system, and initially constructs an integrated information collaborative environment. This initiative not only effectively improves the efficiency of collaboration between departments, but also strengthens the delicacy management of business processes. It ensures real-time sharing and flow of data, realizes panoramic control of the enterprise's operating conditions, and further optimizes resource allocation and decision-making support, laying a solid informatization foundation for the sustainable development of the enterprise.

Refined cost management. For the external environment, Chinese high-quality brands began to rise rapidly under the drive of policy and technology, and the increase in competitive pressure has significantly accelerated the integration of upstream suppliers by the Center. The Center adopts means such as strategic cooperation, re-bargaining, channel mergers and acquisitions and integration, regional agents, and scale procurement to enhance the upstream bargaining power. For the internal operating environment, the Center adopts the following measures for optimization and management. First, it establishes a comprehensive supplier database and procurement database to ensure stable and reliable supply channels; second, it adopts standardized management of laboratory configuration, and unifies laboratory equipment brands and specifications, so as to improve the overall efficiency and quality of testing; third, it establishes a centralized purchasing management model to reduce costs and improve procurement efficiency; fourth, the information system is fully utilized to closely control inventory and logistics distribution, so as to ensure efficient and accurate material flow; and fifth, the Center also works together with the financial cost analysis module to perform real-time monitoring of the laboratory testing costs and laboratory equipment usage through the information system, so as to achieve delicacy management of costs and effectively improve the utilization of resources and the economic benefits.

Forward-looking and consultative customer service. The Center has always insisted on strengthening the construction of its own customer service capabilities, and has been committed to providing customers with forward-looking and consultative comprehensive testing solutions. The customer service team is composed of authoritative experts in clinical testing, hardware

and application engineers, professional clinical promotion team, as well as efficient logistics and distribution team, and these four pillars together constitute a strong service support. Through a combination of online and offline approaches, the Center provides customers with thoughtful support throughout the service cycle. In the pre-sales phase, it provides laboratory site planning, instrumentation and equipment selection and purchase, test programs setup, workflow design and other consulting services; in the sales phase, it offers real-time monitoring and professional guidance to the laboratory site renovation, and instrument installation and commissioning; in the post-sales phase, it provides comprehensive follow-up services, including but not limited to regular maintenance and repair of instruments and equipment, upgrading and maintenance of software systems, guidance on internal quality control and external quality assessment, professional interpretation of test results, support for telemedicine consulting, continuous optimization of laboratory processes, and promotion and popularization of clinical applications, so as to ensure that the customers can enjoy an all-round quality service experience from beginning to end. The customer service capability of the Center has also been recognized by the agent brands, and it is the authorized after-sales service agent of Roche, Leica, and Sysmex.

(5) Focus on R & D and innovation to lead the upgrading of information technology and digital intelligence

The Center focuses on intellectual property rights, and always believes that the science and technology is the first productive force. At present, the Center owns more than 120 invention patents, utility model patents, and software copyrights. To be specific, inventions such as “compositions and methods for microRNA expression profiling of lung cancer”, and “plasma-based microRNA biomarker and method for early detection of colorectal cancer” are of great significance to tumor diagnosis and clinical treatment. Meanwhile, according to relevant laws and regulations and policy requirements, the Center is actively exploring the LDT clinical laboratory self-construction project, with an attempt to present more highlights in precision medicine and product registration. It is bound to promote more cutting-edge testing technology to be standardized and normalized, thus giving rise to a large number of in vitro diagnostic products.

In order to deepen the goal of digital transformation, the Center has optimized and upgraded the financial management system, OA system, e-HR system and other information systems, which greatly improves the standardization of process management, automation of collaborative office, and intelligentization of business data. In addition, EAM asset management system and document cloud data management system have been introduced,

which helps realize the integrated management of internal and external assets and the safe and automatic archiving of core data. As for the laboratory, the new version of self-developed R-LIMS regional laboratory management system and the Logistics-S sample management system optimize the testing process, sample information process, and quality control management process of primary medical service centers, and realize the automated management of the whole life cycle of samples. The LIMS central laboratory management system has introduced intelligent collaborative modules such as the hump data platform, intelligent management platform for instruments and equipment, and test data analysis platform, which has improved the utilization rate of instrument and equipment as well as the reagents and consumables, optimized the testing path, and enhanced the laboratory's ability of big data processing and integration.

4.4 Case discussion

Although scholars have carried out fruitful research on the division of the dimensions of dynamic capabilities, no consensus has been reached yet. The researchers need to choose specific dimensions based on theoretical perspectives, research objects, and data types. Based on the existing research on dynamic capabilities and the development situation of LW Regional Medical Laboratory Center, this study chooses the three dimensions of perception capability, reconfiguration capability and innovation capability to constitute the dynamic capabilities model of this research.

The perception capability reflects an organization's ability to accurately perceive and identify market expectations, which is the core element of dynamic capabilities. From the development practice of the regional medical laboratory center, it can be seen that it has undergone two major service model transformations since its establishment. Organizations need to have perception ability to make correct judgments on the timing and path of transformation, thereby initiating service transformation. Therefore, perception ability has become a key dynamic ability for the regional medical laboratory center to successfully achieve transformation and improve service quality.

Reconfiguration capability reflects the ability of an organization to adapt to perceived changes in the organizational environment by re-establishing a series of resource allocation rules and processes such as organizational structure, workflow, and management system (Helfat & Raubitschek, 2018). In the initial stage of establishment, the Regional Medical Testing Center established a centralized organizational structure that pursues efficiency in order to meet the

characteristics of tight time, heavy tasks, and high responsibility requirements for nucleic acid testing. The center director has the highest resource allocation and personnel command power, and there is a strict division of power and responsibility between superiors and subordinates to ensure that each task is implemented by individuals and can be traced after completion. When regional medical testing centers are in the development stage, in order to cope with more diversified medical testing needs, flat management is implemented, a grid based customer service management model is constructed, and the collaborative integration of various information systems is established, so that management and employees at all levels can have sufficient information communication and sharing. At the same time, the construction of multifunctional teams should be coordinated with grid management. On this basis, an operational management system based on technical quality and service quality has been formed, providing comprehensive and professional medical services to various cooperative clients in the region. The organizational structure, management system, service process, and other aspects established by regional medical testing centers have undergone systematic changes at different times. The ability to reconstruct has become another key dynamic capability for regional medical testing centers to improve service quality.

Innovation capability reflects the ability of a company to identify and absorb critical knowledge or resources to create new tools and apply them for commercial use（Teece ，1997）. In the initial stage, facing the new demand for epidemic prevention and control and nucleic acid testing services brought by the impact of the COVID-19, the Regional Medical Testing Center actively developed new service tools, including nucleic acid testing laboratories, nucleic acid testing kits, COVID-19 screening information management platform, nucleic acid testing laboratory information management system, etc., which effectively met the demand for nucleic acid testing. In terms of transportation of nucleic acid testing samples, the LW Regional Medical Testing Center has developed a dedicated specimen transportation box to ensure the logistics safety of nucleic acid testing. After entering the development period, the LW Regional Medical Laboratory Center continues to adhere to the strategic plan of innovation leadership, continuously increases research and development investment, optimizes innovation management, and in order to better embrace the digital economy era, the LW Regional Medical Laboratory Center attaches great importance to the digital construction of enterprises, helping to promote the digital information industrialization and standardization transformation of the regional medical laboratory center. Obviously, at different stages of development, LW regional medical testing centers need to meet market demand and improve service quality through innovative capabilities, making innovation another key dynamic capability of regional medical

testing centers.

In summary, based on existing research on dynamic capability theory and the development practice of the research object (LW Regional Medical laboratory Center), this study selected three dimensions: perceptual ability, reconstruction ability, and innovation ability to form the dynamic capability model of the research object.

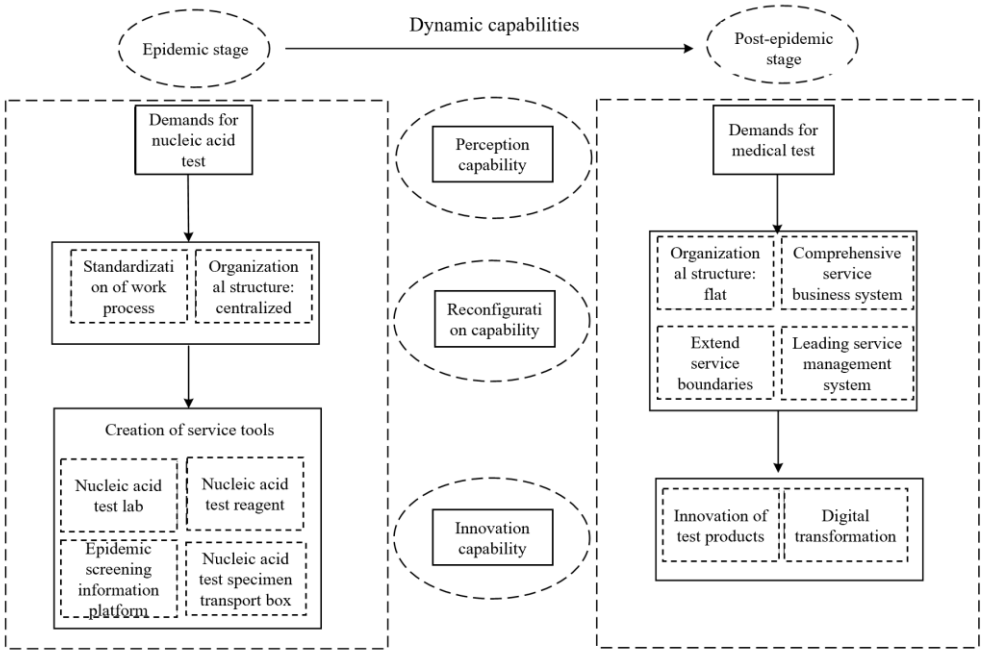

Figure 4.2 Service model evolution

LW Regional Medical Laboratory Center has gone through two stages of development: the start-up period and the development period. In the start-up stage, LW Regional Medical Laboratory Center first discovered the demand for epidemic testing through its perception capability. Next, it reconfigured the organizational structure by its reconfiguration capability and established a centralized organization to ensure that every link of medical testing service is traceable. In addition, it reconstructed the service process and established a standardized nucleic acid testing service system, in pursuit of traceability as well as unified and rapid testing services. Finally, the innovation capability was utilized to develop new service tools in response to the demand for epidemic prevention and control and nucleic acid testing services, including the construction of large-scale multi-scenario nucleic acid testing laboratories, the evaluation of nucleic acid testing kits, the independent research and development of the COVID-19 screening information management platform, the customized development of the nucleic acid testing laboratory information management system, and the development of special specimen transport kits.

In the development stage, the decision makers of LW Regional Medical Laboratory Center perceived the changes in the market environment and made the decision of strategic transformation to become an effective complementary company to public medical institutions, and adapted to the diversity and complexity of the current medical testing industry in China with the service criteria being newer, faster, easier, and cheaper. To this end, LW Regional Medical Laboratory Center first reconfigured its organizational structure by its reconfiguration capability, implemented flat management, and continuously expanded its service boundaries and service ecology to realize the deep integration of the industrial chain and value chain. Finally, relying on its own innovation capability, it carries out a series of R&D and innovation on medical testing technology as well as digital transformation activities to cope with the wave of technological revolution and digitalization trend in the medical testing industry.

The practical development of LW Regional Medical Laboratory Center reflects how it develops different service models through its perception capability, reconfiguration capability and innovation capability, adapts to the changes in the market environment faced in different periods of development, and ensures the quality of the services provided. Based on the above analysis, a service model evolution can be established as shown in Figure 4.2.

4.5 Chapter summary

Based on the development practice of LW Regional Medical Laboratory Center, this chapter summarizes the theoretical model of service quality improvement based on dynamic capabilities of the regional medical laboratory center. LW Regional Medical Laboratory Center has gone through two stages of development: the start up stage and the development stage. In the epidemic stage, it discovers the demand for epidemic testing through its perception capability, adjusts the organizational structure through its reconfiguration capability and innovation capability, develops a new type of service tool for epidemic testing and demands for epidemic prevention and control, and establishes an epidemic-oriented service model to satisfy the demand for epidemic testing of various stakeholders. In the post epidemic stage, LW Regional Medical Laboratory Center discovers new market demands and development opportunities based on its perception ability, implements flat management through its reconfiguration capability and innovation ability, and continuously expands its service boundaries and service ecology to realize the deep integration of the industry chain and the value chain and build a comprehensive service system with rich connotation and reasonable structure. It creates an industry-leading service management system based on the advantages of

the integrated management system, obtains technological innovation products with industry competitiveness, and ultimately establishes a market-oriented service model.

Chapter 5: An Empirical Study on Service Quality Evaluation of Regional Medical Laboratory Center

5.1 Theoretical analysis and hypothesis formulation

5.1.1 The existence of service quality gaps

Parasuraman, Zeithaml, and Berry (hereinafter referred to as the PZB team, 1985; 1988) argue that service quality depends on the customer's pre-purchase expectations, perceived process quality, and outcome quality, emphasizing that the service quality is rated by the customer. They proposed the Gaps in Service Quality model, also known as the 5 Gaps model as shown in Figure 5.1, and believe that service quality is reflected by the gap between "expected service and perceived service", which is affected by five factors, including reliability, responsiveness, empathy, assurance, and tangibles. In this section, based on the 5 Gaps model proposed by the the PZB team, we will analyze whether there are service quality gaps in regional medical laboratory centers.

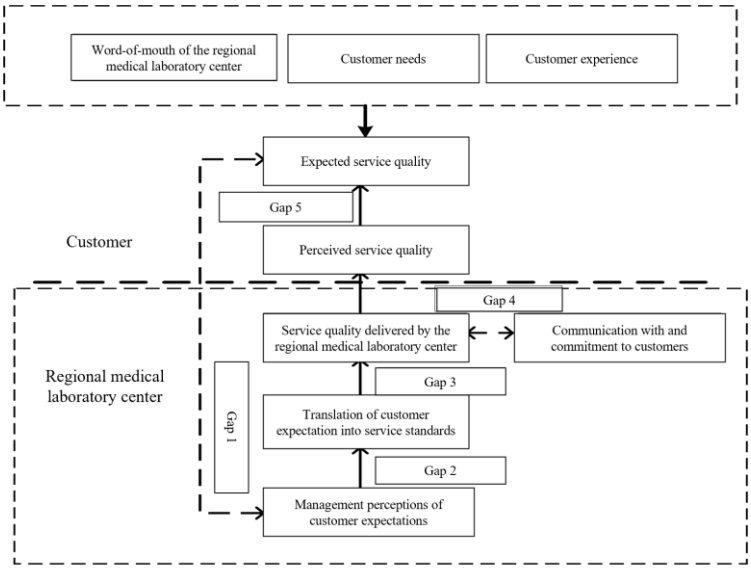

Figure 5.1 Service quality gap model

The PZB team pointed out that differences in the understanding of customers' needs by the company management and service personnel, namely, the discrepancy between their perceptions of customers' expectations and the standards of service actually expected by

customers, constitute the perceived service quality gap. The main reasons for the perception gap are as follows. 1. Inadequate marketing research (including insufficient market research, lack of comprehensive analysis of demand information, and failure to take service quality as the basis for marketing research); 2. Inadequate communication with high-level management (including lack of communication between managers and employees, neglect of managers to communicate with customers, and bloated organizational hierarchies that impede or change customer-related service information); 3. Inadequate remedial measures to deal with service emergencies (including lack of timely remedial measures for service problems, lack of effective resolution mechanisms for remedial measures, and lack of staff incentives to listen to customers' complaints); 4. Inadequate attention to the service relationship (including lack of market segmentation for customers, more attention to transactions than maintenance of relationship with customers, and more attention to new customers than maintenance of relationship with customers).

First of all, LW Regional Medical Laboratory Center has not paid enough attention to the investigation of customer expectations. It has not held a user demand meeting with customers, nor has it issued questionnaires on service quality to them, which has led to the lack of a holistic and accurate understanding of the expectations of its users. The reasons for this situation may be multifaceted. First, because the LW Regional Medical Laboratory Center was established to ease the pressure of nucleic acid testing in Liwan district, it has direct and clear customer groups and needs upon its establishment, so after the end of the epidemic it did not change its thinking in a timely manner, resulting in insufficient attention to investigation of customer expectations, and therefore failure to perceive customer expectations in a timely manner. Second, LW Regional Medical Laboratory Center is a local monopoly enterprise, responsible for the laboratory testing of all secondary public hospitals and community health centers in Liwan district. Due to the difficulty of directly feeling the pressure brought about by the competition in the market, the management are inevitably prone to neglect the customer needs. Finally, the management of LW Regional Medical Laboratory Center are busy with a variety of tasks in their daily work, and they tend to focus more on work with high degree of professionalism. They are also worried that once they begin to collect the views of the users, there will be plenty of problems. In this case, their workload will be much heavier and it will be difficult for them to deal with the situation. Therefore, they seldom communicate with the employees or customers to collect the user's opinions, and usually their subordinate employees directly face the users.

In addition, the bloated organizational hierarchy hinders the transmission of information.

First, front-line service personnel need to go through many levels to deliver information about customer needs. The customer's opinions need to go through four levels before reaching the upper level of leadership, and each level also need to get approval from the leaders before reporting to the upper level. The leaders may subjectively suspend reporting or omit some of the contents of the report, coupled with the long time consumed by each level, the final information reported to the highest leadership may be subject to information distortion. Second, the grassroots staff lacks the motivation to deliver customer information. Grassroots employees usually directly face the users and have the most contact with the users, but influenced by their own work, time and upward feedback channels, coupled with the lack of targeted incentives, they rarely report what they know to the company, and they are more concerned about matters related to their assessment. Sometimes when employees give feedback to their superiors, the superiors may retain the opinions and choose not to report upwards because of considerations of department assessment.

Based on the above analysis, the perception gap in LW Regional Medical Laboratory Center exists due to the lack of attention to the investigation of customer expectations and the bloated organizational hierarchy.

Parasuraman, Zeithaml, and Berry theorized that if the management of a company fails to accurately translate customer expectations into internal service standards that are specific, feasible and meet customer satisfaction, the problem of service standard gap will occur. It can be inferred that failure to set standardized operating procedures and implement optimal service practices at the beginning of the establishment of a financial sharing service center may lead to difficulties faced by employees in dealing with affairs and the inability to effectively control service quality. Similarly, regional medical laboratory centers may also fall into the predicament of low service effectiveness and difficulty in meeting customer needs. There are many reasons for the gap in service standards. 1. Lack of comprehensive service conception (including lack of certain systematic considerations in the development of new services, ambiguous service design standards, lack of an effective combination of service design and service orientation, haphazard service plan management, human errors in service planning, and lack of comprehensiveness of the planning process). 2. Lack of customer-oriented standards (including lack of necessary attention to and understanding of the process of customer service needs by service providers, lack of clear customer-oriented service standards, and lack of a clear directional goal of the management organization). 3. Mismatch between service scenarios and tangible demonstration (including failure to transform the customer expectations of the service to practical scenarios, failure to fundamentally meet the needs of customers and staff in the

process of service, and failure to correct the service scenarios or upgrade and remodel them in a timely manner).

First, the service standards and service conceptions of LW Regional Medical Laboratory Center are not perfect. As shown in the previous case study, the LW Regional Medical Laboratory Center is currently in the transition from epidemic-oriented service model to market-oriented service model, and the relevant service processes and service standards are still in the process of improvement. Therefore, it has not yet established a reasonable customer management mechanism, and lacks targeted customer service strategy, making it difficult to grasp the needs of customers in the promotion of new services.

Second, the LW Regional Medical Laboratory Center lacks specialized personnel in the development of service standards. Most of the management personnel are specialized technicians, which makes it difficult for managers to formulate the perceived customer service expectations into operational service standards.

Based on the above analysis, due to the imperfect service standards and service conceptions, as well as lack of talents specialized in development of service standards, LW Regional Medical Laboratory Center inevitably has standard gap in its service process.

