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Exploring the Factors Influencing Medication Adherence in Patients with Tuberculosis under Information-based Management in Huizhou City, Guangdong Province

CHEN Liang

Doctor of Management

Supervisor:
PhD Abílio Oliveira, Assistant Professor with Habilitation,
ISCTE University Institute of Lisbon

December, 2023

BUSINESS
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Abstract

This research investigates the crucial role of drug adherence in assessing tuberculosis (TB) management effectiveness, focusing on using Internet information management technology for TB patients in Huizhou City, Guangdong Province, China. Employing the E-TBPMS (electronic TB patient management system) integrates qualitative and quantitative methods to examine the factors influencing TB patients' medication adherence. Based on the information-motivation-behavioral skills (IMB) theory, mixed methods research is used to cross-explain how the application of information management technology to manage TB patients improves their medication adherence – a quantitative study to explore the influencing factors and pathways of TB patients' medication adherence, and a qualitative study to clarify the mechanisms influencing TB patients' adherence. A questionnaire was developed for the first study, and a large amount of data was collected and explored to propose a model of the influencing factors of TB patients' medication adherence, aligned with the classical IMB theoretical model. In addition, based on data obtained by interviews, the qualitative study analyzed the multifaceted nature of factors or mechanisms influencing medication adherence of TB patients. This research identifies the knowledge, motivation, social support, side effect management, forgetfulness, and difficulties, among other factors, and highlights the positive impact of the E-TBPMS, for providing automated access to diagnostic and treatment information and personalized regimens, reminders, a communication platform, and recovery progress tracking for TB patients. In conclusion, strategies for the E-TBPMS are proposed, advocating improvements in user experience, personalized services, integration of artificial intelligence technologies, enhanced social interaction functions, and reinforced data security and privacy.

Keywords: tuberculosis; information technology; patient care management; TB patients' medication adherence

JEL: I18, I19

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Resumo

Esta pesquisa investiga o papel crucial da adesão aos medicamentos na avaliação da eficácia da gestão da tuberculose (TB), focada na tecnologia de gestão de informação para pacientes com TB, na cidade de Huizhou, província de Guangdong, China. A utilização do sistema eletrónico de gestão de pacientes com TB (E-TBPMS) integra métodos qualitativos e quantitativos para examinar os fatores influenciadores da adesão destes pacientes aos medicamentos. Partindo da teoria da informação-motivação-aptidões-comportamentais (IMB), procede-se a uma pesquisa mista para explicar como a aplicação da tecnologia de gestão de informação melhora a sua adesão aos medicamentos – um estudo quantitativo para explorar os fatores que influenciam essa adesão, e um estudo qualitativo para esclarecer os mecanismos que influenciam a adesão dos pacientes com TB. Desenvolveu-se um questionário para o primeiro estudo (N=269), sendo tratados muitos dados para propor um modelo dos fatores influenciadores da adesão dos pacientes com TB aos medicamentos, alinhado com o modelo IMB clássico. No estudo qualitativo, obtiveram-se os dados por entrevistas, analisando-se a natureza multifacetada dos fatores influenciadores da adesão dos pacientes com TB aos medicamentos. Entre outros, identificaram-se o conhecimento, motivação, apoio social, gestão de efeitos colaterais, esquecimento e dificuldades, destacando-se o impacto positivo do E-TBPMS, pelo acesso automático a informações de diagnóstico e tratamento, regimes personalizados, lembretes, plataforma de comunicação e rastreamento do progresso de recuperação. Finalmente, são propostas melhorias para o E-TBPMS, baseadas na experiência do utilizador, serviços personalizados, integração de tecnologias de inteligência artificial, funções de interação social, reforço da segurança e privacidade de dados.

Palavras-chave: tuberculose; tecnologias de informação; gestão de cuidados ao paciente; adesão dos pacientes com TB aos medicamentos

JEL: I18, I19

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摘 要

本研究以广东省惠州市结核病患者互联网信息管理技术为研究对象，探讨服药依从性在评估结核病（TB）管理成效中的关键作用。采用 E-TBPMS（肺结核病人电子管理系统），结合定性和定量方法，研究影响肺结核病人服药依从性的因素。以信息-动机-行为技能（IMB）理论为基础，采用混合研究方法交叉解释应用信息管理技术管理肺结核病人如何提高其服药依从性--定量研究探讨肺结核病人服药依从性的影响因素和途径，定性研究阐明影响肺结核病人服药依从性的机制。第一项研究编制了调查问卷，收集并挖掘了大量数据，提出了与经典 IMB 理论模型相一致的结核病患者服药依从性影响因素模型。此外，基于访谈获得的数据，定性研究分析了影响肺结核患者服药依从性的因素或机制的多面性。这项研究确定了知识、动机、社会支持、副作用管理、遗忘和困难等因素，并强调了 E-TBPMS 在为结核病患者提供自动获取诊断和治疗信息、个性化治疗方案、提醒、交流平台和康复进度跟踪方面的积极影响。最后，提出了电子结核病管理系统的发展战略，主张改善用户体验、提供个性化服务、整合人工智能技术、增强社交互动功能以及加强数据安全和隐私保护。

关键词：结核病；肺结核患者的服药依从性；信息技术；患者护理管理

JEL: I18, I19

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Contents

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List of Tables

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List of Figures

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List of Abbreviations

ACRONYMS	DEFINITION
5G	Fifth-Generation
AI	Artificial Intelligence
AIDS	Acquired Immune Deficiency Syndrome
BCG	Bacillus Calmette - Guerin
CDC	Center for Disease Control and Prevention
CGM	Continuous Glucose Monitoring
COPD	Chronic Obstructive Pulmonary Disease
Covid-19	Corona Virus Disease 2019
DOTS	Direct Observed Treatment short-course
E-TBPMS	Electronic-Tuberculosis Patient Management System
eDOTS	electronic Direct Observed Treatment System
GDP	Gross Domestic Product
HIS	Hospital Information System
HIV	Human Immunodeficiency Virus
ICT	Information and Communication Technology
IMB model	Information-Motivation-Behavior model
LMIC	Low and Medium Income Countries
mHealth	mobile Health
PTB	Pulmonary Tuberculosis
SCL-90	Symptom check list-90
SSRS	Social Support Rating Scale
TB	Tuberculosis
WHO	World Health Organization

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Chapter 1: Introduction

1.1 Theme introduction

Tuberculosis (TB) is a chronic infectious disease caused by Mycobacterium tuberculosis, which seriously endangers human health and mainly occurs in the lungs. The status quo of global TB prevention and control is still under a very serious situation. According to the *2021 Global Tuberculosis Report* (World Health Organization [WHO], 2021), it is estimated that in 2020 there will be approximately 2 billion people with latent TB infection worldwide and 9.87 million new patients, with an incidence rate of 127/100,000. So far, TB is one of the significant causes of death worldwide. Before the new coronavirus pandemic, TB was the leading cause of death caused by a single source of infection, ranking even before AIDS, posing a major threat to the life and health of all mankind (WHO, 2021).

China is still the country with the highest incidence of TB in the world and it is among the top 30 countries with a high burden of this infectious disease. According to estimates (WHO, 2021), in 2020, the incidence of TB in China was 59 out of 100,000, the number of newly-developed TB patients was estimated at 842,000, accounting for 8.5% of the global total, the number of deaths caused by TB was about 32,000, and the fatality rate of TB was 4%. Guangdong is a province with a large-scale of economy and population base.

Due to the unbalanced economic development and the rapid growth of migrants, the number of new TB patients in Guangdong Province has been ranked first in the country for a long time, and TB has been ranked among the top three in the morbidity and mortality of Class B infectious diseases. As a result, Guangdong Province has become the one with the heaviest burden of TB in China.

Patient management is an integral part of modern TB control strategy. Identifying positive TB patients as soon as possible and ensuring they access effective treatment management is the most effective public health measure to reduce and control TB transmission. Since the 1990s, WHO's strategy of directly observed treatment short-course (DOTS), widely promoted worldwide, has played an essential role in curbing the spread of TB and improving the cure rate of patients. The key to the DOTS strategy is to supervise and manage the diagnosed infectious TB patients in the whole process, to ensure that patients can take medicine regularly, and to

provide a guarantee for curing the disease to a certain extent (Lagrada et al., 2008).

Medication adherence has been widely mentioned in TB control for many years as an essential indicator of the response management effect. With the implementation of DOTS (Direct Observed Treatment Short-course) strategy in a wide range and for a long time, it has gradually become a focus of research at home and abroad to explore the medication adherence of TB patients under the DOTS strategy. Research results have shown (Zhao et al., 2012; Zheng et al., 2012) that the risk of bad data outcomes of TB patients with poor adherence increased by 1.4 times. Relevant research also shows that the treatment adherence of typical TB patients abroad could be better (Gebreweld et al., 2018; Kebede & Wabe, 2012; Tesfahuneygn et al., 2015). Among them, a survey in 2013 showed that 32% of the 286 patients with TB failed to continue their treatment (Ndeikoundam Ngangro et al., 2013). Herrero in Argentina carried out a survey that indicates the non-adherence rate of TB patients in different provinces and cities in Argentina is 0-27.3%.

The cease of treatment for TB patients in China has always been serious, and non-adherence to treatment is also widespread (Li et al., 2003). In related studies, the lowest reported adherence rate was 43.9%, and the highest was 77.3% (Hu et al., 2014; Ren, 2013).

Failure to follow the doctor’s advice and take medication irregularly is not only likely to lead to treatment failure but also easily leads to medicine-resistant TB, which makes the follow-up treatment and management more complicated and further increases the treatment burden. Since the DOTS strategy has been fully implemented in China, the proportion of TB patients' supervision and management is relatively low, and cases of non-adherence with medication often occur (B. Chen, 2014; J. H. Chen, 2017). Therefore, exploring new management methods for TB patients and improving their medication adherence is extremely necessary and vital.

With the advent of the Internet age, information technology has been widely used with its characteristics of convenient networking, instant messaging, accurate delivery, no geographical restrictions, and strong privacy. In April 2019, WHO released the world's first digital health intervention guide, putting forward new suggestions on ten ways that countries can use digital health technology to improve people's health and essential services through mobile phones, tablets, and computers, and then published the Global Strategy for Digital Health (2010-2020) (Dhingra & Dabas, 2020).

Under the background of the Internet era and the guidance of international strategies, it has become a new trend to apply Internet information management technology in TB prevention and control to manage TB patients, improve the quality of patient management services, improve patients’ medication adherence, and improve patients' treatment outcomes.

To help TB patients have access to more effective treatment and to improve patients' medication adherence, Huizhou City in Guangdong Province of China has designed and developed the "mobile phone integrated management system for TB prevention and treatment" to take the lead, which is based on the WeChat app, and realizes multi-dimensional management of TB patients such as patient referral, diagnosis and treatment, follow-up consultation, health education, and hospital campus management through WeChat enterprise number, WeChat official account and mini-programs. The system was tested in March 2013 and was officially introduced and applied in the whole city in September of the same year.

By 2020, Huizhou, after years of application and discussion of information management technology to manage TB patients, found that the utilization rate of patients in WeChat referral and WeChat follow-up increased year by year. According to a survey, in 2019, the referral rate of WeChat in Huizhou City, Guangdong Province, was 54.1%, and the follow-up rate of WeChat was 84.1% (Li et al., 2020). In addition, the research team also found that the application of this information system can quickly complete the referral registration of TB and suspected TB patients, realize real-time online correction of errors and omissions, improve the accuracy of referral information, improve the efficiency of patient referral, tracking, and management notification, and reduce the loss rate of patients during treatment (Peng et al., 2018; X. F. Li et al., 2020; X. W. Li et al., 2021;).

In the mentioned previous studies, the research team carried out related research from the perspective of TB prevention and treatment service providers, focusing on the use of WeChat referral and follow-up by medical staff in the process of applying the system to manage patients, the accuracy of referral information and the efficiency of patient tracking management notification. It was found that the application of the system can reduce the occurrence of patients' loss of follow-up during treatment, and the actual application effect of the system for TB prevention and treatment service providers was verified.

Since 2012, Huizhou Tuberculosis Prevention and Treatment Institute of Guangdong Province has independently developed a "WeChat-based Multifunctional TB Prevention and Treatment Management Information System," which is referred to as "Electronic Tuberculosis Patient Management System (E-TBPMS)"by using the "Internet+" technology. The "E-TBPMS" system is easy to popularize and relatively simple to use. It can provide detailed services to patients, including WeChat referral, diagnosis and treatment, follow-up, and WeChat health education, with the main aim of improving the effectiveness of tuberculosis control and management. Compared with traditional management techniques, the "E-TBPMS" system has the advantages of strong compatibility, easy promotion, low development and

operation costs, and simplicity of use, making it a powerful supplement to existing measures.

After years of application and continuous improvement, the "E-TBPMS" system has been fully applied in 7 TB prevention and control institutions, comprehensive medical institutions, and 93 primary medical institutions in Huizhou. It improves the contracted services for TB patients, establishes a real-time case reporting system for multidrug-resistant patients, and effectively implements different TB control service packages. In addition, the "E-TBPMS" system has laid a solid foundation and technical support for constructing a hierarchical diagnosis and treatment system and helped in poverty alleviation through accurate health care, basically realizing the full coverage of tuberculosis prevention and treatment services. Through applying the "E-TBPMS" system, tuberculosis prevention and treatment work has significantly improved management and service. In terms of management, the system can track and record patients' medication, monitor the development of patients' conditions, and collect and transmit epidemic information needed by health departments at all levels on time, providing a scientific basis for decision-making. In terms of service, the system provides patients with various service modes, such as online contracting service, online diagnosis and treatment consultation, personalized follow-up visits and health education through the WeChat platform, which facilitates patients' access to health information and improves medication adherence.

Among them, supervisors receive patient management tasks from clinicians in the module of follow-up management for TB patients, communicate effectively with patients, and complete patient management tasks such as first-time household surveys and regular follow-up visits through remote online real-time supervision. Traditional patient follow-up records must be filled out manually, which takes a lot of time and is difficult to adhere to. At the same time, it is inconvenient to revise them due to pen errors and other reasons. Using an electronic form of patient follow-up records, the doctor-in-charge can use his mobile phone to record at any time at the supervisory site, improving work efficiency. Patient records can be automatically selected, printed, and filed. Managers can supervise the work of supervisors through the back-end platform, and patients can also evaluate the supervisory work itself.

In TB control, it is essential to control the spread of TB by improving patients' medication adherence to improve their treatment outcomes. However, at present, the related research on whether using information management technology to manage TB patients' medication adherence needs to be more profound in China, and there needs to be more research evidence on the influencing mechanism, which has a limited guiding role in practical work.

1.2 Research motivation

To explore the influencing factors related to medication adherence in TB patients and to assess the effectiveness and feasibility of digital health interventions in improving patients' medication adherence. TB is a major public health problem worldwide, and global and Chinese TB prevention and control still face serious challenges. Effective patient management is the core of TB control strategies, and patient medication adherence has a significant impact on controlling and preventing TB transmission as well as improving cure rates.

Studies have shown that there are widespread problems with patient adherence to medication, such as irregularity in taking medication and failure to follow medical advice. This non-adherence can lead to treatment failure, development of drug resistance and increased disease transmission, posing a huge challenge to TB prevention and control. Digital health interventions have become a new way to improve patients' medication adherence. By using mobile communication technologies and internet platforms, patients can access timely health information and support to promote medication adherence.

Although some districts have begun experimenting with digital health intervention tools such as WeChat applets to manage TB patients, these attempts have been effective. However, there are fewer evaluations of the effectiveness of digital health intervention strategies and a lack of quantitative research data and comprehensive policy guidance. Therefore, this study aims to fill this research gap by analyzing in depth the status of medication adherence among TB patients in Guangdong Province, assessing the effectiveness of digital health interventions in improving medication adherence and exploring their feasibility and economic benefits.

The study results will provide a scientific basis and policy recommendations for TB prevention and control, as well as lessons learned and replicable experiences for TB prevention and control globally and contribute positively to improving the health and well-being of all human beings.

1.3 Research Aims

The main objective of this research was to assess the effectiveness of applying information technology (Electronic Tuberculosis Patient Management System (E-TBPMS)) in managing TB patients and to explore the factors influencing their drug adherence. In this context, the following research question was formulated:

(1) How does the application of information management technology to manage

tuberculosis patients improve their medication adherence?

This starting question is complemented with two other questions:

(2) What factors affect patients' medication adherence during the application of information management technology to manage TB patients?

(3) What is the mechanism of action of the factors that affect patients' medication adherence?

Based on the above research questions, the research objectives are:

(1) Explore the influencing factors and pathways of adherence of tuberculosis patients.

(2) Construct a theoretical integrated model based on information-motivation-behavioral skills to analyze the correlation and strength of the relationship between factors and medication adherence.

(3) Validate the constructed integration model proposed.

(4) Clarify the mechanisms influencing adherence of TB patients.

(5) Analyze the effect of the current technology (E-TBPMS) on TB patients through the validated mechanisms.

(6) Propose strategies for further optimization (E-TBPMS).

1.4 Research methods

Mixed Methods Research was used to cross-explain the research questions through a quantitative and qualitative sequential design. Quantitative research will first explore the factors influencing medication adherence among TB patients under information management technology. The quantitative study will assess the role of these influencing factors by collecting and analyzing a large amount of data and enriching the existing research on medication adherence among TB patients by constructing a model of the corresponding influencing factors. In the second step, a qualitative study was used to explore in depth the factors of information management technology in influencing the medication adherence behavior of TB patients through the interview method. This qualitative research method will be able to objectively and accurately analyze the factors that influence the behavior of information management technology on medication adherence in tuberculosis patients. In addition, in a final procedure, these theoretical or conceptual models will be conducted to provide a scientific basis for improving the efficiency and effectiveness of patient management in TB prevention and control.

Through in-depth research and accurate modelling, we will better understand the impact of information management technology on medication adherence of TB patients and provide

scientific supervision for relevant policies and measures. The research methods are summarized as quantitative and qualitative studies as briefly described in the next two sections.

1.4.1 Quantitative research

A self-designed questionnaire was developed based on the information-motivation-behavioral skills theory. The survey was administered to patients with active tuberculosis managed by the Mobile-based Integrated Tuberculosis Management System in Huizhou, Guangdong Province, China. The survey included economic information, behavioral habit, health service access, social support, knowledge about tuberculosis, motivation to take medication, behavioral skills, adherence to medication, and evaluation of treatment outcomes. The correlation and relationship between each factor and medication adherence were analyzed through univariate and multi-factor analysis, and a model of factors influencing medication adherence among tuberculosis patients was established.

Economic information from the survey can help to understand the impact of patients' economic status on medication adherence. Behavioral surveys can reveal the effects of patients' lifestyles and dietary habits on medication adherence. The study on health service access can shed light on the impact of patients' frequency and mode of access on medication adherence. Social support surveys can assess the impact of family and friends' support levels on medication adherence. The content of the study on knowledge about tuberculosis will evaluate the impact of the patient's level of awareness of the disease on medication adherence.

Investigations into motivation to take medication can provide insight into patients' motivation and willingness. Behavioral skills surveys assess the patient's ability to use medication correctly and to follow medical advice. Investigations of medication adherence assess the extent to which patients take their medication on time and in the correct dose. A survey of treatment outcomes will provide information on the patient's evaluation and feedback on the effectiveness of their treatment.

The correlation and the relationship between each factor and medication adherence can be analyzed through univariate and multifactorial analyzes. By modelling the factors influencing medication adherence in tuberculosis patients, the role and importance of each factor in influencing medication adherence can be revealed. These findings have important implications for improving patients' adherence behaviors and enhancing treatment outcomes.

1.4.2 Qualitative research

Based on the literature review and the purpose of the study, a detailed interview outline was designed to gain insight into the situation of TB patients. This interview outline will include the following elements to understand the patient's personal situation, treatment experience, and experience with the E-TBPMS:

(1) Demographic information: age: to understand the age distribution of the respondents and to explore the problems and needs that patients of different ages may face; occupation: to understand the occupational background of the respondents, which may be correlated with treatment adherence and use of the system; and education: to understand the level of education of the respondents, which may be related to the understanding of knowledge of the disease and the ability to use the system.

(2) TB diagnosis and treatment experience. Diagnostic process: to understand how patients were diagnosed with TB and to explore whether there was any misdiagnosis or missed diagnosis; Treatment experience: to explore patients' experience in receiving TB treatment, including side effects of medication, treatment cycles, and changes in physical condition.

(3) Experience of using "E-TBPMS". Time and habit of use: to determine the period and frequency of participants' use of the system and their familiarity with its functions and interface. Doctor-patient information exchange: to examine the system's role in doctor-patient communication and to explore the information exchange between patients and medical staff. Motivation and preference for use: to understand respondents' motivation and preference for using the system, which may include convenience and need for information access.

(4) Factors affecting medication adherence behavior. Medication adherence: to understand patients' attitudes and behaviors towards taking medication on time and following the dosage and to explore factors that may affect medication adherence, such as medication side effects, forgetting to take medication and lifestyle. Key links and management functions: Investigate the system's functions in reminding and managing medication adherence and explore the system's role in helping patients establish medication habits and routines.

Rich qualitative data can be obtained through in-depth individual interviews with several patients. Based on these data, we coded and analyzed the data and combined the coding results with the quantitative findings to refine the model of factors influencing medication adherence in TB patients under information management technology.

In-depth interviews are an important research method to understand further and describe patients' experiences and perspectives, thus providing supervision and recommendations for

improving treatment adherence and medication management among TB patients.

1.4.3 Research design

Figure 1.1 shows the Research design.

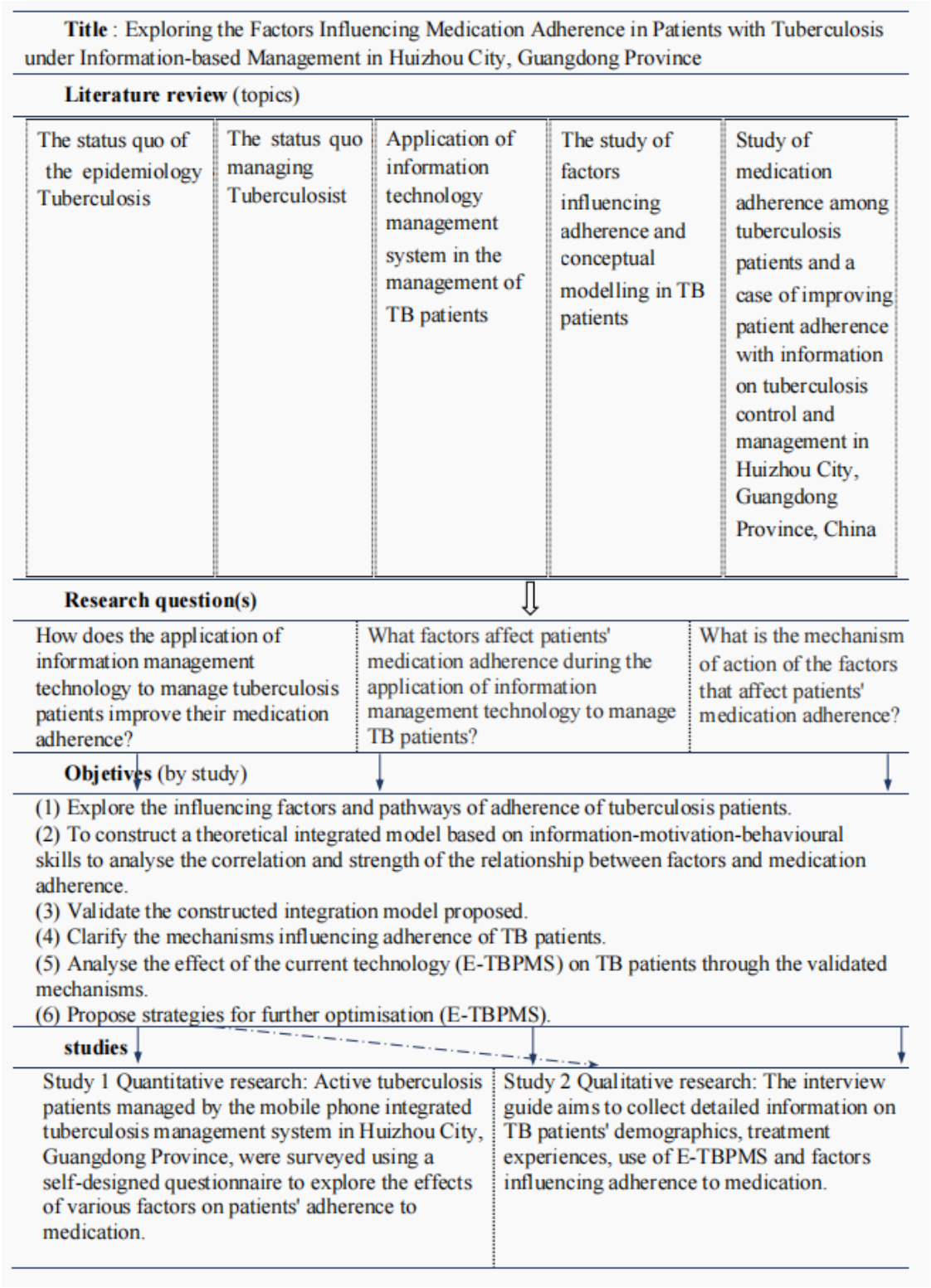

Figure 1.1 Research plan

1.5 Thesis structure

This thesis is divided into seven chapters, aiming to thoroughly explore the influencing factors of information management technology on tuberculosis patients' medication compliance, and to put forward technical and policy suggestions for improving the effect of tuberculosis prevention and treatment. The specific structure is as follows:

Chapter 1: General Introduction

This chapter begins with an introduction and elaboration of the research background, questions, methods, and objectives. This chapter also provides the overall structure and Research plan of the thesis, setting the scene for the detailed content of the subsequent chapters.

Chapter 2: Literature Review

In this chapter, the current epidemiological status of tuberculosis and global patient management, the use of information technology in the prevention, treatment and medication management of tuberculosis patients, explaining the influencing factors and conceptual models of medication adherence in tuberculosis patients, and summarizing the findings of previous studies on medication adherence in tuberculosis patients are presented through the study and report of relevant domestic and international literature, as well as the presentation of the A case study of improving patient adherence with the management information system for tuberculosis control in Huizhou, Guangdong Province.

Chapter 3: Introduction to the Research - Research design

This chapter details an overview of the research for this project, and the theoretical approach used, including the Information-Motivation-Behavioral Skills model (IMB model). On this basis, the study's hypotheses and theoretical framework were established, guiding the research methodology and analyzes in the subsequent chapters.

Chapter 4: Research method, content, and findings of the quantitative study

This chapter focuses on the quantitative study's methodology, content, and findings. The quantitative study used robust statistical methods such as regression analysis to elucidate the causal relationships and predictors of medication adherence. In addition, this chapter highlights the key aspects and role of information management technology in patient medication adherence, emphasizing quantitative dimensions and empirical evidence to support the findings. By integrating quantitative research methods, this chapter aims to contribute to a systematic and empirical understanding of the factors influencing medication adherence among TB patients, thereby enriching the scientific discourse on this critical public health issue.

Chapter 5: Research method, content, and findings of the qualitative study

This chapter focuses on the qualitative study's methodology, content, and findings. The central aim of the study was to explore the complexities of medication adherence among TB patients through a qualitative lens. This required a rigorous qualitative research methodology to capture the nuances of patients' experiences and perceptions during the treatment process. Through in-depth interviews and thematic analysis, qualitative research seeks to uncover the multifaceted aspects of medication adherence and to synthesize the qualitative research findings to draw insightful and substantive conclusions. In addition, the qualitative research methodology aims to provide a comprehensive and nuanced understanding of the various factors that influence patient adherence, thereby contributing to a richer and more comprehensive understanding of this critical issue.

Chapter 6: Research Discussion

In this chapter, we will further explore the impact of information management technology on medication adherence among TB patients through an in-depth analysis of the study results. To gain a deeper understanding of the mechanism of this impact, we will undertake a comprehensive comparison and discussion with relevant research from around the world. Through such comparisons, we will be able to identify the specific mechanisms of the role of information management technologies in TB control. In addition, we will not limit ourselves to describing the results of existing studies but also make some recommendations to improve TB control's efficiency and effectiveness. These recommendations will cover both technical and policy aspects aimed at promoting medication adherence among TB patients and improving the use of information management technologies in TB control. With these improvements, we expect to provide more efficient and effective support for TB control.

Chapter 7: Conclusions

The final chapter of this thesis is a conclusive summary of our findings, highlighting the contributions of the present investigation and the limitations encountered during the research process. We highlight the most important findings obtained from investigating the impact of information management technology on medication adherence in TB patients. By acknowledging the constraints and limitations of the research, we provide a balanced perspective on the significance of the results. We also suggest recommendations for future research, including investigating the long-term effects of information management technology on medication adherence, recurring to different technology interventions, and conducting comparative studies in other healthcare settings.

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Chapter 2: Literature Review

2.1 The status quo of the epidemiology of tuberculosis (TB)

2.1.1 Massive patients suffering from TB

Tuberculosis (from now on referred to as TB), caused by mycobacterium tuberculosis, is a chronic infectious disease in which pathological changes mainly occur in lung tissue, trachea, bronchus, and pleura (Chinese Society of Infectious Disease of Chinese Society of Radiology, 2018; State Health and Family Planning Commission of The People's Republic of China, 2018).

The incubation period of TB is 4 to 8 weeks. Human-to-human respiratory transmission is the main infection mode, and the infection source is TB patients exposed to excreted bacteria. With the deterioration of environmental pollution and the spread of AIDS, the incidence of TB is getting higher.

A quarter of the global population may be infected with mycobacterium, with 90% adults and more male cases than female ones. TB is one of the 13 leading causes of death in the world, and the second largest single vital infection, bringing a significant threat to life and health of all human beings (Vos et al., 2020). Moreover, the rapid growth of drug-resistant TB cases makes it more challenging to realize prevention and control of it (Giovanni & Giovanni, 2015). The *Global Tuberculosis Report 2021*, published by WHO, states (WHO, 2021): the Covid-19 pandemic has had a huge impact on TB control and prevention, with a significant drop in the number of reported cases. 5.8 million new TB cases were diagnosed globally in 2020, lower than that of 7.1 million in 2019. And about 4.1 million cases (41 per cent) of TB are not correctly diagnosed or formally reported to national health authorities, 1.2 million higher than in 2019.

The sharp decline in the detection and reporting of TB cases between 2019 and 2020 may reflect a disruption in the supply of and demand for TB diagnostic and treatment services. Examples of such disruptions or lack of reports include reduced capacity of the health system to continue to provide services, reduced willingness, and ability to seek treatment in the context of the quarantine and related travelling restrictions, fear of the risks of travelling to health facilities during a pandemic, and the stigma associated with TB and coronavirus-like symptoms.

While 2021 continues to be affected, achieving the target of treating 40 million TB patients between 2018 and 2022 set by the UN High Level Meeting is unlikely.