According to the PZB team, there is a discrepancy between what firms advertise and position externally and what they actually deliver, which is referred to as the “communication gap” or “external publicity gap”. Different positioning and publicity strategies strategically shape the form and content of services, and such differences may lead to differences in the actual execution of services by frontline service personnel, such as key indicators of business processing efficiency, business quality, and unit business processing costs, which in turn affects the company’s commitment to its customers and the actual fulfillment of its Service Level Agreement (SLA). The key factors affecting the service communication gap are as follows. 1. Inadequate combinative capabilities of marketing and promotion (service providers are used to treating external communication as an independent part, lack of interaction between marketing in service-related program communication, and lack of execution in the implementation of internal marketing programs). 2. Inadequate management of customer expectations (companies are used to ineffective communication management by a single marketing channel, and customers are not adequately and effectively educated about service expectations). 3. Overcommitment (overcommitment in advertisement and marketing in order to achieve a certain purpose, or overcommitment in the tangible demonstration). 4. Inadequate communication between departments (inadequate communication between the marketing and planning departments, inadequate communication between the advertising and planning

departments, and discrepancies between subsidiaries of various branch offices and the head office). 5. Irrational pricing (sales price is higher than the price for expected service, and sales price is higher than the customer's perceived value).

First, the employees lack competence. When dealing with common complaints in the regional medical laboratory centers, the staff should have comprehensive testing and diagnostic service capabilities, which not only covers the proficient use of a variety of technical platforms, but also includes the training of technical staff, quality management system construction, strategic planning and construction of testing platforms and other in-depth disciplinary development capabilities. In addition, employees should also have the professional ability to interpret complex reports, actively participate in academic exchanges, make effective clinical communication, provide consulting services, as well as make contributions to scientific research and innovation, so as to meet the diversified needs of customers in testing services in an all-round way. In many cases, it is difficult to make a correct diagnosis of clinical diseases merely with a single technology platform; instead, we need to comprehensively analyze the testing data of multiple technology platforms, and make diagnostic and therapeutic decisions under the close cooperation between the medical testing and clinical treatment. The customer complaints involve a lot of professional knowledge and experience, but those who directly deal with customer inquiries and complaints are often not professional personnel, so in the face of some complex issues, they often cannot give proper answers. In addition, as this position is designed to deal with complaints, the customer's attitude is often not very good. The employees may not be able to control their own emotions in the face of such a situation and may have conflicts with the customers, which will exacerbate the contradictions between them.

Second, there is over-commitment for some services. Due to government and industry requirements and the increasingly fierce market environment, in order to better attract customers and obtain government support, LW Regional Medical Laboratory Center managers tend to make over-commitment in the advertising and promotion. The sales staff also have expressions of over-commitment in the communication. As a result, the customers often have high expectations towards its services and will evaluate the service quality based on their expectations. With the advent of the digital era, customers can get information from a variety of channels, such as WeChat official account and website. LW Regional Medical Laboratory Center fails to offer consistent internal and external marketing information, so there will be mismatch between the marketing department and the front-line service personnel, which will lead to gaps between perception and expectation of customers.

Based on the above analysis, there is a lack of competence among the employees of LW

Regional Medical Laboratory Center in communication with customers. In addition, due to the phenomenon of over-commitment for some services, the communication gap exists objectively in LW Regional Medical Laboratory Center.

Parasuraman, Zeithaml, and Berry believe that the gap caused by employees' lack of responsibility or lack of competence is the delivery gap in service performance. The key reasons for the delivery gap are as follows. 1. Lack of relevant human resource policies (inefficient or ineffective recruitment, role positioning ambiguity or conflict, unreasonable arrangement of employees and work technology, unreasonable performance appraisal system, and insufficient teamwork). 2. Mismatch between supply and demand (no timely measures have been taken to balance the supply and demand, the customer portfolio is not scientific enough, and there is over-reliance on price equilibrium). 3. Customers' ignorance of their own responsibilities (customers tend to ignore the responsibilities and obligations they are supposed to assume in the service process, and customers are prone to exert negative impact on each other). 4. Contradictions between service intermediaries (unreasonable match between the goal and performance, the contradiction between the cost and the return, difficulty in control of quality and uniformity, and difficulty in striking a balance between authorization and process control).

The delivery gap mainly comes from the fact that companies do not incentivize their employees enough to strictly enforce service standards. Managers believe that employees should fulfill their due responsibilities and serve every customer, but the lack of scientific incentives, rewards and penalties will make it difficult for employees to truly regard themselves as a part of the company. As the service is intangible, in the implementation of the company-formulated standards, the grass-roots front-line service personnel often have their own understandings due to the factors such as the environment and management levels, which may lead to inadequate implementation.

Parasuraman, Zeithaml, and Berry argue that the gap between the customer's perception of service quality and the expected service quality (customer gap) is the core of the gap model of service quality, which is the reflection of the final service quality results. According to the gap model of service quality, the customer gap refers to the difference between the customer's expectation of the service and the actual perception when receiving the service, and the reason for this gap is caused by four gaps. Based on the previous hypotheses about the perception gap, standard gap, communication gap, and delivery gap, the customer gap should also exist. Accordingly, the hypothesis is finally proposed as follows.

H1: There is a significant difference between perceived services and expected services of customers in LW Regional Medical Laboratory Center.

5.1.2 Differences in the impact of different dimensions of service quality

SERVQUAL categorizes service quality into five dimensions: tangibles, reliability, responsiveness, assurance and empathy. Tangibles refer to the physical and tangible aspects of the service, such as facilities, equipment, appearance, and cleanliness. Reliability is the consistency and dependability of the service, including the ability to deliver promised services accurately and on time. Responsiveness involves the willingness and ability of service providers to help customers promptly and address their needs and concerns. Assurance relates to the competence, courtesy, credibility, and professionalism of service providers. Customers should feel confident in the service provider's abilities and trustworthiness. Empathy refers to the service provider's ability to understand, care for, and empathize with customers' needs, feelings, and concerns.

Established in 2021, LW Regional Medical Laboratory Center has a rather short history, and all its equipment is imported, so compared with other dimensions, tangibles might contribute little to the service quality gap. LW Regional Medical Laboratory Center was established to support the nucleic acid medical testing in the Liwan district, and it is, to a certain extent, fulfillment of a political mission. As a result, LW Regional Medical Laboratory Center attaches great importance to the achievement of customer commitment, and has formed a pragmatic work style and organizational culture, so reliability is also supposed to contribute little to the service quality gap. Since the medical laboratory center has relatively stable businesses and customers in the beginning (nucleic acid testing provided by the government), it is likely to fall into the thinking of inertia and path dependence in the post-epidemic era and fail to respond in a timely manner to the new market demands and customer feedback, so the dimension of responsiveness is likely to contribute a lot to the generation of the service quality gap. As the medical laboratory center has a relatively strong talent pool, and has developed a rigorous business competence training mechanism, the dimension of assurance is supposed to contribute little to the service quality gap.

H2: The five dimensions of service quality (tangibles, reliability, responsiveness, assurance, and empathy) exert different levels of influence on the service quality gap.

5.1.3 Comparison of different types of customers based on the stakeholder theory

The core idea of stakeholder theory is that the survival and development of the organization cannot be separated from various types of stakeholders, and there are different interest demands

among different stakeholders, so it is necessary to formulate a category-based management strategy according to the characteristics and demands of stakeholders to ensure the stable development of the organization. Under the guidance of this idea, we attempt to find out whether there are differences in service quality gaps among the three different categories of customers served by the LW Regional Medical Laboratory Center.

LW Regional Medical Laboratory Center has two categories of customers in terms of medical service institutions, and they present different characteristics and service demands. The first category is the secondary hospitals that are located in areas with populations often reaching hundreds of thousands. As regional comprehensive or specialized medical centers, they are designed to not only provide disease treatment services, but also undertake a number of tasks, such as disease prevention, health care and rehabilitation, as well as participate to a certain extent in medical education and scientific research. They serve a wide range of clients, covering the inhabitants of a number of neighboring communities. The other category is community health service centers, which are based on public welfare attributes and focus on non-profit services. They provide public health services and basic medical services for the community, families and individuals. Their service recipients are specific groups in the community, such as women, children, the elderly, the chronically ill, the disabled and low-income family members. Community health service centers advocate the concept of proactive and door-to-door services, and mainly carry out tasks such as health education, disease prevention, early intervention, rehabilitation care, technical guidance on family planning, and basic diagnosis and treatment of common and frequent diseases, with the aim of staying close to the needs of the public, and promoting the improvement of the overall health of community residents.

H3: There is a significant difference in the perceived service quality of LW Regional Medical Laboratory Center between different categories of medical institutions.

There is a difference between the middle and senior managers and the frontline staff in terms of the perceived service quality of the regional medical laboratory center. Managers hope that through the cooperation in medical laboratory services, it is possible to achieve the optimal integration of organizational resources. In this case, hospitals do not have to purchase expensive testing equipment, but can carry out more diversified tests, while the professionalism and efficiency of the test can also be improved. Through the testing services provided by LW Regional Medical Laboratory Center, managers try to achieve the result of increasing efficiency and reducing burden for the organization. In contrast, grassroots employees are more concerned about their own workload and salary growth, and less concerned about the financial benefits brought by the cooperation between their organization and the LW Regional Medical

Laboratory Center. They pay more attention to whether the change in testing services can reduce their own workload. If the workload increases, will their salary be increased? Managers have higher expectations of the quality of services provided by the regional medical laboratory center than the grassroots staff.

H4: There is a significant difference in the perceived service quality of LW Regional Medical Laboratory Center between customers of different job levels.

Because of the more direct contact with patients, healthcare workers will pay more attention to the professionalism of the testing services provided by the medical laboratory center, and they attach greater importance to the accuracy and timeliness of the test results. In contrast, the logistics personnel are mainly responsible for ensuring the normal operation of the healthcare workers, and they do not directly serve customers. Based on their professional characteristics, they may pay more attention to the safety of the testing and whether cooperation with the regional medical laboratory center can reduce their own logistical support work. Therefore, the two categories of employees are concerned about different aspects of the services provided by the regional medical laboratory center, and they have different interest demands.

H5: There is a significant difference in the perceived service quality of LW Regional Medical Laboratory Center between customers of different occupational groups.

5.2 Research design

In order to better analyze the service quality level of regional medical laboratory centers, we intend to adopt the method of quantitative empirical research. Since regional medical laboratory centers are a relatively new healthcare service model, with little readily available public data for reference, we decided to adopt a large-sample questionnaire to collect the necessary data to support an in-depth exploration of the topic. By designing a well-targeted questionnaire, it is possible to collect a wide range of relevant information about the operation status, service efficiency, technology application, staffing, service quality, and social satisfaction of the regional medical laboratory centers, which can fill the gaps in the existing literature and provides data support and empirical references for the construction and development of regional medical laboratory centers in the future. Such a research method can ensure the timeliness and validity of the data, and more truly reflect the real situation of medical testing services in the region. This chapter involves questionnaire design and sample selection, descriptive statistical analysis of data, reliability and validity of questionnaire, t-test of the questionnaire and IPA analysis.

5.2.1 Sample selection based on stakeholder theory

First, based on the stakeholder theory, the core stakeholders of the regional medical laboratory center are identified, so as to determine the respondents of the questionnaire. On this basis, we further explain specific process of questionnaire design as well as the process to obtain data.

Accurate definition of the stakeholders of the regional medical laboratory center is a prerequisite for evaluation of the service quality of the regional medical laboratory center and subsequent research on service quality improvement. Only by accurately identifying the core stakeholders of the regional medical testing center, can we determine the respondents of the subsequent questionnaire distribution, and complete the scale correction and questionnaire design.

The stakeholders of regional medical laboratory centers involve a wide range of industries and organizations, as shown in Figure 5.2. In exploring the operation and management of regional medical laboratories centers, we can identify several key stakeholders.

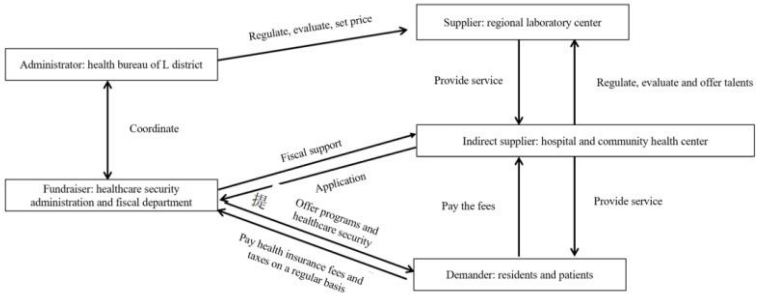

Figure 5.2 stakeholders of regional medical laboratory centers and their inter-relationship

1. Supplier:

Direct supplier: refers to the regional medical laboratory center itself, which is responsible for providing professional medical laboratory services, including laboratory testing, interpretation of results, report issuance, technical updates and personnel training.

Indirect suppliers: including medical device manufacturers and in vitro diagnostic companies that provide testing equipment, reagents, consumables and technical support for the laboratory center.

2. Demander:

Residents and patients: as a direct users of the laboratory services, their demands and satisfaction directly affect the service content and service quality of the laboratory center, while their health data is an important input for the medical testing.

3. Administrator:

District health bureau: responsible for the administrative supervision, policy formulation, qualification approval, quality control, standard implementation and performance evaluation of the regional medical laboratory center.

4. Fundraiser:

Healthcare security administration: responsible for pricing, reimbursement and cost control of testing services through medical insurance payment policies, and can influence the inflow of funds and business strategies of the laboratory center.

Financial department: responsible for financial support for the construction and operation of regional medical laboratory centers, including initial investment, subsidies, and special grants, which is especially critical for public services and infrastructure construction.

In this study, we focus on the main functions and interactions of the above parties to reveal the internal logic and optimization direction of the operation mechanism of regional medical laboratory centers.

Patients: patients are the ultimate beneficiaries and final consumers of medical testing, so their interests should be emphasized. Patients' interests lie in obtaining accurate and timely test results and diagnosis, fair and inexpensive test costs, and at the same time the regional medical laboratory center is required to take the necessary technical and management measures to ensure the confidentiality and security of patient information.

Medical institutions: as the implementor and providers of regional medical testing services, the interests of medical institutions include: optimization of the testing process and improvement of technical levels to meet the needs of patients; provision of rapid and reliable test results for better diagnosis and treatment decisions, and maintenance of their professional reputation; reduction of testing costs and improvement of the operational efficiency of medical institutions.

Health insurance institutions: health insurance institutions are one of the funders of medical testing, and their interests lie in accuracy and validity of the testing results so as to develop appropriate insurance policies and compensation standards based on the testing results. Health insurance institutions need to control medical costs, and avoid waste of medical resources and unnecessary expenses. Regional medical laboratory centers need to provide competitive prices and efficient services to meet the needs of health insurance institutions.

Government departments: government departments are the regulatory and management bodies of regional medical testing services, and their interests lie in formulating appropriate regulations and policies to standardize and regulate the regional medical testing, so as to ensure that the medical testing is legal, compliant and meets the quality standards. They are also

responsible for promoting the sinking of high-quality healthcare resources to the grassroots level to alleviate the pressure on the government expenditure.

Medical equipment and consumables suppliers: medical testing equipment and reagent suppliers are one of the key suppliers of regional medical laboratory centers and need to improve their sales performance to achieve profitability and growth.

Next, the methods of expert interview and field survey are used to screen the core stakeholders. The specific steps are as follows. With the district health bureau and public medical institutions in the district as the targets, we invite 20 experts, including expert consultants with rich experience in hospital management, hospital administrators, health administrators, and scholars in the medical field, and ask them to determine whether or not the listed individuals, groups, and organizations are categorized as the stakeholders of the regional medical laboratory center. At the same time, based on the Mitchell score-based approach, the experts are asked to categorize the selected stakeholders in terms of the three dimensions of legitimacy, urgency, and power, and ultimately come up with a ranking of the stakeholders as subjectively perceived by themselves. The results of the expert consultation are detailed in Annex 1. After counting the results of the expert consultation, it is found that medical institutions rank the highest in terms of inclusion rate (see Table 5.1), so it is finally determined that the survey respondents and questionnaire-distributing groups of this research are the medical staff (including doctors, nurses, and medical technicians) of the 19 community health service centers and the five secondary and tertiary public hospitals in Liwan district.

Table 5.1 Definition of core stakeholders

S.N.	**Gender**	**Who do you think are the core stakeholders, and Why?**
1	M	Medical institutions and government departments. They reduce the burden on government finance and provide services to medical institutions.
2	M	Employees, patients and medical institutions are core stakeholders. They belong to service providers and service users.
3	F	Patients. In addition to reduction of medical costs, they also obtain an efficient experience of medical treatment.
4	M	Medical institutions and patients. Medical services should focus on patient health and revenue. For the long-term healthy development of the third-party regional laboratory centers, only when the interests of both parties are ensured, can it be possible to achieve benign development.
5	M	Medical institutions. It is because they are the core of patient services and are the decision maker and direct risk taker in the selection of a regional laboratory center.
6	M	Government departments are the core stakeholders. “Strengthening the grass-roots healthcare, compensating for the shortcomings, and establishing mechanisms” are the rigid needs of the national health care reform. The government should think comprehensively of how to promote the regional laboratory centers to integrate resources, ensure quality, safeguard the interests of patients, and cooperate with the tertiary hospitals as well as medical colleges and universities, and we do not want to see various departments passing the buck to shirk responsibility.
7	M	The core stakeholders are patients, the government, and the medical institutions.

S.N.	Gender	Who do you think are the core stakeholders, and Why?
8	M	The core stakeholders are medical institutions, patients, and the government.
9	M	The core stakeholders are medical institutions, patients, and the government.
10	M	The core stakeholders are medical institutions, patients, and the government.
11	M	The core stakeholders are medical institutions, the government, and patients.
12	M	The core stakeholders are medical institutions, the government, and patients.
13	M	Medical institutions. They serve as a connecting link between the preceding and the following. They are related to the largest number of stakeholders, and their decisions affect the interests of the widest range of stakeholders.
14	M	Hospitals, government, and testing organizations.
15	F	Hospitals and the government.
16	F	Hospitals, patients, and health insurance are the core stakeholders, because patients who go to the primary and secondary hospitals can enjoy testing programs offered by tertiary hospitals. The improvement of the diagnostic level of doctors can retain patients and enhance the visibility of the hospital. The test can be mutually recognized within the region to reduce the duplication of prescription to avoid repeated payment. It reduces the health insurance and financial expenditures, and at the same time, cuts down expenses.
17	M	1. Medical institutions: academic development; 2. Government: social progress; 3. Operating institutions: institutional development.
18	M	Medical institutions and patients
19	F	Medical institutions, the government, and patients
20	M	Medical institutions are the core stakeholders, as well as the providers, organizers, and leaders of the regional medical laboratory center model

5.2.2 Selection of measurement scale

Service quality models emerged in the 1980s, including the SERVQUAL scale proposed by the Parasuraman, A., Zeithaml, V. A., & Berry, L. L. team (Parasuraman et al., 1988), and the SERVPERF scale developed by Clorindo and Taylor (1992) on the basis of the SERVQUAL scale. After the 1990s, some specialized healthcare service quality scales emerged to address the specificities of the healthcare field, such as the HEALTHQUAL scale, and PubHosQual and HospitalQua scale. Although the subsequent measurement scales are further improvements to the SERVQUAL scale, and can better measure the level of service quality in the healthcare field, scholars at home and abroad still prefer the SERVQUAL scale rather than other scales, which is because the SERVQUAL model can better ensure the consistency of research (Ko and Chou, 2020). In this research, we discuss the service quality of the regional medical laboratory center and the reasons for the service quality gaps based on the gap model of service quality proposed by Parasuraman, A., Zeithaml, V. A., & Berry, L. L., and using the SERVQUAL scale proposed by Parasuraman, A., Zeithaml, V. A., & Berry, L. L. can ensure the consistency of the study. Therefore, we finally choose the SERVQUAL scale as the measurement scale.