China still has a high incidence of TB, confronting a severe challenge in preventing and controlling this disease. In 2020, it is estimated that China reported 842 thousand new cases of TB (833 thousand in 2019, 866 thousand in 2018), with an incidence of 59/100 thousand (58/100 thousand in 2019, 61/100 thousand in 2018). According to estimation, 32 thousand death cases of TB will be reported in China, with a mortality rate of 4%. Since 2000, the incidence of TB has witnessed a downward trend, which was reversed from 2019 to 2020. Plus, China ranks second in 30 countries with the highest TB burdens (WHO, 2018, 2019, 2020).

Guangdong is a large province in China, considering its economic scale and population. Guangdong province also has many migrant population and unbalanced economic development. It is a province with the highest burden of TB in China, where the number of reported cases ranks the first for many years, depicting a gloomy picture.

2.1.2 Increased mortality of TB

In 2020, the sharp dropping in the number of newly diagnosed TB cases was the direct reason for the increase in TB mortality in various regions and countries worldwide.

Due to the pandemic, global progress in reducing the number of TB deaths has been reversed for many years. This is the first time since 2005 that there has been a year-on-year increase (5.6%). In 2020, the global death toll of TB (1.3 million) is nearly twice that of HIV/AIDS (680 thousand), and the Covid-19 pandemic has a more serious impact on the death rate of TB patients than HIV/AIDS. Contrary to TB, the number of people who died of HIV declined between 2019 and 2020. The last time WHO released the estimated global cause of death was in 2019. The results showed that tuberculosis was the 13th leading cause of death in the world and the leading cause of death caused by a single infectious pathogen.

It is estimated that 2020 tuberculosis became the second-largest single cause of death after Covid-19. In the six regions counted by WHO data, the absolute number of tuberculosis deaths in four regions tended to decrease before 2019 and then increase in 2020, which was a global trend. The only exceptions were Africa and the Western Pacific, which showed a flat trend. Among the 30 countries with a high burden of tuberculosis, the number of tuberculosis deaths in most countries increased in 2020.

2.1.3 Slow decline in TB incidence

Affected by Covid-19, WHO adjusted the estimation method of TB cases in 2020 and estimated that 9.9 million new cases (95% CI: 8.9 million-11 million) would be added in 2020, which is equivalent to 127 cases (95% CI: 114-140 cases) per 100 thousand people. Compared with 2019, these two numbers slightly decreased (the incidence rate has decreased by 1.9% and the absolute number of cases by 0.87%, continuing the obvious slow downward trend since 2000.

In 2020, the impact of the cease of TB services on the incidence of it was more limited than that on mortality, mainly for two reasons: first, the end of diagnosis and treatment first affected those who already have the disease, leading to an increase in the number of deaths. Second, with more and more people suffering from TB, the increase in cases impacted the incidence rate. From 2018 to 2019, the annual decline rate of incidence was 2.3%, and the annual decline rate of the absolute number of cases was 1.2%.

Geographically, in 2020, most tuberculosis cases occurred in WHO Southeast Asia (43%), Africa (25%), and the Western Pacific (18%), with a smaller proportion in the Eastern Mediterranean (8.3%), America (3.0%) and Europe (2.3%). Thirty countries with high burden of tuberculosis accounted for 86% of all estimated cases in the world, among which eight countries (Figure 3) accounted for two-thirds of the global total: India (26%), China (8.5%), Indonesia (8.4%), Philippines (6.0%), Pakistan (5.8%), Nigeria (4.6%). Tuberculosis can affect anyone, regardless of age or gender. Adult males bear the heaviest burden, accounting for 56% of all tuberculosis cases in 2020; In contrast, adult women account for 33% and children account for 11%. The proportion of male tuberculosis cases is high, consistent with the national tuberculosis prevalence survey evidence. This evidence show that men are more likely to be infected with tuberculosis than women, and the gap between men in case discovery and reporting is even greater. Of all tuberculosis cases, 8% are HIV-infected.

Among the countries in the WHO African region, the proportion of tuberculosis cases co-infected with HIV is the highest, exceeding 50% in parts of southern Africa. In terms of the number of tuberculosis cases per 100,000 population per year, the severity of the tuberculosis epidemic varies significantly among countries, ranging from less than 5 cases per 100,000 population per year to more than 500 new and recurrent cases. In 2020, the incidence of tuberculosis in 57 countries was low (less than 10 cases per 100,000 population per year), mainly in the WHO Americas region and the WHO Europe region, plus a few countries located in the WHO Eastern Mediterranean and Western Pacific region.

2.1.4 Status quo of diagnosis and treatment of TB

From 2009 to 2012, the number of reported cases of TB in the world was 5.7 to 5.8 million cases per year, rising to 6.4 million cases in 2017 and 7.1 million cases in 2019. Compared with 2019, in 2020, the number of reported cases worldwide dropped significantly. In 2020, the gap between the number of TB patients and the number of newly diagnosed and reported cases will be significantly widened. Previously, the incidence of TB was relatively stable at around 10 million cases per year. In 2020, the number of newly reported cases was 5.8 million, which restored the global level of TB prevention and control in 2012.

Globally, these negative trends suggest that the coverage rate of TB treatment in 2020 will be 59% (95% UI: 53-56%), lower than 72% (95% UI: 65-80%) in 2019. Among the 30 countries with high TB incidence, the countries with the highest treatment coverage in 2020 include Brazil, China, and Thailand. In 2020, the treatment coverage of the eight countries with high TB incidence could have been better, among which the best-estimated value is less than 50%, namely, Central African Republic, Gabon, Indonesia, Lesotho, Liberia, Mongolia, Nigeria, and the Philippines.

The reversal of significant progress in the number of newly diagnosed TB cases each year has seriously affected the progress of global TB treatment targets set by the UN High-level Meeting. From 2018 to 2020, the cumulative number of people receiving treatment was 19.8 million, equivalent to 50% of the target of 40 million in five years (2018-2022).

The decrease in reported cases is because the number of people diagnosed with TB is under-reported and under-diagnosed (TB patients cannot get medical care or be diagnosed when they get medical care). From a global perspective, it is essential for these countries to try to restore the level of TB case detection achieved before the Covid-19 pandemic.

In many countries, it is also necessary to increase the percentage of bacteriologically confirmed cases by using recommended diagnostic methods (rapid molecular detection or culture) according to WHO guidelines. Microbial detection of TB is essential, as it can help patients get a correct diagnosis, and a drug resistance test is also necessary to ensure that the most effective treatment can be selected as soon as possible.

In the investigation of TB diagnosis and examination, it is found that rapid tests are still over-limited. In 2020, only 1.9 million (33%) out of 5.8 million people newly diagnosed with TB were diagnosed by the rapid molecular test recommended by WHO, slightly higher than 28% (among 7.1 million people) in 2019. In 2020, the global coverage rate of HIV testing for TB patients is still high, at 73% (higher than 70% in 2019). However, the absolute number of TB

patients who know their HIV status decreased from 4.8 million in 2019 to 4.2 million in 2020 (a decrease of 15%).

In 2019, the success rate of TB patients treated with the first-line approach was 86%. Among them, the success rate of treating HIV-infected people was still low (77% globally in 2019), and that of children (0-14 years old) was 88%.

2.1.5 Diagnosis and treatment of drug-resistant tuberculosis

In the gap between the estimated number of cases of MDR/Rifampicin-resistant tuberculosis in the world and the number of people receiving treatment in the world in 2020, 10 countries account for about 70%: China, the Democratic Republic of Congo, India, Indonesia, Nigeria, Pakistan, Philippines, Russian Federation, South Africa, and Viet Nam. It is necessary to significantly increase treatment coverage worldwide and strive to improve the detection and diagnosis of drug-resistant tuberculosis and access to treatment in these countries.

Globally, the success rate of treatment for MDR/RR-TB was 59% in 2018 (the latest patient cohort with available data) and 50% in 2012, reflecting the steady improvement of treatment success rate in recent years. Among WHO regions, the treatment success rate in 2018 ranged from 56% in Europe to 69% in Africa. By the end of 2020, 109 countries will be using beta quinoline to treat drug-resistant tuberculosis (the same as in 2019). A total of 90 countries are using complete oral long-term regimens (86 in 2019), and 65 countries are using short-term regimens to treat MDR/Rifampin-resistant tuberculosis. The coverage of rifampicin resistance testing in all six regions of WHO has improved, with the highest level in Europe (93%). Among the 30 countries with a high burden of MDR/Rifampicin-resistant tuberculosis, 18 countries have reached more than 80% coverage in 2020: Azerbaijan, Belarus, China, India, Kazakhstan, Kyrgyzstan, Mongolia, Myanmar, Philippines, Republic of Moldova, Russia Federation, South Africa, Tajikistan, Ukraine, Uzbekistan, Vietnam, Zambia, and Zimbabwe.

In the gap between the estimated number of cases of MDR/Rifampicin-resistant tuberculosis in the world and the number of people receiving treatment in the world in 2020, 10 countries account for about 70%: China, Democratic Republic of Congo, India, Indonesia, Nigeria, Pakistan, Philippines, Russian Federation, South Africa, and Vietnam. It is necessary to greatly increase the coverage of treatment worldwide and strive to improve the detection and diagnosis of drug-resistant tuberculosis and access to treatment in these countries.

2.1.6 The prevention of TB

The main intervention measure to reduce the risk of latent TB infection progressing into active is preventive treatment of TB. Other interventions include prevention and control of infection, and vaccination of children with BCG vaccine, which can provide protection, especially to prevent children from being infected with TB of severe clinical symptoms. WHO guidelines recommend that HIV carriers, family contacts of bacteriological confirmed cases and clinical risk groups (such as dialysis patients) receive preventive treatment of TB.

The number of people receiving TB prevention and treatment in the world increased from 1 million in 2015 to 3.6 million in 2019, but this positive trend changed in 2020, with a decrease of 21% to 2.8 million. This may reflect the impact of the Covid-19 pandemic on health services. The sum of TB cases prevention and treatment from 2018 to 2020 is 8.7 million, which is only 29% of the target of 30 million from 2018 to 2022.

The service of TB preventive treatment needs to continue to strengthen and expand investment, including more screening at the family level (especially among people aged 5 and above), strengthening the follow-up work of TB screening in families and HIV carriers, and increasing the chances of obtaining short-term (1-3 months) rifampicin treatment programs. As of June 2021, 36 countries reported using the shorter approach containing rifapentine, compared with 29 countries reported using it one year ago.

In 2020, 154 countries formulated policies to provide BCG vaccination for the whole population, of which 53 countries reported at least 95% of coverage rate. Worryingly, the coverage rate reported by 31 countries decreased by 5%, and even exceeded 5% from 2019 to 2020. This decline is larger than previous years, which may reflect the interference of the Covid-19 pandemic on the health service system. So far, most people who receive preventive treatment for tuberculosis are HIV carriers. Globally, this number has increased from less than 30,000 in 2005 to 2.3 million in 2020, including 7.2 million in 2018-2020. This means that although it has decreased from 3 million in 2019 to 2.3 million in 2020 (a decrease of 23%).

However, the global sub-goal of providing TB prevention and treatment for 6 million HIV carriers between 2018 and 2022 was achieved ahead of schedule. Six countries, India, Mozambique, Nigeria, South Africa, Uganda, and Zambia, will account for 74% of the patients who will start receiving treatment in 2020. Among the 20 countries that reported the results, the median completion rate of those who started treatment in 2019 was 84%. There was a similar growth pattern until 2019.

However, in 2020, the number of family contacts of tuberculosis patients decreased by 11%

(from 560,000 in 2019 to 500,000 in 2020). During the three-year period from 2018 to 2020, the cumulative number of people who initiated tuberculosis prevention and treatment was 1.5 million, which was only 6.2% of the five-year target of 24 million people during the period from 2018 to 2022; This figure includes 1.2 million children under five years old (accounting for 29% of the five-year target of 4 million) and 320,000 elderly people (accounting for 1.6% of the five-year target of 20 million). Among the 80 countries that reported the results, the median completion rate of patients who started treatment in 2019 was 86% (IQR: 71-96%).

To improve the provision of preventive treatment for tuberculosis, efforts and investments need to be greatly strengthened and expanded. This includes more TB screening at the family level (especially among people aged 5 and above), strengthening the follow-up work of TB screening among families and HIV carriers, and increasing the access to short-term (1-3 months) rifampicin treatment programs. As of June 2021, 36 countries reported using a shorter regimen containing rifapentine, compared with 29 countries using it a year ago.

The ratio of tuberculosis detection rate of health worker to that of ordinary adults reflects the effectiveness of tuberculosis infection control in health facilities. This ratio should be around 1, but in 2020, in 18 countries that reported, 5 or more cases of tuberculosis among health workers, this ratio exceeded 1.

2.1.7 Disease burden of TB patients

To make progress in reducing the burden of treating tuberculosis, it is necessary to provide sufficient funds for diagnosis, treatment, and prevention services for many years. However, the funds of low-and middle-income countries (LMIC), which account for 98% of reported tuberculosis cases, are far from enough. From 2019 to 2020, the expenditure decreased by 8.7% (from $5.8 billion to $5.3 billion), returning to the level of 2016. By 2022, this will be less than half (41%) of the global target of $13 billion per year, and only 39% of the estimated amount required in 2020 in the Global Plan to Eliminate Tuberculosis of the Stop TB Partnership for 2018-2022.

The decline in expenditure during 2019-2020 may reflect several facts, including an 18% decrease in the number of people diagnosed with tuberculosis worldwide 2019-2020, changes in the service delivery mode for example, fewer visits by medical institutions and more reliance on remote support during treatment, and reallocation of resources for COVID-19 response.

Together, these facts mean that between 2019 and 2020, the domestic expenditure on outpatient and inpatient treatment of tuberculosis patients (excluding drugs and diagnosis) decreased by about $400 million.

Of the total $5.3 billion available for the use of TB in 2020, $3.2 billion will be used for the diagnosis and treatment of drug-sensitive tuberculosis (including outpatient and inpatient care) and $2 billion for the diagnosis and treatment of multidrug-resistant/rifampin-resistant tuberculosis (including outpatient and inpatient care). These two funds are less than half of the estimated requirements of the global plan (US$ 8.5 billion and US$ 4.4 billion, respectively in 2020) (38% and 45%, respectively). The remaining funds (< US$ 100 million) include funds for tuberculosis prevention and treatment (including drugs only) and interventions specifically related to HIV-related tuberculosis.

As in the past ten years, most of the funds available in 2020 ($4.3 billion out of $5.3 billion; (81%) were from China, and the overall figures are strongly influenced by Brazil, Russian Federation, India, China, and South Africa (BRICS countries). Together, these five countries accounted for $2.8 billion (65%) of the $4.3 billion domestic available funds in 2020. 95% of the funds of BRICS countries and all the funds of Brazil, China, and the Russian Federation come from domestic sources.

In other low-and middle-income countries, international donor funds remain crucial. For example, in 2020, it accounted for 53% of the available funds of 26 countries with high burden of tuberculosis and two countries (Cambodia and Zimbabwe) on the global tuberculosis watch list, accounting for 59% of the available funds of low-income countries.

During the period of 2010-2020, the total amount of funds provided by international donors averaged $900 million per year, but there were some fluctuations (global group in Figure 29). The main source is the Global Fund to Fight AIDS, Tuberculosis, and Malaria (Global Fund), and its contribution ratio ranges from 69% (2010) to 83% (2017); In 2020, this proportion will be 76%. The U.S. government is the largest donor to the Global Fund, and it provides nearly 50% of international donor funds for tuberculosis. There is an urgent need to increase domestic and international funding for tuberculosis, but data show that the international donor funds for the national tuberculosis planning report are expected to increase by only $147 million from 2020 to 2021.

Only by providing TB diagnosis, treatment, and prevention services in the context of achieving universal health coverage and taking multi-sectoral actions to solve the broader determinants of TB epidemic and its socio-economic impact can we achieve the global goal of reducing TB burden. For example, only less than 6.5% of TB patients die from TB can we reduce TB deaths in 2025. It is only feasible if every TB patient can get timely diagnosis and treatment services.

Universal healthcare coverage is to provide everyone with the services they need without

financial difficulties. By adopting the Sustainable Development Goal, all countries are committed to achieving universal healthcare coverage by 2030: the goal is "to achieve universal health, including financial risk protection, access to quality basic health care services and safe, effective, high-quality and affordable essential drugs and vaccines for all".

Two indicators of 30 countries with high TB burden and three countries on the global TB watch list show that there is still a long way to go to achieve universal health coverage in most of these countries. Among countries with a high burden of tuberculosis, Thailand stands out with a high SCI of 80 and a low level of catastrophic health expenditure (2% of households). Although the data after 2017 are not yet available, the COVID-19 pandemic may have caused many countries to stagnate or reverse the progress of achieving universal health coverage in 2020 and 2021.

Many newly diagnosed TB cases can be attributed to five risk factors: malnutrition, HIV infection, alcoholism, smoking (especially male), and diabetes. Under the Covid-19 pandemic, reducing the risk of TB, including per capita GDP, poverty, and social protection, is more important than ever. Addressing the broader determinants of the TB epidemic requires multi-sectoral accountability.

The political declaration of the United Nations High-level Meeting on Tuberculosis requires the Director-General of WHO to formulate a multi-sectoral accountability framework (MAF-TB) for tuberculosis and ensure its timely implementation. After extensive development work, WHO finalized and released the framework in 2019. To support member countries to adapt and use it, WHO has also made a list to enable countries to evaluate the status of the main factors of MAF-TB.

The implementation results of the checklist show that the adaptation and implementation of MAF-TB are making progress. However, the participation of all relevant departments, including civil society, needs to be strengthened, as does the high-level review mechanism. In view of the impact of COVID-19 pandemic, the full implementation of all components of MAF-TB may help to ensure the restoration of basic tuberculosis services, strengthen social protection, and achieve the global tuberculosis goal faster. According to the global part of MAF-TB, WHO will continue to take the lead in coordinating global TB surveillance, reporting, and review, and provide technical support and guidance to countries and partners.

2.1.8 Research on TB and innovative progress

The report pointed out that if innovative research on TB prevention and control is not strengthened, the strategic goal of eliminating TB formulated in 2030 and 2035 will not be achieved. When these targets were first established, it was emphasized that relevant technological breakthroughs were needed by 2025 so that the annual decline rate of global TB incidence could be accelerated to an average of 17% per year from 2025 to 2035.

Since the reduction of TB incidence from 2015 to 2020 is far from the first 2020 goal of the strategy, and the expected impact of the pandemic in 2019 on TB incidence in 2021 and 2022, a faster rate of reduction of TB incidence is consequently needed. Therefore, the vaccine to reduce the risk of infection or a new therapy to reduce the risk of TB is vital in about 2 billion people who have been infected, a rapid diagnostic technique to make a diagnosis, and a simpler and shorter treatment.

At present, progress has been made in developing new TB diagnostic methods, medicines, and vaccines, but this is limited by the overall investment of 900 million US dollars in 2019, far below the global target of 2 billion US dollars per year. Considering the number of tests, products or methods being developed for TB, the path to fully diagnose TB is still powerful. Among them, a tuberculosis skin test is better than tuberculin skin test. The analysis of a new generation of lateral flow lipopolysaccharide (LPS) shows that its performance is better than that in the current market.

Amplification-based target next-generation sequencing analysis for directly detecting drug-resistant tuberculosis from sputum samples; And the expanding new interferon release detection method for detecting tuberculosis infection. In 2021, there are 25 drugs used to treat drug-sensitive tuberculosis, multi-drug-resistant tuberculosis, or tuberculosis infection in the first, second, or third phase of trials. These drugs include 16 new chemical entities, two drugs that have been approved by the regulatory authorities at an accelerated pace, an antibacterial and anti-fungal drug that has recently been approved by the US Food and Drug Administration (FDA) through the limited population approach, and six drugs that have been converted to use.

Various combination schemes with new drugs or switching to drugs, as well as host-oriented therapy, are all in phase II or III trials. In August 2021, there were 14 candidate vaccines in clinical trials: two in the first phase, eight in the second phase and four in the third phase. They include candidate drugs to prevent tuberculosis infection and tuberculosis and candidate drugs to help improve the treatment outcome of tuberculosis.

The World Health Assembly adopted the Global Tuberculosis Research and Innovation

Strategy in 2020, and WHO launched a situation assessment checklist in 2021 to support national implementation. Health and economic impact assessment of the full value of the new TB vaccine is being prepared, with the aim of guiding investment in later research and vaccine introduction and implementation. WHO has established a research summary related to tuberculosis and COVID-19, and innovative planning measures to deal with the impact of the tuberculosis epidemic are one of the main themes of this report.

2.2 The status quo of managing tuberculosis

2.2.1 DOTS strategies for the management of patients with TB

Diagnosis and successful treatment of TB patients can avoid millions of deaths yearly. According to WHO, a total of 54 million lives had been saved from 2000 to 2017 (WHO, 2018). TB requires at least six months of combined anti-TB treatment, and the adherence of patients during the treatment is an important factor affecting the success rate of treatment.

Therefore, it is the key to TB prevention and control, and the most effective public health measure to reduce the spread of TB and control the prevalence of TB to supervise and manage patient' medication during the treatment. To curb TB, WHO put forward the strategy of directly observed treatment short-course (DOTS) for TB management at the 44th World Health Assembly in 1991, which was recommended as a part of the standard short-course chemotherapy for TB and was widely promoted all over the world in 1995. According to the WHO report, since the DOTS strategy was widely recommended, 73 countries began to implement DOTS strategy in 1995, and in 2000 and 2001, this number increased to 148 and 155, respectively. The implementation of the DOTS strategy has effectively strengthened the effectiveness of the global TB prevention and control (Wang, 2014).

As one of the 30 countries with a high burden of TB, the Chinese government pays close attention to the prevention and treatment of TB. In 1978, China's Ministry of Health held a national conference on TB prevention and control, compiled a report on national TB prevention and control, submitted it to the State Council, and later made it public nationwide. In 1980, the Ministry of Health compiled the *National Tuberculosis Prevention and Control Work Plan* for 1981-1990, which defined the objectives of disease prevention and control. In 1991, the Ministry of Health compiled the *National Tuberculosis Prevention and Control Work Plan* (1991-2000), put forward the objectives of TB prevention and control, and comprehensively promoted and implemented the DOTS strategy in the whole country in response to the call of

WHO.

Currently, the coverage rate of DOTS strategy in China has reached 100%. At the same time, to ensure the implementation effect of the DOTS strategy, China has also implemented TB control project management in the covered areas, which has played an important role in curbing the spread of TB and improving the cure rate of patients.

In the past 30 years, with the implementation of DOTS strategy on a large scale and for a long time, China has achieved certain results in TB prevention and control but also exposed a series of problems. The key of the DOTS strategy is to supervise and manage the confirmed infectious TB patients in the whole process, to ensure that the patients can take the medicine regularly in the whole process and to provide a guarantee for curing the disease to a certain extent (Lagrada et al., 2008).

Previous research shows that, since the national implementation of DOTS, the proportion of supervision and management of TB patients in China is still relatively low (B. Chen, 2014; J. H. Chen, 2017). As early as 2006, some scholars investigated 401 smear-positive pulmonary TB patients in Chongqing, and found that only 15.96% of them were able to implement DOTS, while 72.07% of them were not supervised by anyone (Hu et al., 2006). In addition, DOTS still has some weak links, such as the inability to get direct feedback from patients, unable to cover all patients, unable to update information in time and transmit information in two directions, and hidden dangers in the infection control (Du et al., 2016).

2.2.2 Management of mobile TB patients

To solve the problems faced by DOTS in the actual implementation process, the new international standard no longer insists on implementing DOTS for all patients but requires medical staff to choose the appropriate management mode according to patient adherence based on implementing the correct treatment plan. With frequent population mobility, more and more TB patients are moving across regions. Cross-regional mobile refers to the registered TB patients who are transferred from one county to another in the treatment process, and thus cannot continue to receive treatment and management in the designated medical institutions of the original registered counties. Cross-regional management could then be implemented for cross-regional mobile TB patients.

First, it is necessary to confirm the information of the transferred-out patients, and to contact patients or their family members to collect personal information such as address and contact information of patients, to provide information of the relevant designated medical institutions in the transferred place to patients, and to inform them to accept the follow-up

treatment management. The medical staff of the original management institution will take the initiative to contact the disease prevention and control centers in the transferred place. If patients do not receive feedback information about their status from the center within two weeks, medical staff in the original medical institution will contact patients by phone and find out the follow-up treatment of patients in the place of transfer. For patients who have gone to the local designated medical institutions for following treatment, the district-level designated medical institutions for TB and disease prevention and control will take over their following treatment and management as requested from localization policies.

In the process of attending TB patients, the factors that have impact include social-economic factors, health systems, illness, treatment per se, and patients themselves. Patient-centered care is to understand the requirements and conditions of each patient, respect and respond to patients' preference needs and values, and provide targeted interventions and personalized support to make early diagnosis and provide corresponding treatment. The following measures are to improve patients' experience and quality while receiving treatment, effectively improve their adherence with medical help, thus increasing the rates of successful treatment, and relieve patients' economic and mental pressure caused by diseases and improve their well-being.

Solicitude for patients is divided into four parts:

(1) Medical and health personnel of various medical institutions at all levels provide high-quality diagnosis and treatment services for three groups of people, i.e., patients with potential tuberculosis symptoms, confirmed patients, and their close contacts. Such medical treatment should comply with standardized medical and managing procedures and reasonable examination methods and means; (2) Through extensive educational promotion and down-to-earth care for patients, it is achievable to eliminate discrimination against TB patients, which can help to reduce their mental burden, and strengthen mental health; (3) Financial assistance to tuberculosis patients can be provided in various forms to reduce the economic burden of patients and their families, and to facilitate their recovery to get back to their pre-TB lives. (4) Social support for TB patients also includes eliminating discrimination, ensuring the legitimate rights and interests of TB patients, supporting the lifestyle of TB patients, caring for TB patients, understanding their living habits, advocating a healthy lifestyle including reasonable diet, moderate exercise, smoking and alcohol restriction, psychological balance, and active interference of bad living habits.

2.2.3 Health promotion of TB patients and close contact

Medical staff could convey health knowledge education to patients and treatment guidance to patients, their families, and close contacts during treatments, which can help patients better understand TB, understand the importance of standardized treatment and regular medication, build up the confidence to overcome the disease, promote the treatment and rehabilitation of patients, and reduce the spread of this infectious disease.

The major forms of health education activities for patients include face-to-face health education on treatment compliance, prevention of TB transmission, factors that need patients' attention, and other related information according to their medical history. Medical staff could also inform patients of possible adverse reactions that occur during the disease, and the local disease diagnosis and treatment policy, which will help the patients to be aware of how to cooperate with the treatment.

According to the different treatment stages and psychological status of patients, medical institutions could organize communication for patients and their families, such as symposiums, special lectures, and games; and carry out peer education sessions among patients, encouraging them to join relevant patient care organizations or through volunteer services to obtain psychological support and enhance their confidence in overcoming the disease. Medical staff can explain knowledge of preventing and treating TB to patients' close contacts and can also visit patients at their homes and give away materials to improve the awareness of self-protection of close contacts and reduce the incidence of infection.

2.3 Application of information technology management system in the management of TB patients

2.3.1 E-TB Patient Management System (e-TBPMS)

E-TBPMS mainly includes the following contents:

(1) Initial diagnosis information of patients, including basic information of patients, past medical history, examination data, and initial diagnosis treatment plan;

(2) Follow-up information: related medical history, examination data and treatment plan adjustment;

(3) Follow-up and evaluation information: According to the established treatment plan, the medication method and time, adverse reactions, date of follow-up visit, and follow-up time of

TB patients are regularly evaluated, and isolation activities or medication adjustments are suggested.

The system's users are mainly doctors, nurses, statisticians, data officers, health workers, and administrators.

In recent years, with the development of clinical pharmacy and diagnostic technology, pharmacists and laboratory professionals have been increasingly involved in diagnosing and treating TB patients. Especially in health education, clinical pharmacists have also become one of the main forces and played an active role in the treatment of TB (Konduri et al., 2017).

In patient management, e-TBPMS has become an important auxiliary tool for medical care, prevention, and control personnel. Internet-based e-TBPMS plays an important role in dynamically understanding patients' basic activities and disease development, guiding or adjusting patient management strategies, and providing data support for basic research.

2.3.2 Electronic Direct Observed Treatment System (e-DOTS)

Given the characteristics of a floating population with large mobility and unstable residence, to facilitate patients to take medicine, in 2012, China promoted the Electronic Direct Observed Treatment System or e-DOTS of TB in Shenzhen. This system innovatively replaces the paper medication record card that has been used for many years with an electronic information system and adopt new measures to supervise medication points.

At present, the city has six first-level supervision points (district-level TB control institutions), 47 second-level supervision points (town hospitals) and 534 third-level supervision points (social health centers), forming a strong and sound prevention and control network, which can meet the supervision and medication needs of all TB patients. In addition, when the patient's residence changes, he or she can move to any supervision point in the city to take medicine at any time so that the DOTS strategy can finally be well implemented.

Although it is convenient for floating population TB patients to take medicine at the supervised medicine taking point, there are still cases where patients have poor treatment adherence due to lack of awareness of the harm of TB. In addition, the transportation and nutrition subsidies for floating population TB patients in Shenzhen indirectly improved the adherence of this population and achieved good results. The successful treatment rate of newly smear-positive patients reached 73.6% (Jiang et al., 2010).

Researchers have made a series of other beneficial explorations and attempts to improve patients' treatment adherence, such as electronic medicine boxes, telephone supervision, and WeChat supervision.

2.3.3 Application of electronic medicine box

To effectively solve the problems many medical and health systems face in providing DOTS for TB patients, the new international standard no longer insists on providing DOTS for all patients. It stipulates that medical staff should not only make the right treatment plan, but also be able to evaluate the adherence of patients' treatment management and deal with the cases of irregular medication in time.

In the 1970s, the United States took the lead in developing electronic medicine boxes, which can not only be used as containers for medicines, but also as reminders for patients to take medicines on time and monitors of taking medicines (T. S. Moulding et al., 1970; T. Moulding, 1979). For patients who implement self-management, patients' medication adherence can be improved.

At the same time, medical personnel put a certain number of medicines into the electronic medicine box, and every time the patients take medicines, they will be recorded by the internal device of the electronic medicine box. Although these electronic medicine boxes can't prove whether the medicines taken out by patients are taken every time, compared with other methods, they can accurately evaluate the patients' treatment adherence, and at the same time, their manufacturing cost is relatively low, and they are easy to be filled with medicines repeatedly.

In 2009, China's Ministry of Health - Gates Foundation TB prevention and control cooperation project began to apply electronic medicine boxes in six provinces (cities), including Inner Mongolia, Heilongjiang, Jiangsu, Henan, Chongqing and Hunan (Peng et al., 2013).

In 2011, CDC in China and Peking University compared the medicine-taking records of electronic medicine boxes of TB patients with the detection results of anti-TB medicine residues in urine as the gold standard. They verified that the medicine taking forms of electronic medicine boxes were highly consistent with the medicine-taking behaviors of TB patients (Yuan et al., 2012). Electronic medicine box is expected to become an auxiliary tool for monitoring and promoting patients' medication.