5.2.3 Modification of SERVQUAL

SERVQUAL model, as a service quality evaluation tool, is born in continuous innovation and

evolves in change to adapt to the changing needs and development trends. On the basis of in-depth understanding and full demonstration of the essential features of the SERVQUAL model, when applying it to the healthcare industry, we need to make appropriate adjustments and improvement according to the uniqueness of the healthcare industry and the actual needs of this study. Only in this way, can we ensure the model's scientificity and applicability in the field of medical laboratory services, so that it can accurately reflect and improve the service quality of the regional medical laboratory centers and the customer satisfaction. In addition, the SERVQUAL scale originates from the developed Western countries which differ from the developing countries in terms of the cultural and economic contexts. In order to use this scale in developing countries such as China, we should make appropriate modifications according to the cultural context of China. In fact, most studies based on the SERVQUAL scale have created new dimensions based on the traditional SERVQUAL scale by integrating industry characteristics and social contexts (Teshnizi et al., 2018).

Based on the in-depth comparison and analysis of the current healthcare service quality evaluation standards and their quantitative indicators, and drawing on the essence of previous research results, this study adopts a variety of qualitative and quantitative research tools, such as expert brainstorming and field interviews, to revise and optimize the five core dimensions (namely, reliability, responsiveness, assurance, empathy, and tangibles) covered by the classic SERVQUAL scale and the 22 concrete items. This process aims to ensure that the scale can accurately fit the service characteristics and actual needs of the regional medical laboratory center, and ultimately summarize a set of exclusive dimensional system and specific evaluation indexes applicable to the evaluation of service quality of regional medical laboratory centers as shown in Table a.1.

In the specific modification process, we adopted a combination of three methods: literature method, expert brainstorming method and field research method to modify the indicators of the scale.

First, On the basis of a systematic review of relevant literature and in-depth field investigation at the regional medical laboratory center, we structured and clarified our research ideas, and then constructed questionnaire items suitable for this study. In this process, we focused on referring to previous empirical research results on the use of the SERVQUAL scale to assess service quality, especially on the five core dimensions of the SERVQUAL scale: tangibles, reliability, responsiveness, assurance, and empathy. In the organization and analysis of relevant literature, we screened and learned from the contents closely related to the topic of this research. On the basis of the theoretical framework of service quality evaluation in classical

literature and the mature scale design that has been widely adopted and validated by the industry, we integrated these theoretical essence and practical experience into the design of questionnaire of service quality evaluation for regional medical laboratory centers, which ensures the scientificity and applicability of the scale, and we hope that the scale can more accurately reflect the current status of the services and the quality level of the regional medical laboratory centers. In addition, based on the summary and understanding of the industry characteristics and service characteristics of regional medical laboratory centers elaborated in Chapter 3, we designed the specific measurement items under the five primary indicators and formulated the first draft of scale.

Then, in order to further enhance the scientificity and accuracy of the questionnaire, we actively engaged in in-depth exchanges and discussions with academic experts. I have repeatedly presented the theoretical model of this research and the research variables involved in the academic seminars inside and outside my research team. We had detailed discussion on the meaning of each variable in the questionnaire, the logical correlation among them, and the various details that may be encountered in the measurement process. After extensive consultation with experts, we conducted a careful review and first-round revision of the question items, expressions and format layout of the questionnaire, and finally formed the second draft of the questionnaire. We invited six experts of management and public health (four with doctoral degree, two are management experts and the other two are public health experts, and two with master's degree, one is management expert and the other one is public health expert) to list the specific question items based on the five dimensions of the original SERVQUAL scale. The following principles were required to be followed during the process.

In formulating the service quality evaluation indicators of regional medical laboratory centers, we adhere to the principles of representativeness and value orientation, emphasizing that the selected indicators should not only have good representativeness and be able to accurately capture and measure the key features of the laboratory center services, but also avoid the excessive number of indicators that would lead to a cumbersome and redundant evaluation process and increased difficulty in the analysis of the results, and in particular, we should eliminate the duplication and redundancy among the indicators. Therefore, in the screening of indicators, we do not simply take all the indicators we can find into consideration. Instead, we rigorously select an appropriate number of indicators with substantive significance according to the actual evaluation needs.

In addition, the research emphasizes the systematic and scientific nature of the evaluation indicators. The production process of medical services is complex and diversified, so the

evaluation indicators should have an intrinsic logical connection between them. They should both avoid overlapping and have clear boundaries, forming a clear hierarchical and structured indicator system. In other words, the higher-level indicators are an abstraction of the lower-level indicators, while the lower-level indicators can fully interpret the higher-level indicators, demonstrating obvious systematicity. The selection of indicators must also follow the evidence-based concept. In other words, all selected indicators should have solid evidence support, clear source basis, and precise conceptual definitions, and should be able to accurately highlight the core services provided by the regional medical laboratory center. Only in this way can we ensure that the selected evaluation indicators are scientific and reasonable, which can effectively reflect the current status of the service quality of the laboratory center and provide a strong guide for future improvement.

Furthermore, this study also focuses on their operability when formulating evaluation indicators. This means that the selected indicators should not only meet the needs of the study and the development of regional medical laboratory centers, but also ensure that the users can easily carry out data collection, implementation of evaluation process and horizontal comparison and analysis in actual operation. In short, data collection is simple and fast, evaluation process is easy to implement, and measurement results can be visualized and compared.

After these rigorous research processes, the research team conducted a second comprehensive revision of the questionnaire through field visits and in-depth exchanges with industry experts. First, through the introduction of the supervisor and our own connections in the industry, we conducted a series of in-depth interviews with six senior managers with profound theoretical knowledge of management and rich practical experience in the management of regional medical laboratory centers. We consulted opinions of the experts on whether the logical relationship between the variables involved in the study fits the actual situation of the laboratory center, whether the variables used in the scale can accurately reflect the key issues in the process of service delivery, and whether the expressions of the questionnaire are too theoretical and not easy to understand. In order to further ensure that the language of the questionnaire is easy to understand and avoid the use of overly professional or academic words, the research team then communicated face-to-face with two business managers who do not have an academic background but have certain knowledge of organizational management, and discussed and revised the expression of each question in the questionnaire one by one, striving to make the language of the questionnaire plain and easy to understand. After this round of meticulous polishing, the third version of the questionnaire was

finally formed.

5.2.4 Questionnaire design

The questionnaire design mainly follows three principles as follows. First, consistency of logical principle. The items are from easy to difficult, and the scoring is from specific items to abstract items, so that the questionnaire is more in line with the daily habits of the respondents. Second, the principle of easy to operate. The questionnaire is mainly designed to analyze, organize, and calculate, and all the question items are operable. Third, the principle of being simple and easy to understand. Rare words or too specialized words should not be used, as it will be difficult for the public to understand.

The questionnaire is mainly divided into three parts. The first part is the survey introduction and filling instructions, with the former aiming to clarify the purpose of the survey and eliminate doubts, and the latter aiming to enable the respondents to fill out the questionnaire more effectively and ensure that the questionnaire is true and reliable. The second part is the main body of the questionnaire, consisting of 30 question items. First, there are 8 basic question items which aim to analyze the basic characteristics of the respondents. Second, there are 22 specific question items on the five dimensions of service quality (reliability, empathy, responsiveness, tangibles, and assurance) designed based on the SERVQUAL scale, and under each dimension there are two aspects: service perception and service expectation. These questions require the respondents, in the form of scores, to indicate how they feel about a service, and what they expect from that service (and how important they are). This questionnaire adopts the 5-point Likert scale, with 1-5 representing five degrees, 1 representing very poor, 2 representing relatively poor, 3 representing average, 4 representing relatively good, 5 representing very good. It enables the investigator to make judgments in a clear and quick manner, saves time of the survey, and improves the efficiency as well. In order to ensure the reasonableness and effectiveness of the questionnaire design, we carry out a pre-test of the questionnaire, purify the question items, and finally form the final draft of the questionnaire.

5.2.5 Data collection and pre-processing

This study adopts an online method to distribute and collect the questionnaires. We chose “WJX.cn” as our questionnaire distribution and collection tool, a platform highly recommended for its professionalism and practicality. It is a cloud-based service system that integrates online questionnaire design, data collection, personalized report generation and in-depth analysis of

survey results. Compared with traditional paper-based questionnaires and other online survey tools on the market, it has significant advantages in terms of ease of operation, user-friendliness and cost-effectiveness. Users do not need to have professional programming skills to quickly create and release online questionnaires, and get real-time feedback of results through the system's powerful data analysis functions. It is because of these advantages that "WJX.cn" is widely used by enterprises, academic research organizations and individual users in various industries, making it an ideal choice for conducting efficient and accurate market research and social surveys. In this research, we have also made full use of the features of "WJX.cn" to ensure the smooth implementation of the questionnaire design, distribution, collection and subsequent data processing. The questionnaire is filled out independently by the survey respondents. If there are any questions, the respondents can contact the researcher for explanation, but no personal opinion can be provided or implied to avoid information bias. Ethical approval for the study has been obtained (NFYKDX001).

The service targets of the regional medical laboratory center are hospitals and community health service centers in the administrative district, so the questionnaires were distributed to the medical staff of 5 district hospitals and 19 community health service centers in Liwan district, and a total of 336 questionnaires were collected. In order to ensure data quality, data cleansing was first carried out. We deleted questionnaires that took less than 60 seconds to fill in and questionnaires whose answers were all the same (after evaluation, the average time to fill in the questionnaire is 86 seconds, and the fastest time is 70 seconds), and a total of 4 invalid questionnaires were excluded. Finally, the number of samples qualified analysis was 332.

In this study, we used the statistical analysis software STATA 17.0 for in-depth statistical processing and interpretation of the collected data. For the basic information of the survey respondents, we used frequency counts and percentages for descriptive statistics, which can clearly show the distribution of various types of characteristics in the sample and the relative proportion. For the respondents' expectations and perceptions of the service quality of regional medical laboratory centers, we calculated and reported the corresponding averages in order to compare the gap between the expected level and the perceived experience.

Furthermore, in order to visualize the current status of service quality and its match with expectations, we constructed a two-dimensional analysis chart using the IPA (Importance-Performance Analysis) method. Specifically, the horizontal axis represents the average scores of expectation of each service quality indicator from the perspective of survey respondents, namely, ratings of importance; the vertical axis shows the average scores of perception of each indicator in the actual experience, namely, ratings of performance. We also introduced two

reference lines representing the average scores of expectation and perception of the overall service quality, so as to more intuitively identify the obvious shortcomings of services in the regional medical laboratory centers, namely, those areas that are considered important by the respondents but with low actual perception scores, and these are the key points for improvement and optimization. Through this method, we can use the graph to visually judge and determine the Center's future focus on improvement of service quality.

5.2.6 Basic information of the sample

As shown in Table 5.2, in terms of gender distribution, there are 83 male respondents, accounting for 24.63% of the total number of respondents, and 254 female respondents, accounting for 75.37%. There are more females participating in the survey, accounting for more than two thirds.

Table 5.2 Basic information of the sample

Primary indicator	Secondary indicator	Frequency	Percentage
Gender	Male	83	24.63%
	Female	254	75.37%
Age	29 or below	66	19.58%
	30-39	159	47.18%
	40-49	86	25.52%
	50 or above	26	7.72%
Hospital level	Secondary hospitals	111	32.94%
	Community health service centers	226	67.06%
Educational background	Below bachelor	56	16.62%
	Bachelor	253	75.07%
	Master	25	7.42%
	Doctor	3	0.89%
Personnel type	Physician	132	39.17%
	Nurse	139	41.25%
	Medical technicians	66	19.58%
Professional title	Junior	111	32.94%
	Intermediate	165	48.96%
	Associate senior	43	12.76%
	Full senior	4	1.19%
	Unrated	14	4.15%
Job position	Middle management or above	53	15.73%
	General professional and technical personnel	284	84.27%
Length of service	5 years or below	71	21.07%
	6-15 years	157	46.59%
	6-25 years	71	21.07%
	26 years or above	38	11.28%

In terms of age distribution, the respondents are divided into four age groups. There are 66 respondents under 29 years old, accounting for 19.58% of the total respondents. The group of

30-39 years old has 159 respondents, accounting for 47.18%, which is the largest percentage. There are 86 respondents aged 40 to 49 years old, accounting for 25.52%. There are only 26 respondents aged 50 years old and above, accounting for only 7.72%. It can be seen that the participants in the survey are mainly those aged 30-49, while the participation of young and old people is relatively low.

In terms of the hospital level, the number of respondents filling out the survey in community health centers is 226, accounting for 67.06%, while the number of respondents filling out the survey in secondary hospitals is only 111, accounting for 32.94%. It can be found that the response rate of community health service centers for this kind of survey is significantly higher than that of secondary hospitals.

In terms of the distribution of education, the percentage of respondents with bachelor's degree and above reaches 82.49%, and the percentage of those with bachelor's degree is the highest, reaching 75.07%. The percentage of those with education below bachelor's degree is 16.62%, and the percentage of those with doctoral degree and above is only 0.89%. It can be seen that the majority of the respondents of this survey is people with bachelor's degree and above.

In terms of the type of personnel, there are mainly three types of personnel, including doctors, nurses and medical technicians, of which the number of nurses is the largest, accounting for 41.25%, followed by doctors and medical technicians, accounting for 39.17% and 19.58% respectively. It can be seen that the respondents are mainly medical staff in the hospitals.

In terms of professional titles, the vast majority of the respondents hold intermediate professional titles, accounting for 48.96%, followed by those holding junior professional titles, accounting for 32.94%. The proportions of those with associate senior professional title and unrated personnel are relatively low, accounting for 12.76% and 4.15% respectively. The proportion of those with senior professional title is the lowest, accounting for only 1.19%.

In terms of job positions, the number of middle management or above is 53, accounting for 15.73%, and the number of general professional and technical staff is 284, accounting for 84.27%. It can be seen that the number of general professional and technical staff is significantly larger than that of middle management or above, indicating that the proportion of general professional and technical staff is higher in this survey.

In terms of length of service, most of them have been worked for 6 to 15 years, accounting for 46.59%, followed by 5 years or less and 26 years or more, accounting for 21.07% and 11.28% respectively. The proportion of those with 6-25 years of service is also 21.07%. It can be seen

that the majority of the respondents have neither too short nor too long years of service.

From the results of the descriptive statistical analysis of the respondents, it can be seen that the sample data contains different genders, different age levels, different lengths of service, and different levels of education, and these characteristics guarantee the validity of the sample.

5.2.7 Reliability analysis of survey results

Reliability, or stability of measurement results, refers to the degree of consistency of the results obtained when the same research methodology is used to measure the same object repeatedly. There are many ways to measure reliability, such as test-retest reliability method, alternate-form method, split-half reliability method, and Cronbach's alpha coefficient method, of which the Cronbach's alpha coefficient method is the most widely used at present. Only after the reliability is up to the standard, can we test the validity, so we first carry out reliability analysis of the data, and the evaluation criteria of the Cronbach's α coefficient is shown as per Table 5.3.

Table 5.3 Evaluation criteria of Cronbach's α coefficient

Range of α value	Reliability represented by the α value
$\alpha>0.8$	Very high
$0.7<\alpha<0.8$	Acceptable
$0.6<\alpha<0.7$	Barely acceptable
$0.3<\alpha<0.6$	Relatively low
$\alpha<0.3$	Very low

In this research, we use Cronbach's α coefficient as the basis to test reliability of the external questionnaire for the service quality of the regional medical laboratory center. It is found that the overall Cronbach's alpha coefficient is greater than 0.7, indicating that the scale has a relatively good reliability, and the specific details the Cronbach's alpha coefficient are shown as per Table 5.4.

Table 5.4 Cronbach's α coefficient of different dimensions

Dimension	Amount of indicators	Cronbach's α coefficient	
		Expectation	Perception
Tangibles	4	0.9195	0.9248
Reliability	5	0.9538	0.9467
Responsiveness	4	0.9616	0.9625
Assurance	4	0.9527	0.9394
Empathy	5	0.9520	0.9443
Total	22	0.9798	0.9778

5.2.8 Validity analysis and factor analysis of survey results

After passing the reliability test, the scale needs to be tested and analyzed in terms of validity. The validity of the questionnaire represents the degree of effectiveness of the questionnaire,

which enables the questionnaire to effectively measure the service quality through validity. The design of the questionnaire on the service quality of the regional medical laboratory center strictly follows the theoretical framework of the service quality gap model, and in the process of questionnaire formulation, we have two rounds of in-depth discussions and modifications with the senior management to ensure that the questionnaire content is effective and relevant. Through this rigorous formulation process, the questionnaire content can accurately reflect the dimensions of the service quality gap model, which in turn effectively captures the actual situation of regional medical laboratory centers in terms of service quality, and ensures a high level of validity of the questionnaire content. This questionnaire design not only objectively evaluates the current status of service quality in the laboratory centers, but also provides strong data support and direction guidance for future service quality improvement.

In this research, KMO test (Kaiser-Meyer-Olkin) and Bartlett's Test of Sphericity are conducted using Stata 17.0. If the *p* value of Bartlett's test of sphericity is smaller than 0.05, it means that the variables have a very significant correlation; if the KMO value is closer to 1, it means that the correlation between them is stronger, and on the contrary, if the KMO value is closer to 0, it means that the relationship is getting weaker. The specific criteria are shown as per Table 5.5.

Table 5.5 KMO value Bartlett p value

Category	Range of value	Application for factor analysis
KMO value	>0.9	Extremely suitable
	0.8<KMO<0.9	Very suitable
	0.7<KMO<0.8	Suitable
	0.6<KMO<0.7	Not too suitable
	0.5<KMO<0.6	Barely suitable
	<0.5	Not suitable
Bartlett *p* value	< or = 0.05	Suitable

The details of the specific validity analysis data of the scale are shown as per Table 5.6. It can be seen that the KMO value of the service quality scale is 0.951, while the significance of Bartlett's test of sphericity is 0.000, which indicates that the design of this questionnaire is relatively accurate and valid, and the correlation between the data is also relatively good. This service quality scale can be used for further factor analysis.

Table 5.6 KMO and Bartlett's test

	KMO value	Bartlett *p* value
Expectation	0.956	0.000
Perception	0.964	0.000
Total	0.951	0.000

Factor analysis can be divided into exploratory factor analysis and confirmatory factor analysis. As the five dimensions of service quality are determined, the confirmatory factor

analysis method is more applicable. The construct validity of the questionnaire is first judged by comparing the factor loadings of each item on each factor. We assume that each sub-item can be matched to the corresponding factor, and use principal component analysis and variance maximum rotation method to analyze the questionnaire and the results are shown as per Table 5.7.

Table 5.7 Confirmatory factor analysis of service quality

SN	Item	Factor				
		Tangibles	Reliability	Responsiveness	Assurance	Empathy
T1	Modern equipment	0.62				
T2	Comfortable environment and facilities	0.53				
T3	Clean and well-groomed appearance of employees	0.43				
T4	Professional service support facilities	0.49				
R1	Service commitments met within deadlines		0.60			
R2	Professional fulfillment of service commitments		0.62			
R3	Perception of the company to be reliable		0.54			
R4	Well-established emergency plans		0.55			
R5	Sound service qualifications		0.52			
P1	Timely response to customer complaints			0.88		
P2	Timely response to customer needs			0.93		
P3	Timely answer to customer questions			0.90		
P4	Timely notification of service progress			0.72		
A1	Confidentiality awareness of employees				0.44	
A2	Sense of				0.49	

SN	Item	Factor				
		Tangibles	Reliability	Responsiveness	Assurance	Empathy
	assurance of the service process					
A3	Sense of reliability of the employee's words				0.50	
A4	Adequate support and protection provided by the company for the employees				0.50	
E1	Comprehensive feedback channels					0.95
E2	Convenient delivery time					0.77
E3	Personalized services					0.93
E4	Getting things done once and for all					0.87
E5	Good sense of social responsibility					0.72

Factor loadings are correlations between latent variables and observed indicators. Confirmatory factor analysis often has a minimum requirement for factor loadings, but there has been no uniform standard for the minimum value, and scholars have proposed some empirical guidelines. In factor analysis, standardized factor loadings are an important indicator of the strength of the relationship between a variable and a factor. Various scholars have suggested different thresholds to assess the significance of factor loadings. The ideal standardized factor loading estimate should be 0.5 or higher, and ideally should be no less than 0.7, which implies that the correlation between the variable and the factor is relatively significant, and can explain a large portion of the variance in the variable. For interpretive purposes, even for studies with relatively small samples, 0.4 can be accepted as the minimum threshold for factor loadings.