2.3.4 Message, voice call or video call supervision

A Cochrane systematic evaluation and analysis showed that various reminder systems (telephone, short message, reminder card) had a good effect on improving the adherence of TB patients in taking medicine and seeing a doctor (Liu et al., 2008).

Reminder information in TB patient management can be pushed to TB patients through

short messages on mobile phones, including regular medication, adverse reactions, reasons for treatment interruption, periodic review reminders, examination results such as liver function and chest radiograph, reasonable diet, psychological state, interest and exercise, treatment effect. It is mainly targeted to supervise, dispel doubts and doubts for patients, and guide patients' treatment and lifestyle according to patients' medication, diet, psychological state, and illness changes during treatment. Many studies have carried out medication reminders, health education and regular follow-up through SMS or voice system and corresponding system platforms, which can improve patients' treatment adherence(Lu et al., 2012; Shi & Jin, 2013).

Kruegere et al. (2010) reported that 57 patients were supervised by fixed-line video medication in the United States from 2002 to 2006, and it was found that the supervision cost of medical staff was saved by 140,000 USD dollars.

Australia and Canada also researched the application of this technology and found that it can effectively improve the treatment completion rate and shorten the visit time (Gassanov et al., 2013; Wade et al., 2012). In 2010, Huizhou City used computer equipment to supervise TB patients to take medicine through network video, which reduced the economic burden of patients and improved the work efficiency of medical staff (Zhong et al., 2012).

China has become the country with the largest number of mobile Internet users and the most significant number of smartphone users in the world. With the advent of the network era and the popularity of mobile terminals, communication becomes more flexible and convenient, which provides the corresponding hardware foundation for better management of TB patients.

In addition, the wide application of free instant communication software (such as WeChat, and QQ) provides the corresponding software and platform foundation for timely communication between TB control personnel and patients. At present, vDOT has carried out related research at home and abroad, such as TV vDOT, fixed line vDOT, mobile phone vDOT, social software vDOT, and special APP vDOT (Holzman et al., 2018; Xie et al., 2017). It can improve patients' treatment adherence, reduce patients' medication taking time and cost, make patients obtain high adherence, and improve the working efficiency of TB supervisors, with good "cost-benefi" (Fang, 2017; Lai, 2017). In 2017, a survey of 113 TB prevention and control institutions in the United States found that 47 institutions had adopted vDOT, of which 31 were synchronous vDOT and 4 were asynchronous vDOT. And 41 institutions indicated they would try vDOT next year (Macaraig et al., 2018).

At the beginning of 2020, a sudden COVID-19 epidemic caused countries' concern about global health and global sanitation and epidemic prevention systems and accelerated the development of digital health practice. To prevent the large-scale spread of Covid-19, countries

and regions have successively adopted closed prevention and control strategies.

Under this environment, information collection and updated in the early stage of the outbreak by using digital technologies such as 5G, Internet remote online medical treatment, and artificial intelligence-assisted virus screening in the middle stage. Community health records (health codes) management in the later stage played an irreplaceable role, which led people to further think about the digital health (Sun & Fang, 2020).

Internet plus 5G, mobile medical care, wearable devices, and other emerging technologies are all effective tools for applying information technology to accelerate the development of the digital health industry and provide a good foundation for TB patient management. With the advancement of the national information-based "14th Five-Year Plan", information technology will play an important role in realizing the global end of the TB epidemic.

2.3.5 The status quo of using ICT in managing other chronic diseases

As a public health challenge, the control of chronic non-infectious diseases (diabetes, hypertension, stroke, tumors, cardiovascular and cerebrovascular diseases, chronic obstructive pulmonary disease) and chronic infectious diseases (such as TB, venereal diseases, leprosy, AIDS) has become a major task to human health. The task of prevention and control has not yet been completed, and there is even an increasing trend. For a long time, chronic diseases will be an essential part of disease prevention and control in China.

At present, the research on patients' treatment compliance mostly focuses on common chronic non-infectious diseases such as hypertension, diabetes, and chronic obstructive pulmonary disease. There is relatively little focus paid on the compliance of patients with chronic infectious diseases, especially TB, partly because most patients with infectious diseases are treated in specific infectious disease prevention and control institutions. However, TB patients differ from those with general infectious diseases because the former is mainly treated at home. Yet, TB treatment is like general chronic non-infectious diseases. The treatment cycle is long, which requires long-term medication, leading to a lower level of the patients' adherence. However, the treatment of TB, like chronic non-infectious diseases in general, has a long treatment cycle, requires long-term medication, and patient adherence is generally poor.

With the development of information and communication technology (ICT), more and more practical modes of providing management services for patients with TB and other chronic diseases based on information technology and telecommunication technology are widely carried out worldwide. The development of information technology in medical applications has brought new opportunities to the management of patients with chronic diseases.

In April 2019, WHO released the world's first digital health intervention guide, and put forward new suggestions on 10 means how countries can use digital health technology to improve people's health and basic services through mobile phones, tablets, and computers. In the *Digital Health Global Strategy* (2020-2024), which was subsequently released, the priority position of digital health strategy in the development of medical and health industries around the world was clarified (Dhingra & Dabas, 2020).

In recent years, WHO has been investigating how to use digital technology to improve people's health and health system all over the world. Among them, artificial intelligence, digital medical care, big data, and Internet of Things are all effective tools to accelerate the development of the digital health industry by applying information technology (Golinelli et al., 2020). For example, Estonia, Denmark, and Israel have established national health portal databases, implemented electronic prescriptions, and established health records, which greatly facilitated diagnosis and shortened treatment period (Leitsalu et al., 2015); Canada established the "Canadian Medical Information Network", a non-profit organization, in 2001, which promoted the widespread use of electronic medical records.

At present, in the application of information technology in chronic disease management at home and abroad, nine information management systems for chronic diseases have been formed, including clinical pathway management and precise medical care, a platform for sharing and analyzing chronic diseases data, construction of prevention follow-up and feedback management system, a new form of chronic disease management under the internet plus, electronic health medical record research for chronic diseases, information system for self-management of chronic diseases patients, information system for reporting and prevention and control of chronic diseases, and regional graded diagnosis, treatment and cooperation platform (Zhu et al., 2019). In view of the present situation and characteristics of chronic diseases, China has gradually formed a complete information management technology system (Jiang et al., 2008).

China has developed rapidly in the field of digital health, but there is still a big gap to surpass and achieve the goal of general digital health. Therefore, it is urgent to grasp the great historical opportunity of digital health development and use the digital technology platform to speed up China's entry into a new era of digital health (Xue et al., 2022). Digital health technology takes information technology as the carrier, and its basic carrier mainly consists of electronic medical records, electronic prescriptions, mobile medicine, and telemedicine.

In recent years, the World Health Organization has been investigating how to use digital health technology to improve the global management of patients with chronic diseases.

The specific technology is presented next. Common chronic diseases are diabetes, chronic obstructive pulmonary disease, cardiovascular. Taking the first three kinds of diseases as examples, the author will introduce the progress of information management in related fields.

Diabetes is a chronic metabolic disease, but inappropriate treatment and management of it will lead to various complications, which could be even fatal. Its prevention and treatment are not only about clinical treatment but also closely related to the patients' lifestyle and social environment. It is a comprehensive management mode that needs multi-sector cooperation. Suzhou Science and Technology Park Hospital affiliated with Nanjing Medical University in China is exploring establishing a hospital-wide blood glucose management model based on the hospital information platform, combining the hospital information system (HIS) with the Nova blood glucose management system.

The Nova system includes a blood glucose analyzer (test terminal), a bar-code system, a system workstation, and medical staff terminals (computers, PADs). Nova system shares access to endocrinologists to prescribe patients with blood glucose management in the whole hospital, to adjust patients' treatment plans in real-time. In addition, a blood glucose management team is set up in the whole hospital, including endocrinologists, dietitians, and clinical pharmacists, to provide l knowledge and lifestyle advice to patients to achieve a multi-disciplinary diagnosis and treatment mode and to improve the management efficiency of hospitalized diabetic patients.

The innovations of this management mode are as follows: (1) Nova glucose data is uploaded to the system in time, which ensures the timeliness and accuracy of blood glucose level and improves work efficiency. (2) The direct connection between HIS and Nova system in the hospital ensures that physicians can pay attention to patients' blood glucose level in real-time and avoid wasting time on aligning among different information systems. (3) Subgroups of blood glucose management in the whole hospital are set up in HIS system, which can ensure that the information of diabetic patients after consultation in the endocrinology department is displayed in the management team of endocrinologists. (4) The information-based blood glucose management system in the whole hospital provides a window for endocrinologists to independently prescribe medical orders for patients within the blood glucose management system in the whole hospital, which can adjust the treatment plan in real-time according to the patients' condition and serve non-endocrinologists' diabetic patients more efficiently (Zhou et al., 2022).

Cappon et al. (2019) from South Korea provided blood glucose measurement in an almost continuous way every day by utilizing a micro-invasive continuous glucose monitoring (CGM) sensor worn by diabetic patients and equipped with visual and sound alarms of hypoglycemia

to provide decision support for diabetic patients who need insulin administration, improving insulin dosage adjustment and infusion. CGM equipment has been proven capable of improving the safety and effectiveness of diabetes treatment, reducing the incidence and duration of hypoglycemia, and reducing blood sugar variability. The information intervention methods for diabetes at home and abroad are similar, which indicates that the global research focus on diabetes has changed from the disease itself to intelligent health management under the guidance of information technology.

Chronic obstructive pulmonary disease (COPD) is a chronic bronchitis and/or emphysema characterized by airflow obstruction, which can further develop into a common chronic disease of pulmonary heart disease and respiratory failure. It is related to the abnormal inflammatory reaction of harmful gases and particles, and the disability rate and mortality rate are very high. The global incidence rate of people over 40 has reached 9%-10%. COPD is very common, and it significantly affects patients' daily body functions.

Some studies have shown that increasing physical activity can help COPD patients have better health and quality of life, while digital mobile medicine (mHealth) technology may help COPD patients provide self-management interventions. Bentley et al. (2020) from the United Kingdom developed a mobile health intervention tool (self-management with assistance, rehabilitation, and telemedicine technical support), which works by installing mobile phone applications and activity trackers and can help COPD patients maintain or increase physical activity after lung rehabilitation. Results show that mobile health interventions for COPD self-management tools may be more acceptable to people with smartphone experience and being simple and easy to use is more important than being distinguished.

Regarding cardiovascular diseases, various emerging medical imaging technologies based on artificial intelligence have been widely used in four representative cerebrovascular diseases, such as intracranial aneurysm, arteriovenous malformation, arteriosclerosis and Moyamoya disease. Traditional machine learning and deep learning algorithms perform computer-aided detection and prediction of patients' medical data (Chen et al., 2022). For example, an intracranial aneurysm is a common asymptomatic vascular disease, and its rupture is a fatal irreversible consequence with significant incidence and mortality.

Therefore, aneurysm detection and risk stratification before rupture are crucial to guide preventive measures. AI technology shows great prospects in the health management of aneurysm patients through automatic detection, rupture risk prediction and post-treatment prediction.

In addition to clinical practice, the use of follow-up-related research has shown that

artificial intelligence tools have high diagnostic and prognostic accuracy and may improve the prognosis of patients (Mensah et al., 2022).

2.3.6 Problems faced in applying information technology in patient management

Application-based information management technology is still in its infancy and has not yet been implemented on a large scale worldwide. Different application-based information management technologies are quite different in R&D design, implementation methods, coverage, local economic and cultural background, and resources, which leads to great differences in the promotion and research progress of this technology in different regions.

Some areas have developed and implemented local application programs on a large scale, and some are still exploring this technology's local feasibility, availability, and acceptance. Smartphone-based technology can support tuberculosis patients in an environment with limited resources. However, using mobile health applications to provide medical care services faces some obstacles that affect its implementation effect.

Kruse et al. (2019) pointed out that the three most common obstacles developing countries face in implementing information technology are lack of infrastructure, lack of equipment and technological gap. The costs of applying information technology are relatively high, leading to some patients' failure to be supported to used apps or smartphones (Morse et al., 2020). The gap between urban and rural areas in health services, insufficient health infrastructure and limited human resources have all affected the use of mobile health applications. Applying application-based information management technology is complicated, and elderly patients are more inclined to accept treatment management in a simple way (Li et al., 2019).

In addition, the application-based information management technology has its own security and technical problems that need to be solved urgently. Some patients are worried about using such technologies noting that they may cause privacy and security problems, such as information disclosure (Mbunge et al., 2022). The function realization of some technologies depends on the operation of doctors, which leads to the increase of their workload and the low satisfaction of doctors using this technology (Shi, 2021).

2.4 The study of factors influencing adherence and conceptual modelling in TB patients

2.4.1 An overview of medication adherence

Adherence refers to the degree to which the patients' behavior, including the change of medication, diet, and lifestyle, accords with the doctor's advice (Abdu & Walelgn, 2021). The adherence of patients with chronic diseases is mainly manifested in two aspects, including adherence with medical intervention measures and behavior change. The former mainly refers to patients' medication adherence, while the latter mainly refers to lifestyle such as diet and exercise (Ma et al., 2016).

Medication adherence specifically refers to the degree to which patients carry out medication orders, including medication time, dosage, and other precautions (Waeber et al., 2000). In 2012, Vrijens et al. (2012) defined medication adherence as a multi-factor behavior, involving three key steps of starting, implementing, and stopping, and classified late start or failure to start medication according to the doctor's advice, failure to take medication according to doctor's advice or early stop of treatment as non-adherence behavior.

Plus, Menditto et al. (2019) summarized the behavior of patients who did not follow the doctor's advice to take medicine in the following five aspects: not taking medicine strictly according to the required dose, such as reducing the number of times of taking medicine or increasing or decreasing the dose by themselves; not taking the medicine strictly at the right time, such as self-adjusting the time and interval of taking the medicine; stop taking medicine without authorization; choose medicines that are not required by the doctor's advice; forget to take medicine.

Good medication adherence is of great significance to the treatment effect and disease outcome of patients with chronic diseases who need long-term treatment. However, related studies have shown that it is a common problem for patients with many chronic diseases such as hypertension and diabetes not to follow the medication during the treatment (Bartels, 2004).

Krass (2015) systematically reviewed 27 studies on medication adherence of patients with diabetes mellitus published during 2004-2013, and found that medication adherence of patients with type 2 diabetes mellitus ranged from 38.5% to 93.1%, of which only 6 studies showed adherence higher than 80%.

In an Ethiopian study, the review of Tola Gemeda (2020) showed that the adherence of local adult patients with hypertension was between 31.4% and 88.98%; a research in Spain

found that the medication adherence of patients with chronic diseases was only 55.5% (Fernandez-Lazaro et al., 2019), The medication adherence of patients with different chronic diseases is generally low.

In China, the failure to take medicine is more common for patients with chronic diseases. The research of Morisky (2008) shows that the adherence rate of hypertension patients in China is only 31.2%; another study on medication adherence of 156 patients with hypertension found that 96 patients failed to take medicines on time and according to the doctor's advice, and 61.5% of the total participants had poor medication adherence (Jiang, 2009); Jiang et al. (2011) conducted a survey on elderly diabetic patients, the results showed that only 15.7% of 84.3% patients discharged from the hospital can take the medicine completely according to the doctor's advice.

2.4.2 Studies related to medication adherence in tuberculosis patients

For TB patients, non-adherence with medication not only easily leads to treatment failure, but also to drug-resistant TB, which makes the follow-up treatment and management more complicated and further increases the burden of treatment. It has been reported that the risk of adverse information outcome of TB patients with poor adherence increases by 1.4 times (Zhao et al., 2012; Zheng et al., 2012).