In summary, the appropriate thresholds for standardized factor loadings may vary in different research fields and contexts, but it is generally believed that the higher the loadings, the stronger the relationship between the factor and the variable, and the more reliable the factor structure will be. Researchers need to be flexible in setting the significance level of factor loadings, taking into account the actual research purpose, sample size, and recognized standards of practice in the academia. As for the scale used in this research, the loading values of the

factors under the five dimensions are all greater than 0.4, and most of the factor loadings are above 0.5. Therefore, the overall construct validity of the scale is good.

As shown in Table 5.8,The composite reliability (CR) values of the latent variables of each dimension of the service quality scale are 0.917 (0.924), 0.952 (0.946), 0.968 (0.966), 0.968 (0.958), and 0.959 (0.954), all greater than 0.7, and the average variance extracted (AVE) values are 0.745 (0.758), 0.801 (0.779), 0.871 (0.871), 0.849 (0.812), and 0.797 (0.769), all greater than 0.5, indicating that the scale has good convergent validity. In addition, statistical analyses show that the square roots of the AVE of each latent variable are greater than the correlation coefficient with other latent variables. It means that the trait represented by each latent variable can be measured relatively independently in the data. There is a high degree of differentiation between the scales and no serious measurement overlap. Therefore, it can be concluded that the regional medical laboratory center service quality evaluation scale demonstrates good discriminant validity in its design. In other words, the latent dimensions can be clearly distinguished from each other, corresponding to different aspects of service quality, which guarantees the reliability and validity of the study results.

Table 5.8 Convergent validity and discriminant validity

Dimension	Composite Reliability (CR)		Average variance extracted (AVE)	
	Expectation	Perception	Expectation	Perception
Tangibles	0.917	0.924	0.745	0.758
Reliability	0.952	0.946	0.801	0.779
Responsiveness	0.968	0.966	0.871	0.871
Assurance	0.968	0.958	0.849	0.812
Empathy	0.959	0.954	0.797	0.769

5.3 Result analysis

5.3.1 Descriptive statistics

As shown in Table 5.9 the mean value of perceived service quality of the regional medical laboratory center is 4.27, reaching the level of satisfaction, while the mean value of expected service quality is 4.49. The gap between the two is small, and the services offered by the regional medical laboratory center can meet 95% of the customer's expectations (4.27/4.49), indicating that the overall service level of the regional medical laboratory center is relatively high, but there is still room for improvement. To be specific, the customers pay more attention to the dimensions of tangibles and reliability, and the mean values of expected service quality are 4.55 and 4.54 respectively. The mean values of perceived service quality are 4.36 and 4.37 respectively, and the gap is smaller than the overall gap in perceived and expected service

quality. It indicates that the regional medical laboratory center is able to correctly perceive customer needs and rationally allocate resources to meet the needs. In addition, the service quality of the responsiveness dimension has the worst performance, and the gap between expectation and perception reaches 0.26, which is higher than the overall service quality gap. The service quality of the dimensions of assurance and empathy also performs poorly, and both are higher than the overall service quality gap. Therefore, the regional medical laboratory center needs to pay more attention to the service management in dimensions of responsiveness, assurance and empathy, especially the dimension of responsiveness, so as to better meet the service needs of customers. Data shows that the standard deviation of each dimension is basically less than 1, indicating that there is no big difference between different customers' perception and expectation of service quality.

Table 5.9 Descriptive statistics

Dimension	Perceived mean value	Expected mean value	Perceived standard deviation	Expected standard deviation
Tangibles	4.36	4.55	0.75	0.65
Reliability	4.37	4.54	0.77	0.67
Responsiveness	4.19	4.45	1.03	0.86
Assurance	4.25	4.48	0.93	0.80
Empathy	4.20	4.45	0.94	0.81
Total	4.27	4.49	0.80	0.69

The mean scores for the question item "The Regional Medical Laboratory Center has modern and intelligent medical equipment" shown in Table 5.10, are 4.51 and 4.2 for the expected value and perceived value, respectively, which indicates that most of the participants have high expectations towards modern and intelligent medical equipment and they perceive a certain degree of satisfaction. There are some differences in the distribution of expected values and perceived values. The distribution of expected values is relatively even, while the distribution of perceived values shows a clear skewed pattern with more high scores. This may imply that the participants' expectations of the medical equipment are more consistent, while there are differences in their evaluation of the perceived values. As for the expected value and perceived value, most respondents choose the 5-point option, indicating that most participants hold a relatively high evaluation of the medical equipment in the regional medical laboratory center. The number of options of 3 points and below is relatively small, indicating that most participants have high expectations and perceptions of the medical equipment in the regional medical laboratory center.

Table 5.10 Expected and Perceived Values for Various Services at the Regional Medical Laboratory Center

Item Description	Expected	Perceived

	Average	Average
Modern and intelligent medical equipment	4.51	4.20
Laboratories and lounges are clean, neat, and comfortable	4.50	4.35
Employees are properly-dressed and well-groomed	4.63	4.50
Complete service auxiliary facilities	4.55	4.37
Issue test reports quickly	4.51	4.31
Test reports are accurate and professional	4.49	4.29
Sufficient communication and reasonable medical expenses	4.58	4.45
Fully assessed risks and formulated countermeasures	4.54	4.36
Qualifications for various services stipulated by the state and industry	4.59	4.43
Timely response to customer complaints	4.44	4.18
Respond to individualized customer needs	4.42	4.14
Respond to and answer customer questions in a timely manner	4.43	4.18
Provide full-process service status query and inform customers at key service nodes	4.53	4.27
Protect customer privacy	4.59	4.46
Demonstrate excellent professional quality in service	4.45	4.21
Communicate sufficiently with customers	4.45	4.17
Provide employees with adequate institutional security and resource support	4.45	4.18
Proactive and regular collection of customer needs and suggestions for improvement	4.44	4.15
Reasonable delivery time	4.47	4.27
Provide customers with personalized services	4.43	4.15
Conduct a variety of tests at once without mistakes	4.37	4.04
Environmentally-friendly process for medical waste disposal	4.54	4.39

In summary, participants hold high expectations and perceptions of the modern and intelligent medical equipment owned by the regional medical laboratory center, but there are differences in the evaluation of the actual perceived value. It is recommended to further investigate and analyze the reasons for the differences in the perceived values and take corresponding measures to improve participants' satisfaction.

The mean scores for the question item "The laboratories and lounges of the Regional Medical Laboratory Center are clean, neat, and comfortable" shown in Table 5.10, are 4.5 for the expected value and 4.35 for the perceived value. This indicates that most respondents are satisfied with the cleanliness and neatness of the laboratories and lounges. As for the expected values, most respondents (210, 63.5%) choose the 5-point option, indicating that most of them have high expectations of the cleanliness and tidiness of the laboratories and lounges. As for the perceived values, most respondents (180, 54.6%) choose the 5-point option, indicating that most people are satisfied with the cleanliness and tidiness of the labs and lounges. The distributions of the expected and perceived values are similar, both showing a gradually decreasing trend, indicating that most people's expected values and perceived values are relatively consistent.

The mean scores for the question item "Employees in the regional medical laboratory center are properly-dressed and well-groomed" shown in Table 5.10, are 4.63 and 4.5 for the expected

value and perceived value, respectively. On the whole, the customers are relatively satisfied with the dress code and grooming requirements of the employees, but the expected value is slightly higher than the perceived value. As for the expected value, most respondents (237, 71.51%) choose the 5-point option, followed by the 4-point option (72, 21.36%), indicating that most of the customers have relatively high expectations of dress code and grooming of employees. As for the perceived value, most respondents (211, 63.8%) choose the 5-point option, followed by the 4-point option (84, 24.93%), indicating that most of the customers are satisfied with the dress code and grooming of employees. Generally speaking, the average scores for both expected values and perceived value are above 4.5, indicating that customers have high expectations of the dress code and grooming of employees and believe that these requirements have been met to some extent.

In summary, the overall situation of the dress code and grooming of the employees is good, but there are still some employees who have higher expectations. Therefore, training and management of employee dress codes can be further strengthened to improve employee satisfaction and the overall corporate image.

The mean scores for the question item "The Regional Medical Laboratory Center has complete service auxiliary facilities (such as directional signs, service flow charts, and manuals)" shown in Table 5.10, are 4.55 and 4.37 for the expected value and perceived value, respectively, indicating that the participants have high expectations and perceptions of the service auxiliary facilities of the Regional Medical Laboratory Center. Most respondents choose the 5-point option in both the expected value and perceived value, accounting for 67.36% and 57.86% respectively. It indicates that the majority of the participants in the survey feet that the service auxiliary facilities at the Regional Medical Laboratory Center perform well in meeting their expectations and perceptions. The lowest rated option in expected value and perceived value is 1-point, which occupies 0.59% and 0.89% respectively. This indicates that very few participants in the survey express low expectations and perceptions of the service auxiliary facilities. The proportions of those choose the 4-point option in the expected value and perceived value are 23.15% and 25.52% respectively, indicating that a significant portion of the respondents have moderate expectations and perceptions of the service auxiliary facilities of the regional medical laboratory center.

In summary, the participants hold high expectations and perceptions of the service auxiliary facilities of the Regional Medical Laboratory Center as a whole, and most of them believe that the service auxiliary facilities meet their expectations and perceptions, but still some respondents express low ratings of the expectations and perceptions of the service auxiliary

facilities.

The mean scores for the question item “The Regional Medical Laboratory Center is able to issue test reports quickly” are shown in Table 5.10. As for the expected value, the majority of the respondents (65.28%) believe that the Regional Medical Laboratory Center is able to issue test reports quickly, which is significantly higher than the other options. The average score of the expected value is 4.51, which indicates that the respondents have relatively high expectations of the laboratory center in general. In terms of perceived value, the same majority of respondents (54.9%) believe that the Regional Medical Laboratory Centers is able to issue test reports quickly, but the percentage is slightly lower than that in the expected value. The average score of perceived value is 4.31, which is lower compared to the average score of the expected value, which may indicate that the speed of report issuance perceived by the respondents in their actual experience does not meet their expectations.

In summary, most of the respondents (60.09%) believe that the Regional Medical Laboratory Center is able to issue test reports quickly in terms of both expected and perceived values, which indicates that the respondents’ evaluation of the laboratory center is generally positive. However, the average score of the perceived value is slightly lower than that of the expected value, which may suggest that there is room for improvement in some aspects of the laboratory center to meet the expectations of the respondents.

The mean scores for the question item “The test reports offered by the Regional Medical Laboratory Center are accurate and professional” are shown in Table 5.10. As for the expected value, most respondents (214, 64.69%) choose the 5-point option, followed by 4-point (77, 22.85%), and the average score is 4.49. It indicates that most respondents have high expectations for the accuracy and professionalism of the test reports. As for the perceived value, most respondents (179, 54.3%) choose the 5-point option, followed by 4-point (87, 25.82%), and the average score is 4.29. It indicates that most respondents hold high perceptions of the accuracy and professionalism of the test reports. .

The mean scores for the question item “The Regional Medical Laboratory Center communicates sufficiently with its customers and the medical expenses are reasonable without extra charges” shown in Table 5.10, are 4.58 and 4.45 for the expected and perceived values, respectively. It indicates that most of the respondents’ expectations and perceptions of the service do not differ much. In terms of expected value, most respondents choose the 5-point option, accounting for 69.44%; in terms of perceived value, most respondents choose the 5-point option, accounting for 61.72%. It indicates that most of the respondents are relatively satisfied with the expectations and perceptions of the services offered by the regional medical

laboratory center.

In summary, most respondents hold a relatively high evaluation of the performance of the Regional Medical Laboratory Center in terms of communication, fee reasonableness and avoidance of extra charges.

The mean scores for the question item "The Regional Medical Laboratory Center has fully assessed the risks that may arise during the service process and has formulated corresponding countermeasures" are shown in Table 5.10. In terms of expected value, most of the respondents have high expectations of the service process, with most respondents choosing the 5-point option (very satisfied), accounting for 66.77%. The average score is 4.54, which indicates that the overall expected value is high. In terms of perceived value, the average score of respondents' perceived value of the service process is 4.36, which is lower than that of the expected value. The percentage of respondents who choose the 5-point option (very satisfied) is 58.16%, which is lower than the percentage of expected value. It indicates that there are some problems or deficiencies in the actual service process, making the actual perceived value lower than the expected value. The differences between the expected value and perceived value are reflected in several aspects. The proportions of respondents who choose 1-point (very dissatisfied) are 0.3% and 0.59% respectively in the expected value and perceived value, which is not a big difference. However, the proportions of respondents who choose 5-point (very satisfied) are greatly differed, reaching 66.77% and 58.16% respectively. It indicates that some of the respondents are dissatisfied with the perceived service process. Therefore, the regional medical laboratory center needs to pay attention to these dissatisfied voices and further improve the service quality and measures.

The mean scores for the question item "The Regional Medical Laboratory Center has the qualifications for various services stipulated by the state and the industry" shown in Table 5.10, are 4.59 and 4.43 for the expected value and the perceived value, respectively. In terms of expected value, most respondents (230, 69.44%) choose the 5-point option, followed by 4-point (74, 21.96%). In terms of perceived value, most respondents (204, 61.72%) choose the 5-point option, followed by 4-point (77, 22.85%). It indicates that most respondents give high ratings to the service qualification requirements of the regional medical laboratory center and the overall degree of satisfaction is high.

The mean scores for the question item "The Regional Medical Laboratory Center is able to respond to customer complaints in a timely manner and actively deal with them" are shown in Table 5.10. In terms of expected value, the majority of customers (66.17%) have high expectations of the center's ability to deal with customer complaints, indicating that customers

have high expectations of complaint handling of the laboratory center. In terms of perceived value, the proportion of those who choose 5-point option is 54.9%, which is slightly lower than the proportion in the expected value. However, both the perceived value and expected value show that customers have a high level of satisfaction with the complaint handling of the laboratory center. The mean value of the average scores of the expected value and perceived value is 4.31, indicating that the overall evaluation of customers on the handling of customer complaints by the laboratory center is good. The difference between the perceived value and the expected value is small, indicating that the medical laboratory center can satisfy the customer expectation in complaint handling.

In summary, the regional medical laboratory center performs well in handling customer complaints, and is able to respond to and actively deal with customer complaints in a timely manner.

The mean scores for the question item "The Regional Medical Laboratory Center can actively respond to the individualized needs of customers" shown in Table 5.10, are 4.42 and 4.14 for the expected value and perceived value, respectively. On the whole, the customers have high expectations and perceptions toward the active response of the laboratory center to individualized needs, with average score over 4 points. In terms of the expected value, most respondents (220, 66.47%) choose the 5-point option, indicating that most customers expect the medical laboratory center to respond actively to individualized needs. In terms of the perceived value, most respondents (179, 54.3%) choose the 5-point option, indicating that most customers believe that the medical laboratory center can respond actively to individualized needs.

In summary, customers have relatively high expectations and perceptions towards the active response of the regional medical laboratory center to individualized needs, and most customers believe that the medical laboratory center is able to respond actively to individualized needs.

The mean scores for the question item "The Regional Medical Laboratory Center is able to respond to and answer customer questions in a timely manner" are shown in Table 5.10. The customers' expectations are generally high, with an average score of 4.43. 65.88% of the customers choose the 5-point option, indicating that they expect the center to respond to and answer customer questions in a timely manner. In terms of perceived value, the average score of customer evaluation is 4.18. 56.08% of customers choose a 5-point option, indicating that they believe the center performs well in responding to and answering customers' questions in a timely manner. In terms of the difference between expectation and perception, it can be seen that the customer expectation is high while the perception is relatively low. This may imply that there is room for improvement in the actual services provided by the regional medical

laboratory center in terms of responding to and answering customers' questions in a timely manner. 7.12% of the respondents choose 3-point and 20.47% choose 4-point, and the sum of these two proportions has exceeded 25%, indicating that about one-fourth of the customers have a neutral attitude towards the service performance of the regional medical laboratory center.

The mean scores for the question item "The Regional Medical Laboratory Center can provide full-process service status query and inform customers at key service nodes" shown in Table 5.10, are 4.53 and 4.27 for the expected value and perceived value, respectively. The average score of the expected value is slightly higher than that of the perceived value, indicating that customers' expected value of the service is slightly higher than their perceived value. As for the expected value and perceived value, most respondents (219 and 181 respectively) choose the 5-point option, which means that most of the customers are satisfied with the services; few respondents (1 and 6 respectively) choose the 1-point option, which means that very few customers are dissatisfied with the service; a few respondents (15 and 88 respectively) choose the 2-point and 3-point option, which means that part of the customers are moderately satisfied or slightly dissatisfied with the service; relatively large number of respondents (78 and 78) choose the 4-point option, which means that many customers are generally satisfied with the service and there is still room for improvement.

In summary, although most of the customers are satisfied with the service, there is still a part of customers who are moderately satisfied or slightly dissatisfied with the service. It is recommended that the Medical Laboratory Center should further improve its services to increase customer satisfaction.

The mean scores for the question item "Employees of the Regional Medical Laboratory Center can strictly protect customer privacy" shown in Table 5.10, are 4.59 and 4.46 for the expected value and perceived value, respectively, indicating that the customers have high expectations and perceptions of the Regional Medical Laboratory Center to strictly protect their privacy. Most respondents (230, 68.25% and 207, 61.42%) choose the 5-point option, indicating that a significant percentage of customers believe that employees are able to strictly protect customer privacy. Very few respondents (1 or 0.3% and 3 or 0.89%) choose the 1-point option, indicating that only a very small percentage of customers believe that employees are not able to strictly protect customer privacy.

In summary, employees of the Regional Medical Laboratory Center are able to strictly protect the privacy of their customers, and the customers have a high evaluation of the employees' ability to protect their privacy.

The mean scores for the question item "Employees of the Regional Medical Laboratory

Center demonstrate excellent professional quality in their service" shown in Table 5.10, are 4.45 and 4.21 for the expected value and perceived value, respectively, indicating that customers have high expectations and perception of the employees in demonstrating excellent professional quality. As for the expected value, most respondents (53.41%) choose the 5-point option, followed by the 4-point option (26.11%), indicating that most of the employees expect that they can offer very good service to their customers. As for the perceived value, most respondents (53.41%) choose the 5-point option, followed by the 4-point option (26.11%), indicating that most of the employees believe that they are able to offer very good service to the customers.

In conclusion, the employees of Regional Medical Laboratory Center give their customers a feeling of excellent professional quality in their services, most of them expect that they can offer very good service to their customers, and most of them believe that they can offer very good service to their customers.

The mean scores for the question item "Employees take enough time to communicate with customers and make them feel that their problems can be solved" shown in Table 5.10, are 4.45 and 4.17 for the expected value and perceived value, respectively, indicating that employees perform well in communicating with customers. As for the expected value, most respondents (64.99%) choose the 5-point option ("Strongly Agree"), which indicates that most of the customers have high expectations of the employees in communication with customers. As for the perceived value, most respondents (52.23%) choose the 5-point option ("Strongly Agree"), indicating that most customers believe that employee-customer communication can solve problems. The subtotal mean scores of the expected and perceived values are 4.31 and 4.17 respectively, both of which are above 4, further validating the good performance of employees in communicating with customers.

In summary, employees of the Regional Medical Laboratory Center spend enough time communicating with customers and make them feel that their problems can be solved.

The mean scores for the question item "The Regional Medical Laboratory Center can provide its employees with adequate institutional security and resource support to better serve the customers" shown in Table 5.10, are 4.45 and 4.18 for the expected and perceived values, respectively, which means that the expectations and perceptions of the provision of adequate institutional security and resource support by the Regional Medical Laboratory Center is generally high, but the perceived value is slightly lower than the expected value. As for the expected value, most respondents (210, 63.5%) choose the 5-point option, indicating that most employees have high expectations for the laboratory center to provide adequate institutional

security and resource support. As for the perceived value, most respondents (171, 51.93%) choose the 5-point option, indicating that most employees believe that the laboratory center can provide good institutional security and resource support. The distribution of the expected value and perceived value shows that the 4-point option and 5-point option are most frequently selected options, indicating that most employees are relatively satisfied with the institutional security and resource support of the Regional Medical Laboratory Center.