In some international studies, because of the long disease cycle of treatment, patients must take many kinds of medicines with large side effects, thus it is difficult for them to take drugs according to the doctor's advice. Relevant research also shows that the treatment adherence of common TB patients abroad is not ideal (Gebreweld et al., 2018; Kebede & Wabe, 2012; Tesfahuneygn et al., 2015). Among them, a survey in 2013 showed that 32% of the 286 patients with TB failed to continue their treatment (Ndeikoundam Ngangro et al., 2013).

The cease of treatment for TB patients in China has always been serious, and non-adherence with treatment is also widespread (Li et al., 2003). In related studies, the lowest reported adherence rate was 43.9% and the highest was 77.3% (Hu et al., 2014; Ren, 2013). In addition, in the results of the fifth national epidemiological sampling survey of TB in 2010, the rate of non-adherence (omission of medication or cease of treatment) among registered patients in China was 40.7% (Wang et al., 2012). Yin (2013) investigated the adherence behavior of TB patients, and found that the non-adherence rate was 41.32%, which was also close to the national survey results.

Patients' non-adherence with treatment will directly lead to treatment failure, recurrence of the disease and deterioration of the disease, thus increasing the treatment difficulty of the

disease. For TB patients, non-adherence with treatment may even lead to the occurrence of drug-resistance and the spread of drug-resistant TB bacilli. Therefore, improving the treatment adherence of patients is the key but also a challenge in the current prevention and control work.

Researchers have reached a consensus to consequences of low medication adherence of TB patients. Lower level of medication adherence is the main trigger of adverse treatment results among TB patients, including treatment failure, recurrence, and drug resistance (Pradipta et al., 2020). In an international study of patients with drug-sensitive tuberculosis, non-adherence was the most significant factor influencing adverse treatment outcomes: Adjusted OR for patients who missed 10% or more medication was 5.7 (95%CI: 3.3~9.9) (Imperial et al., 2018). Plus, a global Meta analysis shows that non-adherence of medication is a threatening factor of triggering drug-resistance TB (Pradipta et al., 2018). An Indian cohort study showed that non-adherent patients were four times more likely to have an adverse treatment outcome than adherent patients (OR=4.0, 95%CI: 2.1~7.6) (Subbaraman et al., 2021).

Domestic studies in China have reached similar conclusions. A survey of prognostic risk factors in patients with tuberculosis in Hunan Province showed that poor adherence to medication was a risk factor for failure to cure patients after 6 months of treatment (OR=2.238, 95%CI: 1.032~4.108) (Xu, 2022; Zhuang et al., 2022).

2.4.3 A study of factors influencing medication adherence among tuberculosis patients

In the past half century, the research on the adherence of TB patients mainly started from the influencing factors of it and intervened the significant factors to improve the adherence of patients.

At present, many researchers in China have explored the influencing factors of treatment adherence of TB patients through questionnaires (Chen, 2012; Department of Disease Control Ministry of Health of The People's Republic of China, 2006; Feng & Zhu, 2013; Ren, 2013; Zhang et al., 2014). The existing research conclusions are basically the same, mainly including the following aspects:

(1) Individual factor of patients

Individual factors include patients' age, educational background, healthcare knowledge, and family income. Studies have shown that the adherence of young and middle-aged patients is better than that of the elderly.

The reasons may be that the elderly have poorer memory and understanding towards the disease, lack of knowledge of TB and medicine, and they could easily forget the time and

dosage of taking the medication. In addition, other studies have shown that elderly patients feel that they have a strong sense of inferiority and anxiety, which leads to poor adherence (Zhou, 2012). The adherence of patients with college education or above is higher than that of those with a lower education level, which is mainly because the education experience directly affects patients' awareness of TB, treatment of it and the use of anti-TB medicines.

Those with higher education levels can not only see a doctor in time when symptoms appear, but also strictly follow the doctor's advice during the treatment until they are cured. Studies have shown that the medication adherence of patients with a per capita family monthly income less than that 1000 yuan is significantly lower than that of patients with high income (Zhang & Jin, 2007). Patients from poor families often can't bear the medical expenses during the whole treatment process, which causes low medication adherence. Especially for the main family income earners, the heavy economic burden makes it easier for patients to stop medication and treatment when their symptoms are relieved.

(2) Social factors

Social factors include social support such as family support, and doctor-patient relationship. The research results at home and abroad show that social support is the protective factor of patients' treatment adherence, and the role of family support is particularly important (Ali & Prins, 2016; Sakuntala et al., 2021). Family support includes material and spiritual support. After patients get infected, they lose their income and need a lot of medical expenses, so they need material support from their families.

In addition, family members can improve the medication adherence of patients through medication supervision and spiritual encouragement (Castro-Galarza et al., 2020; Chen et al., 2020); furthermore, the doctor-patient relationship has a great influence on the medication adherence of TB patients. A good doctor-patient relationship can make patients trust medical staff more and be sure that taking medicine according to the doctor's advice will benefit them. According to Chen et al. (2020), regular supervision of family members' medication and spiritual encouragement, good doctor-patient relationships, and knowledge related to TB pathology, plus a high need for policy support, help improve patient adherence to medication.

(3) Treatment factors

This category includes adverse reactions caused by therapeutic medicines' complexity of treatment. The treatment of common pulmonary TB requires the combined application of 3-5 kinds of anti-TB medicines for six months, so there are many adverse medicine reactions, such as kidney and liver function damage. Some patients stop taking medicines or reduce their dosage secretly because they are worried about adverse medicine reactions or can't tolerate the

side effects, resulting in non-adherence. In addition, some studies have confirmed that some patients with TB have poor medication adherence due to the various types of medication, complicated medication methods, and longer treatment courses.

(4) Psychological factors

Scholars such as Lei showed that the SCL-90 symptom checklist was used to evaluate the psychological status of 70 TB patients, and the results showed that there were 28 patients with obvious psychological disorders and poor adherence. After treatment with psychological and antipsychotic medicines, the treatment adherence of these patients was significantly improved (Lei et al., 2002). In addition, a psychological intervention study in India found that the adherence rate of the psychotherapy group was much higher than that of the control group (72% versus 42%) (Janmeja & Mohapatra, 2005). Domestic and foreign studies show that patients with higher stigma tend to have lower medication compliance (Park et al., 2019). Patients with more increased stigma may feel lonely, unsupported, and depressed, which may affect their confidence in taking medication against TB.

2.4.4 Measurement and conceptual modelling of medication adherence among tuberculosis patients

There are many methods to measure medication adherence, but there is no universal standard. Reviewing relevant literature shows that the existing measurement methods of medication adherence mainly include monitoring drug concentration, evaluating the treatment effect, calculating drug dosage, using medicine treatment monitoring system, and self-reporting (Ma et al., 2016). As it is difficult to measure and evaluate the changes in patients' behavior and lifestyle in practical research, most adherence studies use the degree of adherence between patients' medication behavior and doctors' advice to evaluate patients' adherence (Xue et al., 2011).

However, most of the related research on measuring the adherence of TB patients with medication is based on the theory of individual behavior change, and the self-made adherence scale calculates the adherence rate of TB patients with medication to evaluate whether the patients comply with a reasonable diet, healthy behavior, regular exercise, regular medicines, and regular review, and explore the important influencing factors that promote patient behavior change (Gu, 2021; Yang et al., 2019; Yin, 2013).

According to the literature retrieval, the commonly used theories to promote patients' behavior change include: knowledge-belief-behavior theory, health belief model, rational behavior theory and planned behavior theory model, behavior stage change theory, and

information-motivation-behavior skill model (IMB model) (Zhang, 2015).

Among them, "knowledge" means knowledge and learning, which is the basis of behavior change, "faith" means correct belief and positive attitude, which is the driving force of behavior change and "action" is the goal. This theory divides the change in people's behavior into three continuous processes: acquiring knowledge, generating belief, and forming behavior. It holds that people's health-related behaviors are based on healthcare knowledge and driven by related attitudes and beliefs, which explains why people take certain health behaviors to some extent.

Similarly, the health belief model consists of individual health beliefs, behavioral clues, or intentions, behavioral constraints, and other factors. In this model, the influencing factors of behaviors are attributed to whether people know the danger, severity, and susceptibility of certain behavioral consequences. By improving these cognitions, people are encouraged to believe in changing behaviors that endanger health or developing behaviors that promote health, help people gain confidence and self-efficacy to overcome behavioral obstacles, and finally change behaviors and protect and promote health.

The deficiency lies in that both of the above-mentioned behavioral theories overemphasize the subjective psychological process of individuals and to a certain extent, ignore the influence of environment, skills and other factors on the change of healthy behaviors (Fang et al., 2013).

Rational behavior theory holds that behavior attitude and subjective norms jointly determine behavior intention, and intention determines people's behavior (Fishbein, 1980). The theory of planned behavior is a revision based on the theory of rational, planned behavior, which holds that individual behavior is determined by intention.

In contrast, intention depends on the individual attitude towards a certain behavior, others' expectations of the behavior and the ability to consciously implement the behavior. The more positive these three parts are, the greater the possibility of behavior (Ajzen & Kruglanski, 2019).

Compared with the health belief model, the theory of rational, planned behavior and the theory of planned behavior believe that social pressure will play a certain role in individual behavior, but some studies show that the subjective criterion for evaluating social pressure is a relatively weak factor (Lim & Dubinsky, 2005).

The theory of phased change of behavior holds that human behavior change is a complex, gradual, and continuous process, which can be divided into pre-intention stage, intention stage, preparation stage, action stage, and maintenance stage. This model pays too much attention to the cognitive process of the subject and ignores the role of environmental factors on behavior change (Huang, 2000).

In sum, the above models are limited as they only revealed the influencing factors of health

behavioral changes from only one or several aspects.

In 1992, the IMB model proposed by J. D. Fisher and W. A. Fisher (1992) held that behavior change was composed of health-related information, motivation, and behavior skills. Different from the previous health-related behavior change models, the IMB model comprehensively and concisely summarizes the main influencing factors in the process of health behavior change with several key elements, describes the causal relationship between information, motivation and behavior skills and preventive behavior, and shows the whole process of behavior change from the beginning to the formation, so that it is easier to transform into intervention practice to improve the explanation of healthy behavior changes.

In recent years, the IMB model has shown good applicability and operability in the related research on improving the behavior and medication adherence of patients with AIDS, diabetes and heart disease (Brown et al., 2016; Chen, 2014; Mayberry & Osborn, 2014; Zarani et al., 2012). Demis et al. (2008) conducted a study on the youth turnout rate by using the theory of planned behavior and the IMB model, which proved that IMB model has a good prediction effect. Although the study has some limitations, it still shows that the model has a wide range of application fields and a larger mining space.

In recent years, the IMB model has been widely used in the field of health education for chronic diseases (Ranahan et al., 2020).

The IMB model draws lessons from and introduces the rational behavior theory and the understanding of “motivation”, and comprehensively summarizes various factors that may affect behavior. By introducing the concept of “self-efficacy” through social thinking theory, it classifies the related possible factors into three parts: information, motivation, and behavior skills, and constructs the theoretical framework of the model (Hill et al., 2006).

Every element in IMB model is a necessary condition for a healthy behavior change (Fisher et al., 2002). Among them, information is an important basic condition for implementing health behaviors. Motivation includes personal motivation (attitude towards individual health promotion behaviors) and social motivation (perception of social support for designated health promotion behaviors). Behavior skills include personal objective skills for implementing behaviors and self-efficacy for completing behaviors (Fisher et al., 2006).

Predicting the occurrence of disease risk and preventive behavior can provide a basis for formulating behavior intervention plans. IMB model contains three components: information-motivation-behavior skills, covering all decisive factors that affect behavior change. However, the contents of each component are different in different groups of people, so behavior intervention should start with the decisive factors that lead to behavior change and consider

information-motivation-behavior skills to carry out comprehensive intervention.

IMB model requires that before behavioral intervention, a pre-survey should be conducted in the target population, and baseline data of AIDS prevention information, participation motivation, behavioral skills and existing behaviors should be collected to determine the key points of behavioral change in this population, and then an intervention plan should be made for these key points.

For example, Fisher et al. (1999) pointed out that the research among teenagers in cities with more open sexual concepts suggests that "the motivation of individuals to participate in preventive behavior" and "the support provided by their social environment" are the key points in preventive intervention; Kalichman et al. (2005) conducted their research on mental patients with substance addiction, and found that changing their views on condoms and increasing their attitudes in favor of condom use can promote condom use; Scott-Sheldon et al. (2010) used IMB model to predict the condom use of STD outpatients, which shows that the behavioral intervention for this population should focus on enhancing the initiative and correct skills of condom use; Malow et al. (2012) held that the intervention of HIV-positive people with alcohol dependence should comprehensively consider the damage of AIDS virus and age to the nervous system; Walsh et al. (2011) in the risk reduction intervention project based on IMB model, used multivariate potential growth curve to analyze the influence of symbiotic dynamic changes of information, motivation and behavior skills on condom use.

The results showed that long-term preventive behavior depends on behavior skills and can be used to predict safe sex; Fisher (2011) selected young males aged 14 - 21 who have sexual intercourse with the same gender to study whether IMB model can predict the risk of AIDS infection. Path analysis shows that most indicators are suitable for fitting primary and secondary risk models.

In 1992, JD Fisher and his colleagues conducted a case-control study in the University of Connecticut, using IMB model to design and implement interventions to evaluate the effect of changing AIDS high-risk behaviors on AIDS prevention. The results showed that the intervention significantly improved the knowledge of AIDS-related prevention information, led to a positive attitude and motivation, increased the formation of preventive behavior, and a significant increase in condom accessibility, safe sex and condom use rate. Laboratory tests proved that IMB model intervention was also of great significance for the long-term prevention of AIDS. (Fisher et al., 1996) In this regard, the experimental intervention research based on IMB model is widely used in the study of AIDS prevention behavior in different regions and different populations.

The IMB model describes the causal relationship between key factors and preventive behaviors, demonstrates the process of behavioral change from inception to formation, and provides improvements and refinements for explaining health behavior change. Based on the IMB model, this study considered medication adherence among TB patients as a health-related behavior and established the research hypothesis that health-related behaviors affecting health outcomes are influenced by internal factors such as shared information, motivation, and behavioral skills, whereas external factors including the external environment and social support influence health behaviors through internal factors. The hypotheses of this study can be summarized as follows:

Effect of internal factors on adherence: internal factors, such as information, motivation and behavioral skills, interact with each other in terms of adherence and affect medication adherence separately. Information: the patient's knowledge of the disease, medication and treatment effects will affect their adherence. Motivation: patient's judgement of the benefits and risks associated with medication use, as well as information about medication guidelines from social support, will influence their attitudes and willingness to use medication, which indirectly affects medication adherence. Behavioral skills: patient's ability and self-efficacy to take medication as prescribed will also affect medication adherence.

Influence of external factors on internal factors: e.g., health service provision and social support from the health system and personal networks influence internal factors, respectively, and indirectly influence medication adherence through internal factors. External environment: health services provided by professional organizations will provide patients with the necessary information and skills training to enhance their medication adherence. Social support: support from family and friends and family support in the social network will positively influence patient's motivation and behavioral skills to promote medication adherence.

To sum up, compared with the previous health-related behavior change models, applying IMB model to the research of medication adherence of TB patients can more comprehensively explore the critical factors affecting medication adherence, and further provide a scientific basis for formulating effective management strategies for TB patients, building a perfect management model, and effectively improving medication adherence of patients.

Figure 2.1 shows the framework diagram of the classical IBM model. Table 2.1 shows the Comparison of Behavior Change Models.

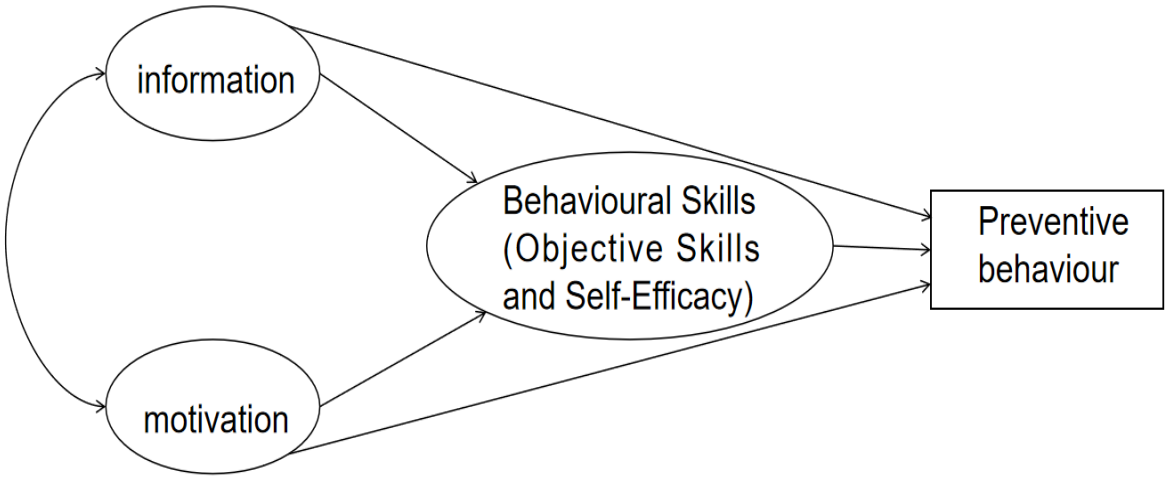

Figure 2.1 Framework diagram of the classical IBM model

Table 2.1 Comparison of behavior change models

Model	Advantages	Disadvantages
Knowledge-Belief-Behavior Model	Emphasizes the role of knowledge and learning	Oversimplifies the complexity of behavior change
Health Belief Model	Considers individual health beliefs	Overlooks social and environmental factors
Rational Behavior Theory	Considers behavior attitudes and subjective norms	Social pressure may play a weaker role in behavior change
Planned Behavior Theory	Considers attitude, subjective norms, and perceived behavioral control	Incomprehensive capturing of influencing factors
Behavior Stage Change Theory	Recognizes behavior change as a gradual process	Overlooks the impact of environmental factors
Information-Motivation-Behavior Skill (IMB) Model	Provides a comprehensive and concise framework	Variability in content across different populations

2.5 Study of medication adherence among tuberculosis patients and a case of improving patient adherence with information on tuberculosis control and management in Huizhou City, Guangdong Province, China

2.5.1 A study of medication adherence in patients with tuberculosis

At present, many studies have proved that the medication adherence of TB patients is related to factors such as their age, education level, family economic status, and health knowledge, but most of them ignore the important role of patient's medication motivation and self-management ability, and the change of patient's attitude and behavior is often the main factor that affects the health outcome or cure rate of patients.

In 2012, Tang et al. carried out TB prevention behavior intervention for junior middle school students in rural areas of northern Jiangsu Province. In this research, the IMB model was introduced into TB behavior intervention. Through self-designed questionnaires, the general situation of rural junior middle school students in five prefecture-level cities of northern Jiangsu Province, knowledge about TB prevention and control, attitudes towards TB, social support and behavior skills were investigated.

According to the fitting index of correlation fitness, the researcher effectively verified that the IMB model of TB constructed by the institute was well fitted with the actual observation data. It was a model that was in line with empirical data, suggesting that preventive motivation had the greatest influence on preventive behavior (Tang et al., 2012). The IMB model borrows and introduces the understanding of "motivation" from the theory of rational behavior, provides a more comprehensive overview of the various factors that may influence behavior, and introduces the concept of "self-efficacy" through the theory of social thinking.

The theoretical framework of the model was constructed by categorizing the possible factors into three parts: information, motivation, and behavioral skills. The research confirms that the interventions based on the IMB model have good applicability and operability in improving the behavioral adherence of patients with AIDS, diabetes, and heart disease. Based on the model, the factors related to patient's adherence to medication include information, motivation, and behavioral skills. The meanings of these elements are as follows: (1) information about adherence refers to whether the patient has knowledge about the disease, medication, side effects, and treatment outcomes; (2) knowledge and ability are not enough to make the patient take action, and the patient's judgement of the benefits and harms of adherence will affect his/her attitude or willingness to take the medication, which will then have an impact on his/her compliance, i.e., motivation for compliance; (3) adherence skills include the patient's objective ability and ability to take medications, and the patient's motivation to do so; and 4) the patient's motivation to take medications. Skills include the patient's objective abilities, such as self-care and communication skills, as well as subjective abilities, i.e., self-efficacy to take medication as prescribed.

2.5.2 A case of improving patient adherence with the tuberculosis control management information system("E-TBPMS") in Huizhou City, Guangdong Province, China

In recent years, the current situation of tuberculosis prevention and treatment in China remains grim, causing serious harm to people's health and has become a major public health and social problem. Traditional Directly Observed Treatment Short-course (DOTS) cannot directly

observe and monitor patients' medication due to various objective factors, thus affecting its actual effectiveness. At the same time, with the increase in the mobile use, the referral and follow-up of suspected patients has posed new difficulties. Therefore, since 2012, the Guangdong Provincial Tuberculosis Control Institute in Huizhou City has developed a multi-functional tuberculosis control management information system called "E-TBPMS", based on WeChat APP. The E-TBPMS system is easy to popularize and relatively simple to use and can provide detailed services to patients based on WeChat APP, including referrals, consultations, visits, and health education. Its main objective is to improve the management effectiveness of tuberculosis control.

Compared to traditional management techniques the "E-TBPMS" system has the advantages of being highly compatible, easy to promote, in need of low cost of development and operation, and simple to use, making it a powerful addition to existing measures. After years of application and continuous refinement the "micro-supervision" system has been fully implemented in seven tuberculosis control institutions, 38 general medical institutions and 93 primary care institutions in all counties and districts of Huizhou. It has not only improved the contracted services for tuberculosis patients, but also established a real-time case reporting system for multi-drug resistant patients and effectively implemented different tuberculosis control service. In addition, the "E-TBPMS" system has laid a solid foundation and technical support for the construction of a graded diagnosis and treatment system and has helped to achieve full coverage of tuberculosis prevention and treatment services by helping to alleviate poverty through precise health care.

The application of the "E-TBPMS" system has made significant improvements in the management and services of tuberculosis prevention and treatment. Firstly, in terms of management, the system can track and record patients' medication status, monitor patients' developing conditions, and collect and transmit epidemic information required by health authorities at all levels on time, providing a scientific basis for decision-making.

Secondly, in terms of services, the system can provide patients with online contracting services, online consultation, personalized follow-up visits and health education through the WeChat platform, making it easier for patients to access health information and improve medication compliance. It is important to emphasize that the successful application of the "E-TBPMS" system cannot be achieved without its integrated support at the technical, management and policy levels. At the technical level, the design and development of the system should consider the characteristics and needs of tuberculosis prevention and treatment, and ensure the safe, stable and easy use of the system. At the management level, health departments

at all levels should strengthen the supervision and management of the system to ensure its normal operation and effective use. At the policy level, relevant policies and documents should be issued to promote and apply the "E-TBPMS" system nationwide.

In summary, through the application and promotion of the "E-TBPMS" system, Huizhou City has made remarkable progress in the management and service of tuberculosis prevention and treatment. However, it still needs to be further improved and promoted in order further to enhance the effectiveness of TB prevention and treatment and safeguard people's health.

2.5.3 Developing process of the "E-TBPMS" in Huizhou city, Guangdong Province

In July 2013, to standardize the management of TB patients, Huizhou Tuberculosis Prevention and Treatment Institute began to explore and develop micro-supervision. In April 2014, to solve the compatibility, ease of use, and convenient promotion of this program on mobile phones, the original APP solution was abandoned and fully converted to WeChat official account solution.

In February 2015, inspired by medical requests provided by physicians, supervision was also introduced into the system management, and the supervisor and supervision work was managed by fully aligning with the official account of the Huizhou Tuberculosis Prevention and Treatment Institute on WeChat. In November 2016, the system was upgraded comprehensively, the operation was optimized, and the physicians' mobile terminal was added. In October 2017, the WeChat referral function was added; referral information can be efficiently transmitted, simplifying referral and tracking processes. In October 2018, the mobile follow-up record function was realized, and the supervisor could efficiently complete the follow-up and related records on-site.

Upon diagnosis, tuberculosis patients can follow the official public account of "Huizhou TB Prevention and Control" on WeChat. During the treatment process, the public account regularly sends notifications such as medication reminders and review and visit reminders to the patient. If the patient clicks medication reminder, it will be regarded as having completed medication on the same day and recorded. Patients can also read health-education posts published by the official account and use quick search and remote communication functions to contact medical workers for TB-related information.

Physicians can edit medical orders in the management system, send the control notice of confirmed patients to supervisors, and check their receiving status, as well as the implementation status of the patients' medical orders and the supervisor's supervision. They can also communicate with tuberculosis patients or other medical staff remotely. On the other hand, the supervisor can receive the control notice of tuberculosis patients through the

management system, view and execute follow-up plan tasks, record and consult follow-up information in real-time, communicate with patients remotely, and check the execution of medical orders of tuberculosis patients.

2.6 "E-TBPMS" Core functions and application

2.6.1 Management of WeChat patients' referral

In China, though TB patients usually to choose large general hospitals as their first visit, when the doctors doubt if the patient has TB or has been diagnosed with the disease, according to the provisions of *the Law of the People's Republic of China on Prevention and Control of Infectious Diseases*, the doctor must refer the patient to the designated medical institutions for TB prevention and control for diagnosis and treatment and management. The referral management module facilitates the needs of this clinical referral work, based on the WeChat platform operation, and can be operated by QR code or message authentication. Patients can quickly complete referral registration by scanning the referral QR code or message authentication from clinicians at the general referral hospital. Patients will then complete registration by scanning the "code in place" provided by the TB hospital information office staff. This process effectively ensures the accuracy and authenticity of the patient' information and avoids problems caused by errors or omissions in key information such as phone numbers. Through online referral, TB control organizations can better manage follow-up visits. At the same time, patients can receive automated navigation and health education links to provide effective supervision of their visits to TB control facilities. Accurate referral information lays the foundation for follow-up and solves the difficult follow-up problem due to incorrect information.

2.6.2 Supervised management of TB patients by clinicians

The physician supervision module includes four main functions: preparation, medication and review reminders, patient management notification and doctor-patient communication. Through this module, medical staff of TB control organizations can quickly generate physician supervision reminders and monitoring tasks for patients, and quickly and accurately send "TB patient management notifications" to the city's 93 communities and health centers. Through the system, patient management information can be accurately linked.

At the same time, patients can also use the system to conduct online consultations and

communicate with medical staff more conveniently.

The operation process of the physician supervision module is relatively simple. First, the medical staff needs to carry out preparatory work, including inputting the patient' basic information, adding a description of his/her condition and suggested treatment plan. Then, the system will generate medication and review reminders based on the physician's supervision to ensure that the patient takes medication and receives reviews on time. The system can also automatically send patient management notifications, such as medication reminders and follow-up hospital visit arrangements. In addition, communication between doctors and patients has become more convenient, as patients can also ask questions to medical staff and get answers through the system.

Through the physician supervision module, TB control institutions can better manage patients, provide personalized treatment plans, and provide timely reminders and supervision to ensure that patients take their medication and follow-ups on time. The module not only improves the work efficiency of medical staff, but also facilitates the patient' treatment experience. At the same time, using the system can also strengthen the communication between medical staff and patients, improve mutual understanding, and further enhance the quality of medical care.

2.6.3 Follow-up supervision of tuberculosis patients by supervisors

The Follow-up Management Module is a very important component in facilitating the collaboration between supervisors and clinicians. After receiving patient management tasks from clinicians, supervisors can use the module to interact efficiently with patients by means of remote online real-time supervision to complete management tasks such as initial household surveys and regular follow-up visits. Compared to the traditional way of manually filling in patient follow-up records, the follow-up management module uses electronic follow-up records, saving time and much easier to maintain.

The traditional way of manually completing follow-up records is time-consuming, error-prone, and if there's any mistake, it will not be that easy to fix. By using electronic records, supervisors can record visits at any time by receiving relevant information from the supervisor's mobile phone, thus it largely improves efficiency.

In addition, the back-office system can automatically record, print, and file data, and managers can monitor the work of supervisors through the back-office system. Such a mechanism not only improves the transparency and quality of work but also helps managers to identify and solve problems and improve the workflow on time.

The functions of the follow-up management module go far beyond that. Supervisors are usually doctors or nursing staff from community service centers, who are responsible for monitoring patient' daily medication intake, adverse reactions to medication, and reminding them of regular follow-up appointments; supervisors could also be the medication managers who have the closest contact with patients. Patient management tasks can be followed up through the system's follow-up management module, and each patient' situation can be tracked. Through prompts and reminders from the system, supervisors can intervene and intervene on time to ensure that patients receive timely attention and treatment.

To save time in travelling to and from the patient' home and to reduce the risk of face-to-face contact for infectious disease control, the patients can voluntarily choose to film a video of his/her medication and upload it to the platform, as well as chatting with the supervisor online, to facilitate remote monitoring and management by the supervisor, and to keep abreast of the patient' response to the medication and changes in his/her symptoms. The supervisor can adjust the follow-up plan and treatment plan according to the patient' follow-up and changes in condition to ensure that each patient can receive the most effective medical services.

Through the follow-up management module, supervisors can also communicate with patients online, answering their questions and providing timely guidance. This is a convenient and efficient way of communicating with patients, which enhances their adherence and satisfaction with treatment.

In addition to the communication between supervisors and patients, the follow-up management module also provides a mechanism for monitoring and evaluation by multiple parties. Managers can monitor and evaluate the work of supervisors through the system back-office to ensure the quality and efficiency of their work.

At the same time, patients can also monitor and evaluate the work of supervisors through this module and make suggestions and comments. This open and transparent working mechanism can motivate supervisors to work harder and improve the quality of their services, as well as identify and solve problems on time and improve work efficiency.

2.6.4 Health education

The health education module is another important part of the tuberculosis prevention and treatment work. It conveys knowledge and information about tuberculosis prevention and treatment to the public through various means, improving public awareness and understanding of tuberculosis. The module includes the official WeChat account of "Huizhou Tuberculosis Prevention and Control", a knowledge base of questions and answers, and the management of

patient consultation messages.

Firstly, the official WeChat account "Huizhou Tuberculosis Prevention and Control" provides the public with a wide range of information on tuberculosis prevention and control through regular posts. These posts revolve around 15 dimensions of knowledge, including information on the basics of TB, prevention and control strategies, public TB prevention and control, prevention and control strategies for medical staff, tuberculosis prevention and control in schools, tuberculosis prevention and control for children, the elderly, women, mobile populations, multi-drug resistant tuberculosis, tuberculosis/HIV co-infection, tuberculosis complicating diabetes, tuberculosis complicating pneumoconiosis, tuberculosis in places of detention, bacillus Calmette-Guerin vaccine and tuberculin testing. These posts not only enrich the public's knowledge base, but also provide practical advice on prevention and treatment, helping the public to better understand and prevent tuberculosis. Secondly, the Quiz Knowledge Base is a tool to facilitate quick access to tuberculosis-related knowledge for the public.

The knowledge base contains many questions and answers on tuberculosis prevention and control searched or browsed by keywords to access relevant knowledge. The content of the knowledge base is comprehensive and covers all aspects of tuberculosis, including causes, modes of transmission, symptoms, diagnosis and treatment options. The public can access the knowledge base to quickly understand and learn about tuberculosis and improve their knowledge of the disease. Finally, the health education module also provides a patient consultation message management function.