In summary, the Regional Medical Laboratory Center is able to provide desirable services to employees in terms of institutional security and resource support, but still some employees are slightly dissatisfied with the perceived value. Therefore, further improvement and enhancement of the quality of institutional security and resource support can be considered to meet the higher expectations of employees.

The mean scores for the question item "The Regional Medical Laboratory Center asks customers about their needs and suggestions for improvement on a proactive and regular basis" are shown in Table 5.10. The overall expected value is high, with an average score of 4.44, and most respondents (65.58%) choose the 5-point option, indicating that the Regional Medical Laboratory Center performs well in terms of customer expectations and customers have high expectations of its services. As for the perceived value, the average score is 4.15, and most respondents (52.52%) choose the 4-point option ("Agree"). The perceived value is lower compared to the expected value, which may indicate that the services of the Regional Medical Laboratory Center have not yet fully met the expectations of the customers in practice.

In the comparison of the expected and perceived values, it can be seen that customers' expectations are generally higher than their perceptions. It indicates that customers have high expectations of the services of the laboratory center, but the actual experience may not fully meet these expectations. Therefore, the Regional Medical Laboratory Center may need to further improve its services to meet the expectations of its customers.

The mean scores for the question item "The delivery time arranged by the Regional Medical Laboratory Center is very reasonable" shown in Table 5.10, are 4.47 and 4.27 for the expected value and perceived value, respectively. On the whole, the respondents have a high evaluation of the rationality of delivery time arranged by the Regional Medical Laboratory Center. The distributions of the expected and perceived values are similar in that the number of respondents choosing the option gradually increases as the point of the option increases, showing a trend of gradual increase. Most respondents choose the 5-point option in the expected and perceived values, accounting for 61.13% and 53.12% respectively, indicating that the majority of the respondents believe that the delivery time arranged by the Regional Medical Laboratory Center

is very reasonable. The 1-point option has the least number of choices in both the expected and perceived values, accounting for 0.59% and 1.48% respectively, indicating that only a very small number of respondents believe that the delivery time arranged by the Regional Medical Laboratory Center is very unreasonable.

In summary, most of the respondents hold a high opinion of the delivery time arranged by the Regional Medical Laboratory Center and consider it very reasonable.

The mean scores for the question item "The Regional Medical Laboratory Center can provide customers with personalized services" are shown in Table 5.10. The average scores of the expected value and perceived value are 4.43 and 4.15 respectively, indicating that the customers have high expectations and perceptions of the personalized services provided by the Regional Medical Laboratory Center. As for the expected value, most respondents (217, 64.39%) choose the 5-point option, followed by the 4-point option (80, 23.74%), which indicates that most of the customers have high expectations for personalized services. As for the perceived value, most respondents (178, 52.82%) choose the 5-point option, followed by the 4-point option (87, 25.82%), which indicates that most of the customers are highly satisfied with the personalized services provided by the laboratory center. The scores for expected and perceived value are relatively high, indicating that the Regional Medical Laboratory Center has made some achievements in the provision of personalized services. However, the score of perceived value is slightly lower than that of expected value, and there may be some room for improvement.

In summary, the Regional Medical Laboratory Center has achieved some success in providing personalized services, but further improvements are needed to meet customer expectations and increase customer satisfaction.

The mean scores for the question item "The Regional Medical Laboratory Center can meet the needs of customers to conduct a variety of tests at once, and do not make mistakes" are shown in Table 5.10. As for the expected value, customers have high expectations for the laboratory center to meet their needs of conducting a variety of tests at once, and respondents choosing the 5-point option (Strongly Agree) reach 61.72%. As for the perceived value, respondents choosing the 4-point option (Relatively Agree) and 5-point option (Strongly Agree) account for 25.82% and 48.37% respectively, totaling 74.19%, which indicates that the customers have a relatively high satisfaction with the laboratory center. The average scores of the expected value and perceived value are 4.37 and 4.04 respectively, indicating that the customers' expectations are slightly higher than their perceptions. It suggests that there is still room for improvement in meeting the multiple testing needs of customers.

In general, the Regional Medical Laboratory Center performs well in meeting customers' multiple testing needs at one time, but there is still room for improvement. In order to further improve customer satisfaction, the laboratory center may consider taking measures such as process optimization and service quality improvement.

The mean scores for the question item "The Regional Medical Laboratory Center has an environmentally-friendly process and program for the disposal of medical waste" shown in Table 5.10, are 4.54 and 4.39 for the expected value and perceived value, respectively. In general, the respondents have high expectations and perceptions of the environmentally-friendly process and program for the disposal of medical waste. As for the expected value, most respondents (64.99%) choose the 5-point option, followed by those who choose the 4-point option, accounting for 26.41%. It indicates that most of the respondents have high expectations on the environmentally-friendly process and program for disposal of medical waste. As for the perceived value, most respondents (55.49%) choose the 5-point option, followed by those who choose the 4-point option, accounting for 31.16%. It indicates that most of the respondents have high perceptions on the environmentally-friendly process and program for disposal of medical waste.

In summary, the environmentally-friendly process and program for disposal of medical waste in the Regional Medical Laboratory Center has been highly expected and perceived by the respondents, and the overall evaluation is good.

5.3.2 Testing the existence of service quality gaps

Firstly, use the sample T-test method to test the hypothesis H1: "There is a significant difference between the perceived service and expected service of LW Regional Medical Laboratory Center's customers."The principle of questionnaire sample T-test is to use the T-test function to compare and analyze two groups of paired samples to see and infer the difference between the means of the two samples. In this research, we use the T-test of sample means to test whether the service quality gap exists, including the following two parts of the analysis. First, test of the gap between the overall customer service quality expectation and perception; and second, test of the service quality gaps embodied in each specific question item.

The calculation process to test the gap between the overall customer service quality expectation and perception is as follows. Sum up the average scores of all the question items and divide them by the total number of question items to get the scores of the customers' perceived and expected service quality, then use the T-test command of Stata 17.0 to carry out

a T-test on them, and we will get Table 5.11, which presents the test results of the gap between the expected and perceived customer service quality.

As for the test of service quality gaps embodied in each specific question item, the calculation process is as follows. In the survey on the evaluation of the service quality of regional medical laboratory centers, first, by counting the frequency of the ratings given by each respondent to each questionnaire item, we calculated the frequency of all customers' choices for each questionnaire item in terms of both expectations and actual perceptions, and multiplied the frequency with the corresponding scores to obtain the total score for each questionnaire item. These total scores were then aggregated and divided by the number of validly returned questionnaires to obtain the average score for each question item. Following this method, the expected and perceived mean scores were calculated for all question items in turn. Next, we subtracted the expected mean score from the perceived mean score for the same question item to obtain the mean difference between expectation and actual perception on that question item. This process was calculated in the same way for all the questionnaire items throughout the questionnaire.

Finally, we used t-tests to statistically test the differences in the expected values and perceived values to determine if the differences were significant. Through this series of rigorous data processing and statistical analysis, we were able to gain insight into the problems in the service quality of regional medical laboratory centers and the room for improvement , thus providing a scientific basis for the improvement of the service quality of the regional medical laboratory centers. If the difference is significant, it indicates that there is a service quality gap on the question item.

(1) Customer gap situation

As shown in Table 5.11, the average score of the overall expected value is 4.500, the average score of the overall perceived value is 4.278, and the difference between the average scores of the overall expected value and perceived value is 0.220. The difference between the two passed the T-test at the one percent significance level, indicating that there is a significant difference between the service expectations and actual service perceptions at LW Regional Medical Testing Center. The service quality gap exists, confirming hypothesis H1. the difference between the average score of the expected value and perceived value of tangibles is 0.191, the difference between the average score of the expected value and perceived value of reliability is 0.171, the difference between the average score of the expected value and perceived value of responsiveness is 0.263, the difference between the average score of the expected value and perceived value of assurance is 0.226, and the difference between the

average score of the expected value and perceived value of empathy is 0.246. The customer gap is influenced joint by empathy, tangibles, reliability, assurance, and responsiveness, in which the difference of reliability is the smallest and the difference of responsiveness is the largest, indicating that the influence of reliability on customer gap is relatively low in the five dimensions, while the influence of responsiveness is relatively large.

Table 5.11 T test of service quality gap

Dimension	Expected value E		Perceived value P		Service quality P-E	T test of paired samples	
	Mean	S.D.	Mean	S.D.		t	P value
Total	4.500	0.038	4.278	0.044	-0.220	7.4129	0.00
Tangibles	4.551	0.035	4.360	0.041	-0.191	7.3778	0.00
Reliability	4.543	0.037	4.371	0.042	-0.171	6.3658	0.00
Responsiveness	4.458	0.047	4.195	0.057	-0.263	6.4485	0.00
Assurance	4.484	0.044	4.258	0.051	-0.226	6.2558	0.00
Empathy	4.452	0.044	4.205	0.052	-0.246	6.7653	0.00

According to the test results shown in Table 5.12, the expected values of the service quality range from 4.3 to 4.6, and the standard deviations are all below 1, indicating that the scores of customers in the items regarding expectation are relatively high, and present relatively good representativeness and universality. As for the actual perception of the customers, the scores range from 4.1 to 4.5, and the standard deviations of the items are all below 1, indicating that the actual experience of customers for the regional medical laboratory center is relatively high, and the laboratory center can fairly meet the customer expectations and needs. It means that the service quality of the Center has been recognized by the majority of customers, and its service performance has a wide range of social acceptance and high representativeness, which can, to a certain extent, reflect the overall service level of the medical laboratory industry in the region. It also provides positive feedback and confidence support for further improving and optimizing the service quality of the regional medical laboratory center. According to the comparison of the perception and expectation of the 22 items, the perceived values are generally lower than the expected values, with an average difference of about 0.15, indicating that the psychological gap of customers between the perception and expectation is relatively stable. Paired samples t-test of the total values of expectation and perception is carried out, and the resulting values are also positive, indicating that the expected values are higher than the perceived values. The Sig value is also lower than 0.05, indicating that there are significant differences between expectations and perceptions, and there is room for further improvement in terms of the service quality of the regional medical laboratory center.

Table 5.12 T test on the subdivision dimension of service quality gap

Dimension	Measurement item	Expected value E	Perceived value P	Service quality	T test of the paired samples

		Mean	S.D.	Mean	S.D.	P-E	t	P value
Tangibles	T1	4.515	0.0433	4.199	0.050	-0.316	7.9989	0.00
	T2	4.503	0.041	4.355	0.046	-0.148	5.0526	0.00
	T3	4.632	0.039	4.509	0.041	-0.123	4.6372	0.00
	T4	4.557	0.040	4.380	0.047	-0.178	5.8760	0.00
Reliability	R1	4.509	0.043	4.319	0.048	-0.190	5.5375	0.00
	R2	4.494	0.043	4.292	0.050	-0.202	5.7905	0.00
	R3	4.581	0.039	4.455	0.043	-0.127	4.5042	0.00
	R4	4.542	0.040	4.364	0.048	-0.178	5.4577	0.00
	R5	4.590	0.038	4.428	0.046	-0.163	5.1593	0.00
Responsiveness	P1	4.443	0.052	4.181	0.061	-0.262	6.2017	0.00
	P2	4.424	0.055	4.148	0.064	-0.277	6.3015	0.00
	P3	4.434	0.053	4.181	0.063	-0.253	5.8904	0.00
	P4	4.533	0.041	4.271	0.052	-0.262	6.0204	0.00
Assurance	A1	4.560	0.036	4.460	0.044	-0.136	4.7655	0.00
	A2	4.449	0.050	4.208	0.059	-0.240	5.5557	0.00
	A3	4.449	0.052	4.171	0.060	-0.277	6.3015	0.00
	A4	4.446	0.050	4.193	0.059	-0.253	5.5947	0.00
Empathy	E1	4.440	0.054	4.154	0.063	-0.286	6.5800	0.00
	E2	4.476	0.042	4.277	0.051	-0.199	5.1322	0.00
	E3	4.433	0.052	4.160	0.063	-0.274	6.1252	0.00
	E4	4.367	0.056	4.048	0.065	-0.319	6.4876	0.00
	E5	4.545	0.039	4.389	0.044	-0.157	5.1447	0.00

(2) Tangibility gap situation

According to the test results shown in Table 5.12, the gap between the perceived service quality and expected service quality is the biggest in T1 (The regional medical laboratory center has modern and intelligent medical equipment.), reaching 0.316, while the gap is the smallest in T3 (The staff of the regional medical laboratory center is neatly dressed and well-groomed), being only 0.123. It indicates that the gap in the dimension of tangibles is mainly because the service equipment fails to meet the expectations of customers, and the regional medical laboratory center needs to upgrade the medical equipment to better meet the needs of customers.

(3) Gap of reliability

According to the test results shown in Table 5.12 the gap between the perceived service quality and expected service quality is the biggest in R2 (The regional medical laboratory center can guarantee adequate communication with the customer, and the fees are reasonable with no extra charges.), reaching 0.202, while the gap is the smallest in R3 (The regional medical laboratory center has made adequate assessment of the potential risks, and has formulated corresponding disposal measures.), being only 0.127. It indicates that the gap in the dimension of reliability results mainly from insufficient communication with the customers as well as failure of the price to reach the customer's expectations. The regional medical laboratory center should strengthen cost control to provide lower service prices and strengthen customer relationship management, so as to truly perceive customer needs.

(4) Gap of responsiveness

The test results of the gap in the dimension of responsiveness show that the gap between the perceived service quality and expected service quality is the biggest in P2 (The regional medical laboratory center can respond to and answer customer questions in a timely manner.), reaching 0.277, while the gap is the smallest in P3 (The regional medical laboratory center can provide whole-process service status query, and inform customers at key service nodes.), being only 0.253. It indicates that the gap in the dimension of responsiveness results mainly from the untimely response. The regional medical laboratory center needs after-sales service and timely response to customers.

(5) Gap of assurance

The test results of the gap in the dimension of assurance show that the gap between the perceived service quality and expected service quality is the biggest in A3 (The regional medical laboratory center can provide adequate institutional guarantee and resource support for employees to better serve the customers.), reaching 0.277, while the gap is the smallest in A1 (Employees of the regional medical laboratory center can give customers an impression of excellent professional quality in the service.), being only 0.136. It indicates that the gap in the dimension of assurance is mainly because the management cannot provide institutional guarantee and resource support for the employees to serve the customers. The regional medical laboratory center needs to further empower the staff and provide resource support to give full play to the ability of the staff.

(6) Gap of empathy

The test results of the gap in the dimension of empathy show that the gap between the perceived service quality and expected service quality is the biggest in E4 (The regional medical laboratory center can meet the customer's needs for a variety of tests at one time, and does not make any mistakes.), reaching 0.319, while the gap is the smallest in E5 (The regional medical laboratory center has an environmentally-friendly process and program for disposal of medical waste.), being only 0.157. It indicates that the gap in the dimension of empathy results mainly from the lack of flexible testing capacity of the regional medical laboratory center. The regional medical laboratory center needs to further upgrade its testing equipment to provide flexible testing capacity.

5.3.3 Differential testing of the impact across different dimensions

This section will use regression analysis to test the differences in the impact of different

dimensions of service quality, that is, to test hypothesis H2: The five dimensions of service quality (tangibles, reliability, responsiveness, assurance, empathy) have different degrees of impact on service quality. To ensure that the output regression coefficients are directly comparable, the data were standardized before regression analysis. Regression analysis was performed using Stata 17.0 software, employing the least squares method. The regression coefficients obtained are shown in Table 5.13. It can be observed that the dimensions significantly affecting the service quality gap are responsiveness and empathy. The former passed the test at the one percent significance level, while the latter passed the test at the five percent significance level. Tangibles, reliability, and assurance did not significantly affect the service quality gap. Comparing the regression coefficients of different dimensions, it is evident that the order from largest to smallest is responsiveness, empathy, tangibles, reliability, and assurance. This indicates that responsiveness and empathy dimensions contribute significantly to the service quality gap at LW Regional Medical Laboratory Center, and there are significant differences between each dimension, confirming hypothesis H2. Therefore, in the subsequent optimization process of service quality management at the Regional Medical Laboratory Center, attention should be focused on responsiveness first, followed by empathy.

Table 5.13 Test of differences in the impact of different dimensions

	Service quality gap		
	Regression coefficients		Standard error
Tangibles	0.297		(0.2223)
Reliability	0.110		(0.3462)
Responsiveness	0.881***		(0.3258)
Assurance	0.0280		(0.3586)
Empathy	0.685**		(0.3103)
_cons	4.702***		(1.3661)
Observations		337	
adj. R2		0.94	
F-value		4.14	

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3.4 Classification test

As shown in Table 5.14, the average score of the overall expected value of the secondary public hospitals is 4.612, and the average score of the overall perceived value is 4.392; the average score of the overall expected value of the community health service centers is 4.441, and the average score of the overall perceived value is 4.221. It can be found that, whether it is the public hospitals or the community health service centers, the quality of services provided by the regional medical laboratory center can well meet the service demands of the customers, and compared to the community health service center, the secondary public hospitals have higher expectations and perceptions for the service quality of the regional medical laboratory center. By comparing the service quality gap between the two, it is found that the service quality gap of secondary public hospitals is smaller than that of community health service centers, which suggests that the regional medical laboratory center may be more concerned about the service quality of public hospitals than community health service centers.

Table 5.14 Comparison of service quality gaps between different types of hospitals

Dimension	Expectation E		Perception P		Service quality P-E		T value	
	Hospital	Center	Hospital	Center	Hospital	Center	Hospital	Center
Total	4.612	4.441	4.392	4.221	-0.219***	-0.220***	4.8934	5.7258
Tangibles	4.577	4.539	4.343	4.369	-0.234***	-0.170***	4.9997	5.4784
Reliability	4.654	4.488	4.441	4.336	-0.212***	-0.151***	4.6308	4.5472
Responsiveness	4.627	4.375	4.415	4.085	-0.211***	-0.289***	4.1222	5.2066
Assurance	4.615	4.420	4.402	4.186	-0.213***	-0.233***	4.3549	4.8079
Empathy	4.585	4.386	4.358	4.129	-0.227***	-0.256***	4.8326	5.1941

Note: *** means passing T test at the significance level of 1%

The scores of each dimension show that the expected values and perceived values of service quality of secondary public hospitals are higher than those of community health centers in all the dimensions. To be specific, the gap of expected value between hospitals and community health centers is the smallest in the dimension of tangibles, while the gap is the biggest in the dimension of responsiveness. It indicates that the expectations of hospitals and community health centers for the services provided by the regional medical laboratory center are basically the same in the dimension of tangibles, but their expectations are largely different in the dimension of responsiveness. In terms of the perceived services, except for the dimension of tangibles, the perceived service quality of the hospitals is higher than that of the community health centers in all the other dimensions, especially responsiveness.

As shown in Table 5.15, the average score of the overall expected value of the management is 4.554, and the average score of the overall perceived value is 4.112; the average score of the overall expected value of the grassroots employees is 4.488, and the average score of the overall perceived value is 4.307. It can be found that both the management and the grassroots employees basically recognize that the quality of services provided by the regional medical laboratory center can meet their own service expectations, but compared to the grassroots employees, the management have higher expectations of the quality of services provided by the regional medical laboratory center but lower perceptions. By comparing the service quality gap between the two, it is found that the service quality gap of secondary public hospitals is smaller than that of community health service centers, which suggests that the regional medical laboratory center may be more concerned about the service quality of public hospitals than community health service centers. By comparing the service quality gap between the two, it is found that the service quality gap for grassroots employees is smaller than that for the management, which may be due to the fact that the management do not have direct contact with the services provided by the regional medical laboratory center, while the grassroots employees are able to more directly perceive the services provided by the regional medical laboratory center.

Table 5.15 Comparison of service quality gaps between different job positions

Dimension	Expectation E		Perception P		Service quality P-E		T value	
	Manager	Employee	Manager	Employee	Manager	Employee	Manager	Employee
Total	4.554	4.488	4.112	4.307	-0.443***	-0.180***	4.6797	5.9904
Tangibles	4.555	4.551	4.190	4.390	-0.365***	-0.160***	4.2406	6.1510
Reliability	4.608	4.531	4.192	4.403	-0.416***	-0.128***	4.4650	4.8658
Responsiveness	4.540	4.444	4.040	4.222	-0.500***	-0.221***	4.0618	5.2145
Assurance	4.550	4.473	4.090	4.288	-0.460***	-0.185***	4.0701	4.9785
Empathy	4.520	4.440	4.044	4.234	-0.476	-0.206	4.8426	5.3099

The scores of each dimension show that the expected values and perceived values of the management are higher than those of the grassroots employees in all the dimensions. To be specific, the gap of expected value between the management and the grassroots employees is the smallest in the dimension of tangibles, while the gap is the biggest in the dimension of

responsiveness. It indicates that the expectations of the management and the grassroots employees for the services provided by the regional medical laboratory center are basically the same in the dimension of tangibles, but their expectations are largely different in the dimension of responsiveness. In terms of the perceived services, the perceived service quality of the grassroots employees is higher than that of the management in all the dimensions. The gap of perceived value between the management and the grassroots employees is the smallest in the dimension of assurance, while the gap is the biggest in the dimension of reliability.

As shown in Table 5.16, the average score of the overall expected value of the medical personnel is 4.507, and the average score of the overall perceived value is 4.297; the average score of the overall expected value of the logistics personnel is 4.460, and the average score of the overall perceived value is 4.199. It can be found that both the medical personnel and the logistics personnel basically recognize that the quality of services provided by the regional medical laboratory center can meet the service needs of different stakeholders, and compared to the logistics personnel, the medical personnel have higher expectations and perceptions for the quality of services provided by the regional medical laboratory center. By comparing the service quality gap between the two, it is found that the service quality gap of the medical personnel is smaller than that of the logistics personnel, which suggests that the medical personnel recognize the quality of service provided by the regional medical laboratory center more than the logistics personnel.

Table 5.16 Comparison of service quality gaps between different categories of employees

Dimension	Expectation E		Perception P		Service quality P-E		T value	
	Medical	Logistics	Medical	Logistics	Medical	Logistics	Medical	Logistics
Total	4.507	4.460	4.297	4.199	-0.209***	-0.260***	6.5975	3.3949
Tangibles	4.570	4.477	4.399	4.204	-0.171***	-0.272***	6.7819	3.3481
Reliability	4.551	4.512	4.403	4.242	-0.147***	-0.269***	5.3773	3.4511
Responsiveness	4.457	4.462	4.189	4.215	-0.267***	-0.246***	5.6806	3.1144
Assurance	4.494	4.446	4.276	4.185	-0.218***	-0.261***	5.3468	3.2989
Empathy	4.464	4.403	4.219	4.148	-0.245***	-0.254***	5.9702	3.1710

The scores of each dimension show that the expected values and perceived values of service

quality of the medical personnel are higher than those of the logistics personnel in all the dimensions. To be specific, the gap of expected value between the medical personnel and the logistics personnel is the smallest in the dimension of reliability, while the gap is the biggest in the dimension of responsiveness. It indicates that the expectations of the medical personnel and logistics personnel for the services provided by the regional medical laboratory center are basically the same in the dimension of reliability, but their expectations are largely different in the dimension of tangibles. In terms of the perceived services, except for the dimension of responsiveness, the perceived service quality of the medical personnel is higher than that of the logistics personnel in all the other dimensions, especially tangibles.

5.3.5 IPA quadrant analysis

In 1977, Martilla et al. proposed the Importance-Performance Analysis (IPA), a method that allows researchers to propose targeted and practical recommendations for improvement based on the distributional position of indicators in a coordinate system. In this study, we constructed an IPA chart with the score of expectation (score of importance) of each indicator of service quality as the horizontal axis, and the score of the actual perception (score of performance) of each indicator of service quality as the vertical axis. In addition, the average scores of expectation and perception on the overall service quality of the laboratory center are used as the reference lines, so as to identify the weaknesses of the laboratory center in terms of service quality and the direction for optimization.

In this way, we can clearly identify the service quality indicators that are considered very important by the customers but fall short of the expectations in actual perception, and these are the key aspects that the laboratory center needs to improve as the top priority. Conversely, for those indicators with less importance but good performance in actual perception, the laboratory center can continue to maintain or moderately optimize them. Through the IPA analysis chart, we are able to provide more targeted and effective service quality improvement strategies for the regional medical laboratory center.

The distribution of the indicators is shown as per Figure 5.2. (1) Quadrant 1 (High importance - high performance area): Items in this quadrant are the testing programs or service links that are considered extremely important by the service users and also show excellent quality in the actual experience. Although data analysis reveals that the actual perception of these programs or services may still be slightly lower than the expected level, resulting in certain negative and statistically significant differences in satisfaction, such programs or

services are already in a good state compared with those in other quadrants. Therefore, in terms of prioritization, these items do not fall into the category of urgent improvement, but they still need attention to ensure that they continue to maintain a high level of performance. They can consolidate the service advantages, and further improve customer satisfaction. A maintenance and optimization strategy should be adopted for the segmented question items in this quadrant. The items distributed in this quadrant include T2, T3, T4, R1, R3, R4, R5, A1, and E5.

(2) Quadrant 2 (Low importance - high performance area): Items in this quadrant are those that are of low importance to the customers, but perform above customer expectations. Two strategies can be adopted for the items in this quadrant: one is to maintain the status quo without excessive input; the other is to adjust and optimize such service elements according to the actual situation, and allocate excess resources to other service quality dimensions on the basis of meeting customer service expectations. The only question item distributed in this quadrant is P4.

(3) Quadrant 3 (Low importance - low performance area): Indicators in this quadrant represent relatively low levels of customer expectations and actual perceptions of the content of these services. In other words, these service programs do not have a high level of concern in the minds of customers, and do not perform well in actual implementation, resulting in relatively low satisfaction levels that fall short of expectations. For this type of indicators, although they are not as urgent as the items in the first quadrant (high importance-low performance area) in the improvement sequence, they should also be treated as a sub-priority for improvement, because once these items are improved and upgraded, they may bring unexpected results and significantly increase customer satisfaction. For example, in the regional medical laboratory center, if certain auxiliary services, waiting time optimization or satisfaction with specific non-core testing items are located in quadrant 3, targeted improvement measures may improve the overall quality of service, as well as increase customer’ s goodwill and trust in the laboratory center. The items distributed in this quadrant include P1, P2, P3, A2, A3, A4, E1, E3, and E4.

(4) Quadrant 4 (High importance - low performance area): The items in this quadrant reflect that service users have relatively high expectations of the quality of a particular service in the regional medical laboratory center, but the actual experience falls far short of the expectations, resulting in low levels of satisfaction. These items are the core focus of urgent attention in service quality improvement. For example, if the sample processing speed, accuracy of test results, the doctor’s professionalism in interpreting the report or the attitude of the service personnel and other key service elements fall in this quadrant, it means that the Center should

prioritize the investment of limited resources in these areas. It should resort to multiple approaches such as the optimization of the process, enhancement of the technology, and strengthening of personnel training to significantly improve the service quality of these aspects, so as to improve the overall satisfaction and trust of the service recipients. The items distributed in this quadrant include T1 and R2.

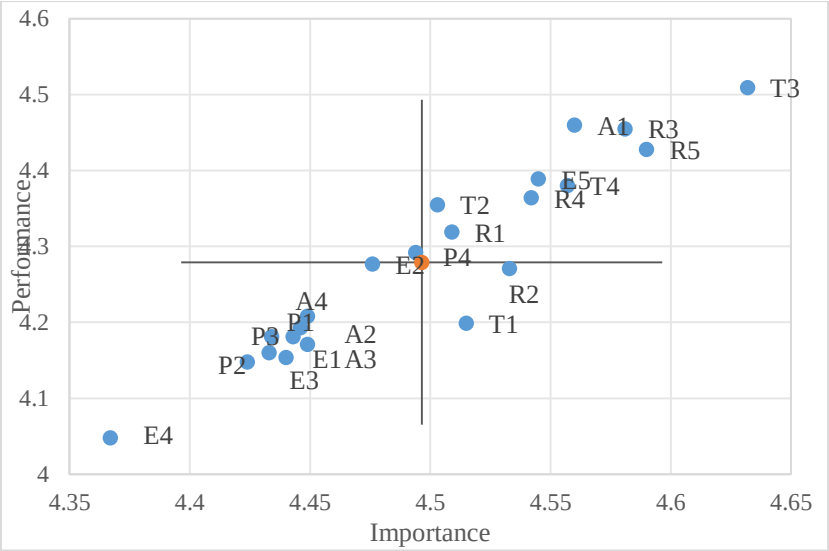

Figure 5.3 IPA analysis chart

5.4 Chapter summary

Based on the Gap Model of Service Quality, this chapter empirically analyzes the service quality level of the LW regional medical laboratory center and the specific dimensions that cause the service quality gap, which lays the foundation for the subsequent optimization and improvement of service quality. First, the SERVQUAL scale is modified using the literature research method and group discussion method to make it meet the requirements of service quality measurement for regional medical laboratory centers. On this basis, the service quality level of the LW Regional Medical Laboratory Centers is assessed through the questionnaire survey method, and statistical analysis methods such as frequency and percentage indexes and sample t-tests are used to analyze whether there are service quality gaps in LW Regional Medical Laboratory Center. Furthermore, IPA quadrant analysis is used to reflect more intuitively the weaknesses in the service quality of the regional medical laboratory center and the directions that need to be prioritized for improvement. Generally speaking, the service quality of the LW Regional Medical Laboratory Center is at a relatively high level, which can basically meet customer expectations, but there is still a gap with customer expectations, and there is room for further optimization and improvement, especially in the dimension of

responsiveness. In addition, it is found that customers attach great importance to the degree of modernization and intelligence of the medical equipment of the regional medical laboratory center, as well as the accuracy and professionalism of the test reports provided, but LW Regional Medical Laboratory Center performs poorly in these two dimensions, and the focus should be placed on these two aspects in the subsequent optimization and improvement of service quality. Group comparisons show that different service recipients have different expectations and perceptions of the service quality of the regional medical laboratory center.

Chapter 6: Service Quality Improvement of the Regional Medical Laboratory Center

6.1 Current status of regional medical laboratory center services

During the transition process, the service quality management of LW Regional Medical Laboratory Center still needs improvement. From the empirical analysis in the previous chapter, it can be observed that there is still a gap between the service quality provided by LW Regional Medical Laboratory Center and the service quality expected by customers. In order to further improve the service quality, the author combines years of work experience in regional medical Laboratory centers, integrates the actual situation of LW Regional Medical Laboratory Center with the service quality gap model, and analyzes the reasons for the gap between the service quality provided by regional medical Laboratory centers and customer expectations from four aspects: cognitive gap, standard gap, communication gap, and delivery gap. Based on this analysis, optimization suggestions are proposed.

Firstly, there is an analysis of the cognitive situation of the Regional Medical Laboratory Center. LW Regional Medical Laboratory Center has not conducted user demand symposiums with customers nor distributed surveys on service quality. Consequently, LW Regional Medical Laboratory Center lacks a comprehensive and accurate understanding of user expectations, resulting in insufficient attention to customer expectation research. Secondly, LW Regional Medical Laboratory Center has multiple organizational levels, and frontline service personnel need to pass through many levels to convey customer demand information, which may lead to loss of most analytical value by the time it reaches the leadership, causing information distortion.

Secondly, there is an analysis of the service standard situation of the Regional Medical Laboratory Center. The service standards and service concepts of LW Regional Medical Laboratory Center are not well developed. As demonstrated in the previous case analysis section, LW Regional Medical Laboratory Center is currently transitioning from an epidemic-oriented service model to a market-oriented service model. The relevant service processes and standards are still being improved and are in the transitional stage. Therefore, LW Regional Medical Laboratory Center has not yet established a reasonable customer management mechanism, failed to segment customers based on hospital type, distance, test demand, etc.,

lacks targeted customer service strategies, and makes it difficult to grasp customer needs when promoting new services. LW Regional Medical Laboratory Center lacks specialized talents in service standard formulation. Most of the management at LW Regional Medical Laboratory Center are specialized technical personnel, making it difficult for managers to translate perceived customer service expectations into actionable service standards.

Next is the analysis of the communication situation at the Regional Medical Laboratory Center. Employees at the Regional Medical Laboratory Center need to possess comprehensive testing and diagnostic capabilities in handling common complaint resolution services, involving a lot of professional knowledge and experience. However, those directly handling customer inquiries and complaints often lack expertise in this area. Consequently, when faced with complex issues, they often cannot provide satisfactory answers to customers. Additionally, given that this position deals with complaints, customer attitudes are often not very positive. Sometimes, employees fail to control their emotions and conflicts with customers arise, exacerbating tensions between them.Due to increasingly stringent government industry requirements and market competition, in order to better attract customers and obtain government support, managers at LW Regional Medical Laboratory Center may make some exaggerated promises in overall advertising campaigns. However, LW Regional Medical Laboratory Center has not been able to handle internal and external marketing information in a unified manner. Consequently, there may be discrepancies between the marketing and advertising strategies of the company's marketing department and frontline service personnel, leading to disparities between customer expectations and perceptions during the service delivery process.

In terms of service delivery at the Regional Medical Laboratory Center, the delivery gap mainly arises from the insufficient motivation provided by the company to ensure strict adherence to service standards by employees. Managers believe that employees should inherently perform their core duties well and serve each customer effectively. However, without corresponding scientific incentives and reward mechanisms, it becomes challenging for employees to truly integrate into the company. Services themselves are intangible, and when the relevant standards set by the company reach frontline service personnel, various factors such as the environment and management levels may lead to issues in execution based on the individual understanding of service personnel. This can easily result in inadequate execution.

6.2 Strategies for the service quality improvement of regional medical laboratory center

Based on the actual situation of the regional medical laboratory center, we focus on the five key factors affecting the service quality of the regional medical laboratory center, find out its gaps and shortcomings, and make continuous improvement and enhancement of the customer service management in accordance with the opinions and feedback of the customer on the five dimensions of service quality.

6.2.1 Strategy to bridge the perception gap

Research on the management of customer expectations should be strengthened. First of all, the thinking of the management to perceive service quality should be strengthened to investigate the real expectations of the customers from multiple channels. The root cause of the perception gap in the regional medical laboratory center is that the thinking of the management is still stuck in the epidemic period, with inertia for service management and insufficient attention paid to service quality, so the first thing we need to do is to reverse the thinking and cognition of the management. In the investigation of customer expectations, the following approaches can be taken. We can use the WeChat official account, questionnaire, and on-site visit to carry out random sampling of customer service expectations on a regular basis. We can also regularly carry out customer forums, and randomly select 20 customers for face-to-face interview every quarter, so as to obtain an in-depth understanding of the customer's expectations and perceptions. The problems raised by them should be recorded, and then we can call back to find out the user's expectations are realized. In the service process, it is encouraged to make full use of face-to-face opportunities to capture the ideas of the users, and understand their expectations, which can not only obtain information directly but also reduce the economic costs. It is also applicable to place suggestion boxes in the place where the customers often visit or some eye-catching positions of the service place, and collect suggestions and questions from customers every week. There should be multiple channels established to understand customer expectations and minimize the perception gap.

A flat organizational system can be established to strengthen the information connection within the company. It is necessary to encourage the employees to attach more emphasis on the service quality. Important information collected by employees in the daily work should be conveyed to the higher-level departments, and the importance of the information is divided into

three levels. In the first level, the information should be conveyed to the supervisor; in the second level, the information should be conveyed to the department leadership; in the third level, the information should be conveyed to the leaders in charge. The employees should endeavor to ensure that the leaders can be informed of the latest situation immediately, and those whose feedback effectively helps the company to reduce losses should be given appropriate incentives. The company's current management structure should also be optimized and streamlined. The management process of the company should be simplified without affecting the normal operation. Currently, there are at least four or five processes for the instructions to be transferred from the management to the grassroots employees, which can easily lead to inaccuracy in information transmission. Timeliness and correctness of information transmission are especially important for the engineering departments of the company, so it is necessary to designate special persons in charge of information transmission in the same levels to avoid passing information back and forth in the same level. The construction of flat company management system can streamline the internal links within the company to a certain extent, so that the company's senior management can get a timely grasp of the user reviews and complaints to make the corresponding decisions.

6.2.2 Strategy to bridge the standard gap

It is necessary to improve the user-centered service quality standards. As for the development of service quality standards in Liwan district, we can learn from the service quality standard management model of Guangzhou KingMed Diagnostics, which is also an industry leader in Guangzhou. It is also necessary to further improve the service quality assessment system based on the company's actual operation situation, which includes, but is not limited to, the formulation of more detailed quantitative assessment standards, such as clear regulations and assessment on testing efficiency, accuracy, report issuance time, customer waiting time, service attitude and other key indicators, as well as the establishment of a sound system of supervision standards, which ensures the effective implementation of the service quality standards through methods such as internal audits and regular inspections.

In addition, it is also crucial to establish a mechanism and criterion for handling user complaints to ensure that user feedback can be responded to and handled in a timely, fair and effective manner, which helps to enhance user satisfaction and also serves as an important reference for service quality improvement. In this way, the company is able to provide clear behavioral guidance when offering training on service quality to its employees, prompting them

to standardize and normalize their service behaviors. This is a move to comprehensively improve the service quality of the regional medical laboratory center, and provide users with better and more satisfactory medical service experience. A variety of effective channels can be used to investigate and collect the customer's real expectations and there should be a detailed and in-depth analysis of the questionnaire results, so as to identify the aspects that are valued by the customers. In addition, company managers can communicate with front-line service personnel and users to jointly develop the company's service standards, so as to achieve the goal of offering customer-centric services. Finally, according to the user industry categories, industry characteristics, user categories and user characteristics, we can design targeted customer service strategies to grasp the customer demands in promoting new services.

Cooperation between industry, academia and research should be strengthened, and talents for service standard development should be introduced. The region where the LW Regional Medical Laboratory Center is located has rich resources of universities and research institutes, including 30 national key laboratories (partner laboratories), 6 provincial and ministerial key laboratories and more than 130 new R&D institutions, as well as 172 institutions of higher learning. The LW Regional Medical Laboratory Center can make full use of local industry-academia-research cooperation resources and cooperate with universities to build research bases. On the one hand, the Center can attract high-quality service standard-setting talents from the universities, and on the other hand, it can also strengthen the innovation capacity of the company, accelerate product development and enhancement, and enhance the high-end testing programs, technology promotion and application. In addition, in collaboration with high-quality customers, a big data platform can be established for the transformation of scientific research projects, which can help improve market competitiveness and sustainable development.

6.2.3 Strategy to bridge the communication gap

The employees' ability to interpret test reports and their communication skills should be strengthened. For all types of test items and interpretation of test results, a set of working standards should be formulated. There should be training on the standards of operating procedures. In regional medical laboratory centers, in order to ensure the high quality and standardization of medical laboratory reports, testing experts with rich experience and professional knowledge should be arranged to carry out quality control. First of all, the experts need to strictly control the test reports issued, including verification of test results, and review and authorization of release to ensure the accuracy and legitimacy of the report. At the same

time, the interpretation of test reports should be standardized to provide clear, accurate and easy-to-understand medical descriptions for the reference of clinicians and patients. In addition, the Center should also strengthen the whole-process management of the test samples, including the receipt, storage, processing, testing and disposal of samples to ensure the quality of samples and the reliability of test results. On this basis, the Center also needs to strengthen the communication and collaboration with clinical departments to understand the clinical needs in real time, ensure the timely delivery of test reports, and answer the questions of clinicians and patients about the content of the reports, so as to effectively ensure the completeness, accuracy and timeliness of the report, and improve the quality and efficiency of the entire medical service.

Management of service commitment should be strengthened to maintain the consistency of publicity. Moderate service commitment can be conducive to the customers' favorable impression on the LW Regional Medical Laboratory Center, but excessive commitment will lead to the undesirable implementation of the services, thus generating a sense of loss and feeling of deception for the customers, which will affect the word-of-mouth and corporate image of the LW Regional Medical Laboratory Center. Therefore, before the LW Regional Medical Laboratory Center uses advertising to make service commitments, it must first understand the current level of actual services, make sure that the daily services can stably reach the level of promised service, and optimize and adjust the services based on the corporate development and market competition in a targeted manner. It should strengthen management of the employee integrity to avoid exaggerated publicity for personal interests. At the same time, the employees should have a unified cognition of the service level of the regional medical laboratory center to ensure that the service perceived by the customers is consistent with the corporate commitment, avoiding customer dissatisfaction caused by inconsistency between internal and external commitments.

6.2.4 Strategy to bridge the delivery gap

Scientific and effective human resource policies should be formulated. Scientific and effective human resource policies can motivate employees to take the initiative to perform in the customer-oriented manner, and ensure that the services delivered by the employees are with high quality. Without scientific and effective human resource policies, the service design and standards are difficult to implement no matter how good they are. Therefore, human resources can be optimized and improved through the following aspects. First, the LW Medical Laboratory Center should examine the service value orientation and willingness of the

candidates in the recruitment in addition to their service ability, and the patience, affinity and willingness to serve should also be examined. Second, a competitive salary system should be established, and a complete career development channel enables the company to not only find good employees but also retain these talents. Third, in order to maintain staff motivation and win their recognition of the company's vision, the LW Medical Laboratory Center should support and understand the employees' understanding and interpretation of the company's vision. Fourth, the employees should be treated as the customers. The LW Medical Laboratory Center should carry out internal customer satisfaction survey on a regular basis to investigate the employees' views on the current service work. Fifth, a scientific and reasonable employee assessment and performance incentive system should be established, and the company's vision and value should be linked to the service results of the employees to assess and reward the work of the employees. After being recognized and rewarded, the employees will offer better service to the customers, which will increase customer satisfaction.

6.3 Chapter summary

This chapter attempts to put forward corresponding suggestions on service quality improvement based on the Gap Model of Service Quality as well as the evaluation results of service quality in Chapter 5. The analysis of the reasons shows that the management of the LW Regional Medical Laboratory Center do not pay enough attention to the investigation of customer expectations, and its hierarchical structure is also bloated, which leads to the emergence of the perception gap. Due to the imperfection of the service quality standards and the lack of talents in the development of service standards, there appears the standard gap. Due to insufficient competence of the staff and the over-commitment of some services made by the LW Regional Medical Laboratory Center, there appears the communication gap. The incentives given by the enterprise for the employees who strictly implement the service standards are not enough, which leads to the emergence of the delivery gap. Based on the above reasons, targeted recommendations on service quality improvement have been proposed: strengthen research on the management of customer expectations; establish a flat organizational system to strengthen the company's internal information links; improve the user-centered service quality standards; strengthen the cooperation between industry, academia and research, and introduce talents for the formulation of service standards; enhance training on the employees' ability to interpret test reports and their communication skills; enhance the management of the service commitment to

maintain the consistency of publicity; and establish a scientific and effective human resource policy.

Chapter 7: Conclusions

7.1 Major research results and implications for management

Based on the theory of dynamic capabilities, we explore how the LW Regional Medical Laboratory Center evolved different service models before and after the COVID-19 epidemic to adapt to the environmental changes by utilizing the perceptual capability, reconfiguration capability, and innovation capability. It is found that the LW Regional Medical Laboratory Center goes through two stages of development: the epidemic stage and the post-epidemic stage. In the epidemic stage, the LW Regional Medical Laboratory Center discovers the demand for epidemic testing through its perception capability, and realizes the adjustment of organizational structure through its reconfiguration capability as well as innovation capability. It develops a new type of service tool for the demand of epidemic testing and prevention and control, and establishes an epidemic-oriented service model to satisfy the demand for epidemic testing of various stakeholders. In the post-epidemic stage, the LW Regional Medical Laboratory Center discovers new market demands and development opportunities based on its perception ability, implements flat management through its reconfiguration capability and innovation ability, and continuously expands its service boundaries and service ecology. It has realized the deep integration of the industry chain and the value chain. A comprehensive service system with rich connotation and reasonable structure has been constructed, and an industry-leading service and management system has been created. By obtaining technological innovation products with industry competitiveness, the LW Regional Medical Laboratory Center finally establishes a market-oriented service model.

Furthermore, this research attempts to obtain first-hand data through questionnaire surveys to assess the service quality of LW Regional Medical laboratory centers through the Gap Model of Service Quality and with the LW Regional Medical Laboratory Center as the sample. On this basis, the research further analyzes the reasons that impede the enhancement of the quality of regional medical services, and puts forward countermeasures and suggestions to optimize the quality of services. It is found that on the whole, the service quality of the LW Regional Medical Laboratory Center is at a high level and basically meets customer expectations, but there is still a gap with the customer expectations, and there is room for further optimization and

improvement, especially in the dimension of responsiveness. It is found that customers attach great importance to the degree of modernization and intelligence of the medical equipment, as well as the accuracy and professionalism of the test reports provided, but the performance of the LW Regional Medical Laboratory Center in these two aspects is poor, and the subsequent optimization and improvement of service quality needs to focus on these two aspects. Through reason analysis, it is found that the management of the LW Regional Medical Laboratory Center pay insufficient attention to investigation on customer expectations, and the hierarchical structure is also bloated, resulting in the emergence of perception gap; the imperfect service quality standards and the lack of talents in formulation of service standards result in the emergence of standard gap; the lack of staff competence and overcommitment of the LW Regional Medical Laboratory Center in some services result in the emergence of communication gap; the insufficient incentive provided by the enterprise to award the staff strictly implementing service standards results in the emergence of delivery gap. Based on the above reasons, targeted service quality improvement recommendations have been proposed, including strengthening research on the management of customer expectations; establishing a flat organizational system, and strengthening the company's internal information links; improving the user-centered service quality standards; strengthening the cooperation between industry, academia and research, and introducing talents in service standard formulation; increasing training on the employees' ability to interpret test reports and their communication skills; improving the management of service commitment to maintain the consistency of publicity; and formulating scientific and effective human resource policies.

7.2 Research contribution

The contributions of this study are as follows. First, we have conducted a secondary development of the service quality scale for regional medical laboratory centers. After reviewing relevant studies on healthcare service quality, it is found that although the SERVQUAL model and the service quality gap model have been widely used in existing studies on service quality in the healthcare field, there have been no service quality measurement scales developed specifically for the regional medical laboratory center. Based on this gap in the literature, we analyze the core stakeholders of regional medical laboratory centers based on the stakeholder theory, clarify the interests of core stakeholders through field research and structured interviews, and formulate a service quality measurement scale for regional medical laboratory centers that is suitable for the local context. It not only enriches the research in

regional medical laboratory centers and service quality, but also provides a powerful tool for managers to find out the service management omissions and understand the service quality level of regional medical laboratory centers.

Second, the introduction of the service quality gap model into the research of regional medical testing centers has expanded the application scenarios of the service quality gap model and related research on regional medical testing centers. Although the service quality gap model has long been proposed and has been applied in the field of healthcare, a review and review of relevant literature have found that there are almost no studies applying the service quality gap model to the research object of regional medical testing centers. Although research related to regional medical testing centers is receiving increasing attention from scholars, existing research mainly summarizes practical experience and mostly uses qualitative research methods to answer questions about how regional medical testing centers develop and what obstacles exist. This article is based on sample data from the LW regional medical laboratory center, empirically testing the service quality level of the regional medical laboratory center. Through the service quality gap model, the reasons for the service quality gap and countermeasures are analyzed, enriching relevant research and providing useful insights for managers to better manage and develop regional medical laboratory centers.

Finally, based on the theory of dynamic capabilities, the research on the development model of regional medical laboratory centers has been enriched. Although there have been studies summarizing the typical development models of regional medical laboratory centers, the relevant research is mostly based on simple summaries of practical experience and lacks theoretical guidance. This study uses a case study method, taking the LW Regional Medical Laboratory Center as a typical case, introduces dynamic capability theory analysis, and constructs a development model for the regional medical laboratory center, which is an effective supplement to related research.

7.3 Research limitations and prospects

This study adopts the method of questionnaire survey, and there may be bias in the selection of survey samples and sample size, which might affect the reliability and validity of the research results. In addition, due to limitations in time and space, this study fails to cover all the regional medical laboratory centers, so the generalizability and feasibility of the findings need to be further verified and analyzed. In future studies, researchers can further expand the scope of time and space of the study, increase the number and diversity of survey samples, and improve the

reliability and validity of the results. In addition, other research methods and tools, such as field observation and case study analysis, can be used to further explore the influencing factors of the service model of regional medical laboratory centers, and compare the service quality of regional medical laboratory centers that adopt different development models to see whether there are differences between them, so as to provide a suitable path for the subsequent development of regional medical laboratory centers.

Bibliography

Amporfro, D. A., Boah, M., Yingqi, S., Cheteu Wabo, T. M., Zhao, M., Ngo Nkondjock, V. R., & Wu, Q. (2021). Patients satisfaction with healthcare delivery in Ghana. *BMC Health Services Research*, *21*(1), 722.

Bergman, J., Jantunen, A., & Saksa, J. M. (2004). Managing knowledge creation and sharing: Scenarios and dynamic capabilities in inter-industrial knowledge networks. *Journal of Knowledge Management*, *8*(6), 63-76.

Bleich, N. S., Ozaltin, E., & Murray K. L. C. (2009). How does satisfaction with the health-care system relate to patient experience? *Bulletin of the World Health Organization*, *87*(4), 271-278.

Camisón, C., & Forés, B. (2010). Knowledge absorptive capacity: New insights for its conceptualization and measurement. *Journal of Business Research*, *63*(7), 707-715.

Cepeda, G., & Vera, D. (2007). Dynamic capabilities and operational capabilities: A knowledge management perspective. *Journal of Business Research*, *60*(5), 426-437.

Charkham, J. P. (1992). Corporate governance: Lessons from abroad. *European Business Journal*, 4(2), 8-16.

Chen, H. W., Hou, Y. Q., & Guan, M. (2021). 区域医学检验中心发展现状及展望 [Current situation and future prospect of regional medical laboratory center]. *International Journal of Laboratory Medicine*, *42*(12), 1409-1413.

Cheng, Y., & Zhong, Y. S. (2019). 企业网络动态能力对协同创新生态系统的影响机理——基于新兴技术企业的理论分析 [The mechanism of firms' network dynamic capabilities on collaborative innovation ecosystems: A theoretical analysis based on emerging technology firms]. *Industrial & Science Tribune*, *18*(04), 79-81.

Danilov, A. V. (2021). The measurement of degree of satisfaction of patients at evaluation of quality of applied services in hospital on the basis of SERVQUAL technique. *Probl Sotsialnoi Gig Zdravookhranenniiai Istor Med*, 29(4), 904-908.

Dong, B. B., Ge, B. S., & Wang, K. (2011). 资源整合过程、动态能力与竞争优势:机理与路径 [Resource integration processes, dynamic capabilities and competitive advantage: Mechanisms and paths]. *Journal of Management World*, (03), 92-101.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? *Strategic Management Journal*, *21*(2), 1105-1121.

Endeshaw, B. (2021). Healthcare service quality-measurement models: A review. *Journal of Health Research*, *35*(2), 106-117.

Epstein, R. M., & Hundert, E. M. (2002). Defining and assessing professional competence. J*ournal of the American Medical Association*, 287(2), 226-235.

Fraser, S. W., & Greenhalgh, T. (2001). Complexity science: Coping with complexity, educating for capability. *BMJ*, *323*(7316), 799-803.

Frederick, W. C. (1998). Creatures, corporations, communities, chaos, complexity. *Business & Society*, *37*(4), 358-389.

Freeman, R. E. (1984). *A stakeholder approach*. Pitman Books Limited.

Freeman, R. E. (2004). The stakeholder approach revisited. *Zeitschrift für Wirtschafts- und Unternehmensethik*, *3*(5), 228-241.

Guo, M. Y., Wang, D., & Guo, J. B. (2018). 第三方医学实验室的现状及发展前景分析 [Analysis of the current situation and development prospects of third-party medical

laboratories]. *Shanxi Medical Journal*, *47*(20), 2483-2485.

He, Q., Li, Q., & Chen, J. (2022). Study on the improvement of medical service quality in Beijing Tianqiao Community Health Service Centre. *Engineering Management in Production and Services*, *14*(4), 61-76.

He, X. G., Li, X. C., & Fang, H. Y. (2006). 动态能力的测量与功效:基于中国经验的实证研究 [Measurement and efficiency of dynamic capabilities: An empirical study in China]. *Journal of Management World*, (03), 94-103+113+171.

He, Y., Chen, C. G., Wu, X. L., Yuan, Y. Q., Li, B. S., & Wang, K. H. (2020). 临床医学检验中心发展面临的机遇与挑战 [Opportunities and challenges for the development of medical laboratory centers]. *International Journal of Laboratory Medicine*, *41*(13), 1652-1655.

Helfat, C. E., & Peteraf, M. A. (2009). Understanding dynamic capabilities progress: A developmental path. *Strategic Organization*, *7*(1), 91-102.

Helfat, C. E., & Raubitschek, R. S. (2018). Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. *Research Policy*, *47*(8), 1391-1399.

James, J. C., & Martilla, J. A. (1977). Importance-performance analysis. J*ournal of Marketing*, *41*(1), 77-79.

Javed, S. A., & Ilyas, F. (2018). Service quality and satisfaction in healthcare sector of Pakistan : The patients' expectations. *International Journal of Health Care Quality Assurance*, *31*(6), 489-501.

Jia, S. H., & Chen, H. H. (2002). 利益相关者的界定方法述评 [Review of methods to define stakeholders]. *Foreign Economy and Management*, *24*(5), 13-18.

Jiang, Z. H., Luo, J. M., & Meng, Z. Y. (2020). 动态能力、结构洞位势与持续竞争优势——青岛红领1995—2018年纵向案例研究 [Dynamic capability, structure hole status and sustained competitive advantage: A longitudinal case study of Qingdao Redcollar from 1995 to 2018]. *R&D Management*, *32*(03), 152-164.

Jiao, H., & Cui, Y. (2008). 企业动态能力理论整合研究框架与重新定位 [Dynamic capabilities in the enterprise: Integrated framework of theory and re-positioning]. *Journal of Tsinghua University (Philosophy and Social Sciences)*, *23*(2), 46-53.

Kerr, M., & Trantow, D. J. (1969). Defining, measuring, and assessing the quality of health services. *Public Health Rep (1896)*, *84*(5), 415-24.

Ko, C. H., & Chou, C. M. (2020). Apply the SERVQUAL instrument to measure service quality for the adaptation of ICT technologies: A case study of nursing homes in Taiwan. *Healthcare (Basel)*, *8*(2),108.

Kroneman, M. W., Maarse, H., & van der Zee, J. (2006). Direct access in primary care and patient satisfaction: A European study. *Health Policy*, *76*(1), 72-79.

Lei, J. S. (2007). 服务及服务质量理论研究综述 [A review of theoretical studies on services and service quality]. *Productivity Research*, (20), 148-150.

Li, X. W., & Wang, Y. J. (2004). 企业动态能力理论综述与前瞻 [A review and outlook of the theory of dynamic capabilities of firms]. *Contemporary Finance & Economics*, (10), 103-106.

Li, Z. X., & Hui, C. (2021). 民营第三方检测行业经营状况与问题分析 [Analysis on the management situation and problems of private third-party testing institutions]. *Quality Exploration*, (2), 97-101.

Liu, H. W., Tu, S. Y., Li S. J., Liu, S., Lu, J. M., Li, H. J., Huang, X., & Xue, D. (2012). 上海市社区卫生服务中心临床免疫检验的现状调查 [Investigation on the current situation of clinical immunoassay tests in community health service centers of Shanghai]. *Chinese Health Resources*, *15*(03), 274-277.

Liu, X. (2018). 公立医院利益相关者的确定及分类管理 [Definition and classification of stakeholders in public hospitals]. *Management Science*, (1), 185-187.

Lu, T.Y., Chen J.L., & Zheng X.C. (2023). SERVQUAL模型在医疗服务质量评价中的应用现状[The current application of the SERVQUAL model in the evaluation of medical service quality]. *Comprehensive Nursing*, *21*(2), 183-186.

Luo, Y., & Jiang, J. M. (2011). 利益相关者理论及其分析方法在卫生领域的应用进展 [Progress on the application of Stakeholder Theory and its analytical method in healthcare]. *Chinese Health Service Management*, *21*(2), 183-186.

Ma, S. Y., Chen, H. W., & Hou, Y. Q. (2017). 区域临床检验中心信息化进程中的问题与对策 [Problems and countermeasures in the informatization process of regional clinical testing centers]. *International Journal of Laboratory Medicine*, 38(21), 3063-3064.

Malfait, S., Van Hecke, A., Hellings, J., De Bodt, G., & Eeckloo, K. (2017). The impact of stakeholder involvement in hospital policy decision-making: A study of the hospital's business processes. *Acta Clin Belg*, *72*(1), 63-71.

Mason, A. N. (2022). The most important telemedicine patient satisfaction dimension: Patient-centered care. *Telemedicine Journal and E-health*, *28*(8), 126-1214.

Mitchell, K. R., Agle, R. B., & Wood, J. D. (1997). Toward a theory of stakeholder identification and salience: Defining the principle of who and what really counts. *The Academy of Management Review*, *22*(4), 853-886.

Mohammadi-Sardo, S. S. (2019). Emergency department patient satisfaction assessment using modified servqual model: A cross-sectional study. *Advanced Journal of Emergency Medicine*, *3*(1), e3.

Nielsen, C. P., Lauritsen, S. W., Kristensen, F. B., Bistrup, M. L., Cecchetti, A., & Turk, E. (2009). Involving stakeholders and developing a policy for stakeholder involvement in the European network for Health Technology Assessment, EUnetHTA. *International Journal of Technology Assessment in Health Care*, *25*(S2), 84-91.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985), A conceptual model of service quality and its implications for future research. *Journal of Marketing*, *49*(4), 41-50.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988), SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing*, *64*(1), 12.

Plaza-Úbeda, J. A. & Burgos-Jiménez, J., & Carmona-Moreno, E. (2010). Measuring stakeholder integration: Knowledge, interaction and adaptational behavior dimensions. *Journal of Business Ethics*, *93*(2). 419-442.

Polluste, K. E. A. (2004). Evaluation of primary health care reform in Estonia from patients' perspective: Acceptability and satisfaction. *Croatian Medical Journal*, *45*(5), 582-587.

Rahim, A., Ibrahim, M. I., Chua, S. L., & Musa, K. I. (2021). Hospital Facebook reviews analysis using a machine learning sentiment analyzer and quality classifier. *Healthcare (Basel)*, *9*(12), 1679.

Rahim, A., Ibrahim, M. I., Musa, K. I., Chua, S. L., & Yaacob, N. M. (2021). Patient satisfaction and hospital quality of care evaluation in Malaysia using SERVQUAL and Facebook. *Healthcare (Basel)*, *9*(10), 1369.

Sher, P. J., & Lee, V. C. (2004). Information technology as a facilitator for enhancing dynamic capabilities through knowledge management. *Information & Management*, *41*(8), 933-945.

Shen, Z., Liu, Y., Fan, J. W., Ren, J. K., & Liang, Y. M. (2019). 我国区域医学检验中心的发展现状与挑战 [Status and challenges of regional medical laboratories in China]. *Chinese Journal of Clinical Laboratory Management*, *7*(04), 199-202.

Snojb, M. D. (2002). The measurement of perceived differences in service quality. *Journal of Vacation Marketing*, 8(4), 362-379.

Sumaedi, S., Yarmen, M., & Yuda-Bakti, I. G. M. (2016). Healthcare service quality model: A

multi-level approach with empirical evidence from a developing country. *International Journal of Productivity and Performance Management*, *65*(8), 1007-1024.

Tambor, M., Pavlova, M., Golinowska, S., Sowada, C., & Groot, W. (2015). Towards a stakeholders' consensus on patient payment policy: The views of health-care consumers, providers, insurers and policy makers in six Central and Eastern European countries. *Health Expectations*, 18(4), 475-488.

Teece, D. J. (2007). Explicating dynamic capabilities: The nature and micro-foundations of (sustainable) enterprise performance. *Strategic Management Journal*, 28(13), 1319-1350.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.

Teshnizi, S. H., Aghamolaei, T., Kahnouji, K., Teshnizi, S. M. H., & Ghani, J. (2018), Assessing quality of health services with the SERVQUAL model in Iran: A systematic review and meta-analysis. *International Journal for Quality in Health Care*, 30(2), 82-89.

Uddin, S. M. F., Sabir, L. B., Khan, M. N., & Athar, M. (2022). Developing a scale measuring patient expectations and service quality of hospitals in India during COVID-19. *Hospital Topics*, *100*(4), 159-165.

Wang, C. L. (2007). Dynamic capabilities: A review and research agenda. *The International Journal of Management Reviews*, *43*(4), 917-955.

Wang, H. D. (2018). 关于建设区域性医学诊断中心的思考 [Thinking on establishing regional diagnostic center]. *Soft Science of Health*, *32*(05), 43-46.

Winter, S. G. (2003). Understanding dynamic capabilities. *Strategic Management Journal*, *24*(10), 991-995.

Wisell, K., Winblad, U., & Sporrong, S. K. (2016). Stakeholders' expectations and perceived effects of the pharmacy ownership liberalization reform in Sweden: A qualitative interview study. *BMC Health Services Research*, *16*(1), 379.

Yucesan, M. G. M. (2020). Hospital service quality evaluation an integrated model based on Pythagorean fuzzy AHP and fuzzy TOPSIS. *Soft Computing*, *24* (5), 3237-3255.

Zeng, P., Deng, T. Z., & Song, T. B. (2013). 社会资本、动态能力与企业创新关系的实证研究 [The relationship among social capital, dynamic capabilities, and enterprise innovation]. *Science Research Management*, *34*(4), 50-59.

Zhen, L., & Li, R. G. (2023). Developing online medical service quality indicators in China from the perspective of online-offline integration: A modified Delphi-AHP study. *International Journal for Quality in Health Care*, *35*(2),38.

Zollo, M., & Winter, S. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science*, *13*(3), 339-351.

Annex A: Relevant Tables

Table a.1 Service quality evaluation scale

Dimension	SN	Detailed items	Description	Expected value (E)					Perceived value (P)				
				1	2	3	4	5	1	2	3	4	5
Tangibles	T1	Modern equipment	The Regional Medical Laboratory Center is equipped with modern and intelligent medical equipment.										
	T2	Comfortable environment and facilities	The laboratories and lounges of the Regional Medical Laboratory Center are clean, tidy and comfortable.										
	T3	Clean and well-groomed appearance of employees	Employees of the Regional Medical Testing Center are dressed in a standardized manner and are clean and neatly groomed.										
	T4	Professional service support facilities	The Regional Medical Laboratory Center has complete service support facilities (directional signage, service flow charts, and user manuals).										
Reliability	R1	Service commitments met within deadlines	It is able to issue testing reports quickly.										
	R2	Professional fulfillment of service commitments	The test reports are accurate and professional.										
	R3	Perception of the company to be reliable	The Regional Medical Laboratory Center is able to ensure that there is adequate communication										

Dimension	SN	Detailed items	Description	Expected value (E) 1	2	3	4	5	Perceived value (P) 1	2	3	4	5
			with the customer and the fees are reasonable with no extra charges.										
	R4	Well-established emergency plans	The Regional Medical Laboratory Center has fully assessed the risks that may arise during the service process and has arranged the countermeasures accordingly.										
	R5	Sound service qualifications	The Regional Medical Laboratory Center has the qualification requirements for various services stipulated by the state and the industry.										
	P1	Timely response to customer complaints	The Regional Medical Laboratory Center is able to respond to customer complaints in a timely manner and deal with them proactively.										
	P2	Timely response to customer needs	The regional medical testing center is able to respond positively to the individual needs of customers.										
Responsiveness	P3	Timely answer to customer questions	The Regional Medical Laboratory Center is able to respond and answer customer questions in a timely manner.										
	P4	Timely notification of service progress	The Regional Medical Laboratory Center is able to provide full-process service status query and inform customers at key service nodes.										

Dimension	SN	Detailed items	Description	Expected value (E) 1 2 3 4 5	Perceived value (P) 1 2 3 4 5
Assurance	A1	Confidentiality awareness of employees	Regional Medical Laboratory Center employees are able to strictly protect client privacy.		
	A2	Sense of assurance of the service process	Regional Medical Laboratory Center staff can give customers a sense of professionalism in their services.		
	A3	Sense of reliability of the employee's words	Regional Medical Laboratory Center staff spend enough time with customers and make them feel that their problems can be solved.		
	A4	Adequate support and protection provided by the company for the employees	The Regional Medical Laboratory Center is able to provide adequate institutional safeguards and resource support for its staff to better serve its clients.		
Empathy	E1	Comprehensive feedback channels	The Regional Medical Laboratory Center will proactively and regularly ask for customer needs and suggestions for improvement.		
	E2	Convenient delivery time	The drop-off times scheduled by the Regional Medical Laboratory Center are very reasonable.		
	E3	Personalized services	The Regional Medical Laboratory Center is able to provide personalized services to its clients.		
	E4	Getting things done once and for all	The Regional Medical Laboratory Center is able to meet the multiple		

Dimension	SN	Detailed items	Description	Expected value (E)					Perceived value (P)				
				1	2	3	4	5	1	2	3	4	5
			testing needs of its clients at one time without making mistakes.										
	E5	Good sense of social responsibility	The Regional Medical Laboratory Center has a green process and program for the disposal of medical waste.										

Annex B: Consultation Form of the Stakeholders

SN	**Do you think that the government departments (health bureaus, healthcare security bureaus, finance bureau, price bureau, and medical products administration) are stakeholders of the regional medical laboratory center? What are their interest demands?**	**Do you think that medical institutions (secondary hospitals and community health centers) are stakeholders of the regional medical laboratory center? What are their interest demands?**	**Do you consider patients as stakeholders of the regional medical laboratory center? What are their interest demands?**	**Do you consider suppliers of drugs, medical devices, and consumables as stakeholders of the regional medical laboratory center? What are their interest demands?**	**Do you consider employees of the company as stakeholders of the regional medical laboratory center? What are their interest demands?**	**Who do you think are the core stakeholders, and Why?**
1	Yes. These are all government departments related to healthcare work. The regional medical laboratory center can reduce the government's investment in the purchase of equipment for medical institutions, improve the efficiency and quality of testing, improve the ability to serve the public, and improve the	Yes. Their interest demands are to reduce investment in equipment, improve testing efficiency and quality, and expand the variety of testing services.	Yes. Their interest demand is convenience. They can do a wider variety of tests at a community hospital (small hospital) without having to go to a large general hospital.	Yes. Their interest demand is to supply medical products to the regional medical laboratory centers.	Yes. Company employees want more business, better benefits and higher personal income.	Medical institutions and government departments. They reduce the burden on government finance and provide services to medical institutions.

	public's satisfaction with medical services.					
2	The government is definitely the stakeholder. The government wants to further utilize social capital to solve the problem of insufficient fiscal input. At the same time, the government also needs to regulate the regional medical laboratory centers.	Yes. They want to get testing services at a more favorable price with better quality.	Yes. The core demands of patients are the quality and timeliness of test results.	Yes. Their core interest demand is to earn higher profits. Good performance of the regional testing center will inevitably compress the hospital's testing business, which will affect the interests of the supplier.	Yes. They want to receive reasonable compensation for their work and job benefits.	Employees, patients and medical institutions are core stakeholders. They belong to service providers and service users.
3	Yes. The healthcare security administration needs to broaden sources of income and reduce expenditure for health insurance, so its demands are reflected in cost control and effective cost reduction. Reduction of procurement costs will increase or stimulate an increase in the economic benefits of testing centers, and service sinking can enhance the testing level of grass-roots institutions, which is conducive to the hierarchical diagnosis	Yes. The construction of standardized regional medical testing laboratories and the sinking of service resources are more conducive to the hierarchical diagnosis and treatment, and are conducive to enhancing the development of the standardized construction of primary health care institutions. It can also enhance the level of clinical diagnosis and treatment. Mutual recognition of test results greatly reduces the cost	Yes. They want mutual recognition of results, which can reduce the cost of healthcare and improves satisfaction and medical experience.	Yes. Centralized procurement of consumables and standardized laboratory construction contribute to cost reduction, and the interest demand is to ensure a large enough enough volume.	Yes. As mentioned before, regional medical testing is beneficial in enhancing the economic efficiency of the testing centers.	Patients. In addition to reduction of medical costs, they also obtain an efficient experience of medical treatment.

	and treatment, and this is the interest demands of the health bureau.	of medical care, and is conducive to improving patient satisfaction in secondary hospitals.				
4	The stakeholders include health bureau, healthcare security bureau and finance bureau. The health bureau wants to improve the capacity and efficiency of testing services, improve the capacity of primary care services, and improve the mutual recognition rate of test results. The healthcare security bureau wants to improve primary service capacity to guide insurance participants to receive initial diagnosis in primary medical institutions, improve the mutual recognition rate of testing to save test expenditures, carry out centralized procurement of test consumables, and reduce test costs. The finance bureau wants to reduce the financial investment in medical institutions testing	Yes. Both of them want to improve capacity of testing services, enhance patient loyalty, improve patient satisfaction, and increase healthcare revenue.	Yes. They want to improve test accessibility and convenience, improve the efficiency of medical consultations without having to make additional visits to the hospital for tests, and strengthen the mutual recognition of test results.	Yes. After improving the service capacity of the grassroots medical institutions, the consumption of drugs and equipment consumables at the grassroots level has subsequently increased, and more investment is needed in the grassroots level.	Employees of the third-party testing center are stakeholder. Their income comes from the enterprise's revenue, and they want to carry out more types and quantities of tests to improve corporate profits.	Medical institutions and patients. Medical services should focus on patient health and revenue. For the long-term healthy development of the third-party regional laboratory centers, only when the interests of both parties are ensured, can it be possible to achieve benign development.

	equipment and personnel.					
5	Yes. Health bureau focuses on quality control, healthcare security bureau focuses on fees, finance bureau focuses on cost, price bureau focuses on pricing, and the medical products administration focuses on reagents.	Yes. Secondary hospitals are concerned about quality and safety, testing accuracy, number of services offered, ease of specimen transportation and timeliness of test reports, as well as charging. Community health centers, whose revenue and expenditure are separate, are concerned about testing accuracy and timeliness of reports.	No. Patients primarily go to medical facilities to get treatment and are not directly concerned with where the tests are actually conducted.	Medical equipment suppliers and reagent suppliers are stakeholders. If the regional medical laboratory center model is adopted, investment in laboratory equipment and reagents in each hospital is bound to be affected.	No.	Medical institutions. It is because they are the core of patient services and are the decision maker and direct risk taker in the selection of a regional laboratory center.
6	The mentioned government functional departments are all stakeholders, and they want to reduce investment, lower costs, increase efficiency and improve access to healthcare for the general public.	Medical institutions are also stakeholders, and their core demand is to facilitate hierarchical diagnosis and treatment, meet the needs of residents to be examined nearby, so that patients can be assured that they will be treated in the community health centers and secondary hospitals.	Patients are also stakeholders, and their core demand is to ensure homogenization of tests, mutual recognition of results, and reduction of financial burden	The suppliers concerned are also stakeholders and they have just one core demand, no matter who is in charge, please use my equipment and procure my drugs and consumables.	This is a personnel payment issue within the center, and every employee wants to work less and get more payment.	Government departments are the core stakeholders. “Strengthening the grass-roots healthcare, compensating for the shortcomings, and establishing mechanisms” are the rigid needs of the national health care reform. The government should think comprehensively of how to promote the regional laboratory centers to integrate resources, ensure quality, safeguard the interests of patients, and cooperate with the

						tertiary hospitals as well as medical colleges and universities, and we do not want to see various departments passing the buck to shirk responsibility.
7	Yes. The government is mainly designed to provide a better medical service to the public. The tasks are to ensure quality, accessibility, equalization, homogenization of services, so the government is able to improve the regional testing capacity by improving the services of the regional testing centers, which can further improve the level of regional health care.	Yes. They want to provide a high level of testing services, provide projects supported by the development of disciplines, receive some subsidy to tackle with the lack of capital investment; and obtain value-added benefits in the joint operation of medical institutions and community health centers or private institutions.	Yes. They want access to high quality healthcare and medical testing services, and they are concerned about the accuracy and timeliness of the test results.	To some extent, yes. They want integration of resources, which can facilitate the application and development of some new projects and technologies, and they also want to promote the use of medical equipment, drugs and consumables.	Yes. Their interest demand is to provide a platform for work and increase their income.	The core stakeholders are patients, the government, and the medical institutions.
8	Yes. They are good complements for the public medical institutions. They can conserve resources, and enhance the level of development of hospital disciplines, as well as the diagnosis and treatment level.	Yes. They focus on a strong technological support that assists healthcare organizations to enhance their services and technology and automation of service skills. They are also concerned with accuracy and timeliness of results,	Yes. They are concerned with test result accuracy, timeliness, and cost.	Yes. Resource integration.	Yes. Good benefits and high income.	The core stakeholders are the medical institutions, patients, and the government.

		so as to enhance patient satisfaction.				
9	Yes, but not obvious.	They are the core stakeholders. They focus on testing quality, results, and speed.	Yes. They focus on test result accuracy, timeliness, cost.	Not too relevant. They focus on reduction of prices.	Good benefits, high income, and professional title advancement.	The core stakeholders are the medical institutions, patients, and the government.
10	Yes. They want efficiency and quality regulation, thus reducing the pressure of regulatory responsibility.	They are the main stakeholders. They focus on high quality of service, accurate results, reasonable price, increase of service cooperation without damaging the interests of the existing partners, decrease of competition and conflict, improvement of service, technical level, equipment update speed, brand effect and price reasonableness, steady enhancement of the regional testing center's market share, reasonable distribution of benefits with the medical institutions, and social responsibility.	Yes. They focus on quality of service, accuracy of results and reasonableness of prices.	The relationship is not particularly obvious. They focus on price reduction, centralized purchasing, and overall industry enhancement.	Increased testing capacity, good benefits, high income, and professional title advancement.	The core stakeholders are the medical institutions, patients, and the government.
11	They are indirect stakeholders. They want to optimize resources and fully amplify healthcare resources. They hope to improve the quality and	They are direct stakeholders. They focus on empowering healthcare organizations to improve service	They are indirect stakeholders. They hope that the grassroots can enjoy a high level of testing, thus	The relationship is not clear. There is a driving force to improve industrial capacity.	Yes. They want more learning opportunities, promotion and income.	The core stakeholders are the medical institutions, the government, and patients.

	level of services and reduce costs.	capacity, quality control, and treatment level.	improving the standard of treatment.			
12	The health bureau is the stakeholder, and the others are the regulators. They want favorable regulation and intensive management.	Yes. They focus on enhancement of the level of testing services, improvement of the level of diagnosis and treatment, and most importantly, accuracy and timeliness of the test results.	Yes. They want accurate testing in close proximity, and promotion of rational drug use through reduction of testing expenses.	The relationship is not particularly obvious. They focus on price reduction, centralized procurement, and overall industry enhancement.	Yes. They focus on increase of income, job stability, and increased room for promotion.	The core stakeholders are the medical institutions, the government, and patients.
13	Yes. They focus on easy access to health care, improved capacity at the grass-roots level, total cost control, and controlled inputs	Secondary hospitals: redistribution of benefits and capacity building of medical technology disciplines to support the development of the discipline, and seeking of greater revenue and patient market. Community: obtain technical solutions to the common and frequent diseases in the standardized diagnosis and treatment pathway, more flexibility in allocation of human resources, and focus on clinical and health management. The entire medical community agree on the goal of retaining patients, and	Yes. They focus on easy access to medical care and cost control.	Yes. They focus on disruption of the traditional value chains and more centralized procurement.	Yes. They focus on greater customer recognition, technical learning, and revenue enhancement.	Medical institutions. They serve as a connecting link between the preceding and the following. They are related to the largest number of stakeholders, and their decisions affect the interests of the widest range of stakeholders.

		avoid the occurrence of major diseases.				
14	Yes. They focus on increasing capacity and enhancing effectiveness.	Yes. They focus on increasing capacity and improving benefits.	Yes. They focus on speed, accuracy and low price.	Yes.	Yes.	Hospitals, government, and testing organizations.
15	Irrelevant.	Yes. They focus on testing services.	Yes. They focus on testing services.	I don't know.	I don't know.	Hospitals and the government.
16	Yes. The health commission can achieve mutual recognition of results across the region to reduce duplicate prescription and repeated testing. Standards of fees and charges should be strictly enforced, and make sure that the those pay by the primary and secondary institution charges can enjoy the testing capacity of tertiary institutions.	Yes. They mainly focus on the upgrading and updating of equipment, standardization of laboratories, training of personnel, and increase in the number of testing items.	Yes. They can enjoy testing services identical to those offered by the tertiary medical institutions but at the expense of charges identical to those in the primary and secondary medical institutions.	Yes, to a certain extent. Once the testing center selects certain brands of equipment and consumables, there will be huge procurement needs.	Yes. They focus on improvement of their capabilities in various aspects, such as learning and promotion of new projects and fast improvement business capabilities.	Hospitals, patients, and health insurance are the core stakeholders, because patients who go to the primary and secondary hospitals can enjoy testing programs offered by tertiary hospitals. The improvement of the diagnostic level of doctors can retain patients and enhance the visibility of the hospital. The test can be mutually recognized within the region to reduce the duplication of prescription to avoid repeated payment. It reduces the health insurance and financial expenditures, and at the same time, cuts down expenses.
17	Yes. The government and health bureau: actively cooperate with	Yes. They focus on strengthening discipline development, upgrading	Yes. They focus on improving testing capacity to meet the	Yes. They want to break the traditional pattern.	Yes. They focus on career development and	1. Medical institutions: academic development; 2. Government: social

	the government in healthcare and enhance people's satisfaction with medical services. Healthcare security and finance bureau: include social funds, strengthen mutual recognition of results, rationalize health insurance expenditures and ensure efficient financial expenditures. Price bureau, medical products administration: resource integration, price control, compliance supervision, safe operation.	service capacity, reducing operating costs and playing a leading role.	need for convenient access to health care, reducing the financial burden on families and promoting family well-being.	Centralized procurement has resulted in a major change in the pattern of external suppliers and service providers, so it is necessary to change the marketing model.	improved treatment.	progress; 3. Operating institutions: institutional development.
18	No	Yes. They focus on accuracy and timeliness of test results.	Yes. They focus on accuracy of results, which is conducive to disease diagnosis.	No.	Yes. They focus on room for promotion and salary increase	Medical institutions and patients
19	They focus on solving the problem of the lack of testing professionals, addressing the medical needs and improving the quality of health care, thereby saving the country's financial investment in health care.	They focus on solving the problem of lack of testing professionals, addressing medical needs and improving medical quality.	Patients are able to perform many tests without having to go to a large hospital, which reduces their queuing time and money.	Increase of business volume.	Increase of business volume.	Medical institutions, the government, and patients
20	No. The government is an instructor, a watchdog, not a stakeholder.	Yes. They focus on (1) homogenization of test results, (2) academic and technical improvement,	Yes. They focus on (1) high-quality test results to ensure the success of the	No. The interests of suppliers and regional medical laboratory center	Yes. They want a stable platform for development and a	Medical institutions are the core stakeholders, as well as the providers, organizers, and leaders of

	(3) high-quality results to avoid doctor-patient disputes, and (4) reasonable performance incentives.	diagnosis and treatment, and (2) avoidance of duplicate tests.	are at odds with each other.	long-term learning platform.	the regional medical laboratory center model