The public can use this function to provide advice and suggestions to the medical staff of the tuberculosis control facility for more professional guidance and assistance. The medical staff will respond to patient's enquiries in a timely manner and provide professional answers and advice. In the process, a close and convenient communication channel is established between the public and the medical staff, promoting good interaction and communication between doctors and patients.

In summary, the health education module provides the public with a convenient way to access knowledge and information on tuberculosis prevention and treatment with the quiz and knowledge base and patient consultation message management through the official WeChat account of "Huizhou Tuberculosis Prevention and Control". Providing timely and accurate knowledge and answers helps the public to understand the prevention and treatment of tuberculosis and improve their health literacy and self-protection ability.

The application of the health education module will further promote the development of tuberculosis prevention and control, promote social concern and participation in tuberculosis,

and contribute to the overall control and elimination of tuberculosis.

2.6.5 Statistical analysis

Statistical analysis is the most essential session of tuberculosis control, as it provides a basis for decision-making and evaluation by collecting, collating, and analyzing relevant data. The statistical reporting module is an important part of the tuberculosis control system, and it consists of four sections: trends in patient numbers, monitoring and implementation, actions of physicians' guidance, and patient distribution maps.

The first part of a trend in patient numbers focuses on forming a monthly curve of new patients added to the system with time as the X-axis and quantity as the Y-axis. This curve allows the user to visualize the trend of patient growth each month and to adjust and decisions accordingly. Users can select a specific time to view for more detailed data and trends as required. The monitoring and implementation section focuses on the follow-up records due for implementation and the completed follow-up records for each month in two-time curves. This design gives the user a clear picture of the monthly follow-up tasks and the actual completion status. The time periods for monitoring and execution are optional and can be set by the user as required. The action of the physicians' guidance is mainly formed by two-time curves for the monthly medical guidance record and the completion record.

These curves provide a visual representation of the physicians' guidance actions and the completion of the tasks. Users can select specific time periods to view according to their specific needs to understand the physicians' guidance efforts and results. A special section is the patient distribution map, which shows the distribution of patients, categorized according to their personal information, including county, gender, occupation, and age. Such a distribution map can help users have a more comprehensive understanding of the patient' situation and characteristics and provide a reference basis for formulating appropriate prevention and treatment strategies. Users can use the module's functions to locate and filter data geographically to obtain more targeted statistical information.

The statistical analysis module provides an important basis for decision-making and evaluation of TB control by collecting, collating, and analyzing relevant data. Health worker scan visualize data and trends in all aspects to make scientific and rational decisions through patient changes, supervision and enforcement, doctor-directed actions, and patient distribution charts.

2.6.6 Summary of the "E-TBPMS" functional module

In summary, the three modules of health education, supervisory management by clinicians and supervisory management by supervisors are closely related to patient adherence.

The health education module communicates knowledge about TB prevention and treatment to the public through the information provided by the official WeChat account, the question bank and the information management function for patient counselling. The official WeChat account regularly publishes various aspects of TB knowledge and provides practical prevention and treatment advice to help the public better understand and prevent TB.

The supervision and management module for clinicians includes several functions such as preparation, medication and review reminders, patient management notifications and doctor-patient communication. Clinicians can enter basic patient information and create treatment plans in the system. The system generates medication and review reminders based on the clinician's monitoring to ensure that patients take their medication and reviews on time. The system can also automatically send patient management notifications, such as medication reminders and follow-up appointments. Patients can also communicate with healthcare professionals through online consultations.

The Supervisor's Supervision Management Module completes tasks such as home surveys and regular follow-up visits through online, real-time remote supervision. Electronic follow-up records save time and are easier to maintain than the traditional manual completion of follow-up records. Supervisors can receive relevant information to complete visit records anytime via mobile phones, improving efficiency. The back-office system can automatically record, print, and archive data, and managers can monitor the work of supervisors through the back-office system. Supervisors can communicate with patients online, while the module also provides a multi-party monitoring and evaluation mechanism.

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Chapter 3: Research Methods

The research will be conducted in Huizhou City, Guangdong Province, China, and consists of two studies. A cross-sectional research method combining qualitative and quantitative was used. This research adopts Mixed Methods Research to explore and explain the research questions through the quantitative and qualitative cross-sectional design.

A questionnaire based on the Information-Motivation-Behavioral Skills Theory will be designed for patients with active TB managed by the Integrated Mobile Phone Management System for TB Prevention and Control in Huizhou City, Guangdong Province, China. The research included patients' basic information, knowledge of tuberculosis, motivation to take medication, behavioral skills, medication adherence, and treatment effects evaluation.

The correlation and strength of the relationship between each factor and medication adherence were analyzed through univariate and multivariate statistical techniques to get the relationship between each variable and establish the model of influencing factors of medication adherence in TB patients. The results were combined to assess and validate the model of factors influencing medication adherence among TB patients under information management technology.

The quantitative research analyzed the factors influencing TB patients' medication adherence. The qualitative analysis answered the question of the impact of "information management technology" on TB patients' medication adherence from the interaction perspective of patients and doctors (clinicians and supervisors), including:

(1) Explore the influencing factors and pathways of adherence of tuberculosis patients.

(2) Construct a theoretical integrated model based on information-motivation-behavioral skills to analyze the correlation and strength of the relationship between factors and medication adherence.

(3) Validate the constructed integration model proposed.

(4) Clarify the mechanisms influencing adherence of TB patients.

(5) Analyze the effect of the current technology (E-TBPMS) on TB patients through the validated mechanisms.

(6) Propose strategies for further optimization (E-TBPMS).

3.1Theoretical framework for the study of medication adherence factors in tuberculosis patients.

Figure 3.1 shows a diagram of the theoretical framework that describes the influencing factors and the relationships between them that affect medication adherence in TB patients.

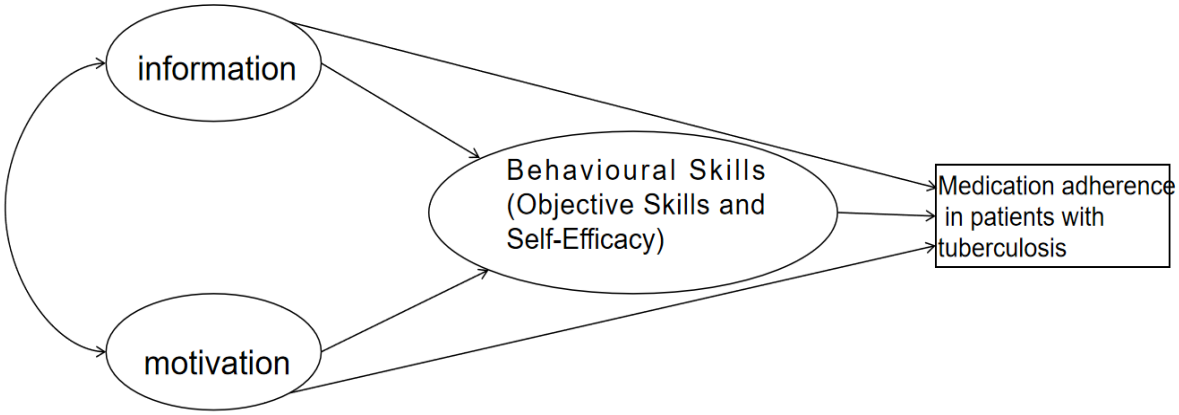

Figure 3.1 A theoretical framework for the study of medication adherence factors in tuberculosis patients

This theoretical model has an interactive and interrelated relationship between three elements or dimensions: information, motivation, and behavioral skills. TB patient information provides the basis for knowledge about TB control and motivates individuals to take medication; motivation to take medication drives individual patients to take action and influences the development and use of their behavioral skills; and improved patient behavioral skills lead to individuals being more confident and able to take effective action (Fisher et al., 1996).

For medication adherence, the IMB model suggests that the accuracy, clarity, and understandability of information have a significant impact on adherence. When people are provided with clear and trustworthy information, they are more likely to understand it and take it as required. Motivation and behavioral skills also have a significant impact on patient adherence. Individual patients are more likely to adhere if they have a positive motivation and desire to follow medical advice or health behaviors. At the same time, an individual's behavioral skills, including the ability to make plans, control incentives and avoid temptations, also play an important role in maintaining adherence. In the model, information, motivation and behavioral skills are three key variables that affect adherence in TB patients. These variables can be assessed and quantified using a variety of methods. The accuracy, clarity and comprehensibility of information can be assessed using questionnaires, face-to-face interviews or observation. These methods can be used to understand the patient's level of knowledge about

TB and understanding of treatment regimens and medicines. Motivation can be assessed using questionnaires or rating scales. These assessments can be used by the researcher to obtain information about the patient's attitude to treatment, expectations of recovery and the importance of health. Behavioral skills can be observed and assessed by observing and evaluating the patient's behavior in real life. For example, behavioral skills are assessed in terms of the patient's ability to take medication on time, to follow medical advice and to manage the side effects of medication.

3.2 Quality control

Regarding quality control, the researchers made several actionable recommendations to ensure the consistency and reliability of the research. A project group of the research team was set up, with the author as the main team member, with regular meetings to report on the progress of the research and training before the formal start of the research to ensure that all team members had a clear understanding of the research objectives and process, and that adequate knowledge and experience was shared. Through regular meetings and training, team members could get to know and learn from each other, improving the consistency and reliability of research implementation.

During the research process, all members had a thorough understanding of the tools and methods used and paid particular attention to the management of the system and network context when using the information management tools to ensure the smooth operation of the system, minimize information loss and errors, and ensure the reliability and consistency of the data. All patients, as participants in this research, agreed to participate freely and voluntarily, giving their informed consent (for the use of the data just for scientific purposes).

At the data collection and analysis stage, to protect their personal information, we anonymized the data to prevent leakage of personal information, and actively verified the data to ensure accuracy and reliability.

3.3 Technology roadmap – methodological approach

Figure 3.2 shows the technology roadmap of this research, according to the methodological approach.

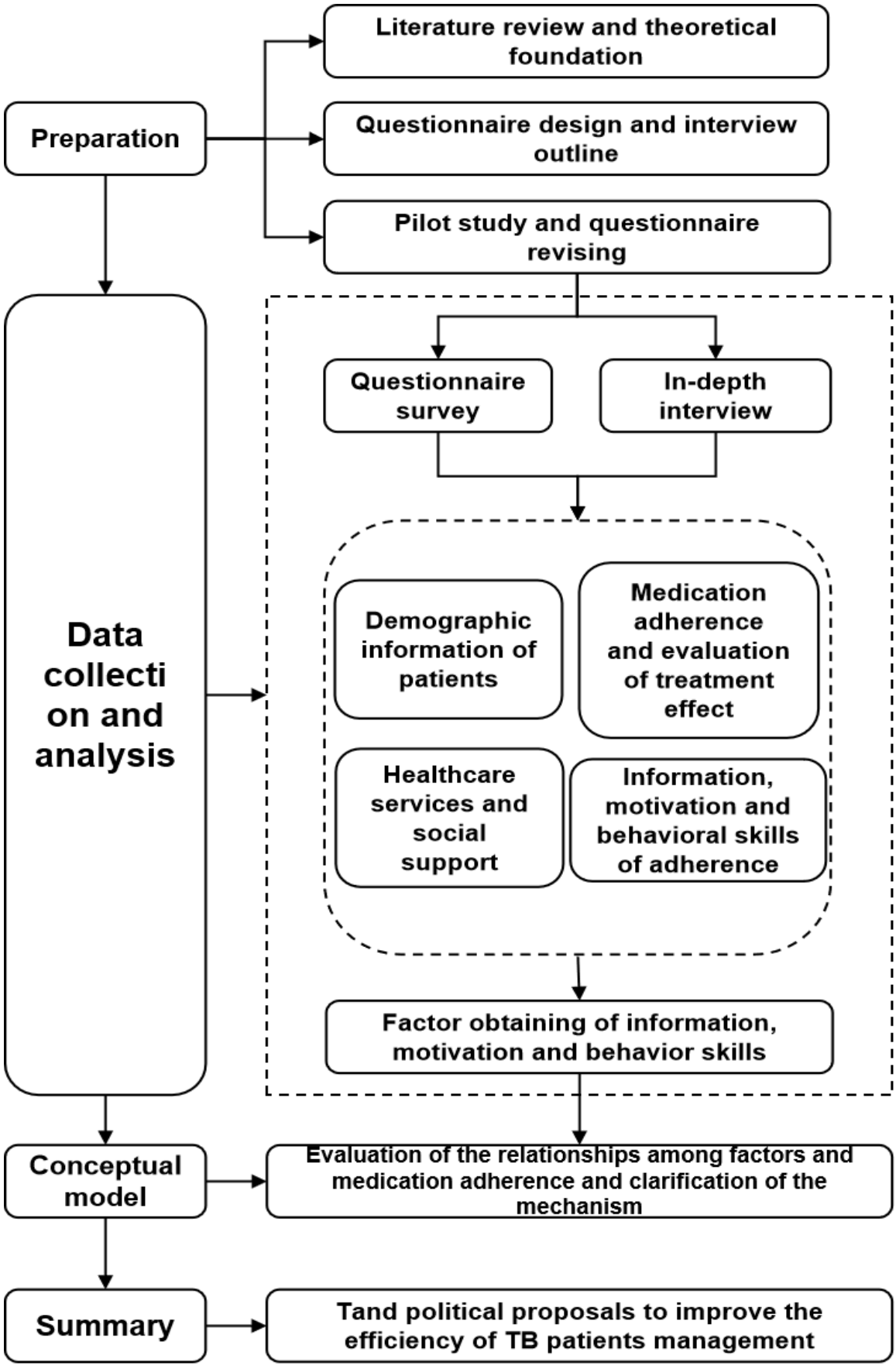

Figure 3.2 Technology roadmap – methodological approach

The main goal of this research is to explore and evaluate the use of (E-TBPMS) for the management of patients with active tuberculosis (TB) in Huizhou City, Guangdong Province, China. As a methodological approach, we use a cross-sectional research design, combining quantitative and qualitative research, and collect comprehensive data through participant observation and interviews. The quantitative study will collect a large amount of quantitative data to evaluate the effectiveness of the E-TBPMS system. It will select a certain number of samples from TB patients in Huizhou City. Using questionnaires and systematic data collection, the researcher will collect relevant quantitative data such as patients' basic information, symptoms and treatment. We will also analyze statistical data on system use, such as frequency of system logging and function use.

The qualitative study will be conducted through participant observation and in-depth interviews to obtain subjective experiences and opinions about the use of the E-TBPMS system by patients with active tuberculosis. A subset of participants will be selected from the quantitative study to conduct face-to-face interviews with them. Through these interviews, the researchers will collect detailed descriptions of participants' experiences of the system, its effectiveness, and suggestions for improvement.

Through these two consecutive studies, we expect to learn more about patients with active TB when they are managed using the E-TBPMS system. The quantitative study will provide detailed data on the use and effectiveness of the system, while the qualitative study will provide participants' subjective experiences and opinions.

We hope these results will better guide and improve the use of the E-TBPMS system.

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Chapter 4: Study 1 - Quantitative Research

4.1 Objectives of quantitative study

In terms of quantitative research, to collect the necessary data, a questionnaire was designed based on the information-motivation-behavioral skills theory to obtain information about patients with active tuberculosis (see Questionnaire in Annex A).

The research site was chosen in Huizhou City, Guangdong Province, China, a representative area with a high number of TB patients in the region. The questionnaire is used to collect basic information about the patients, including age, gender, occupation, and education level. In addition, we will investigate the patients' level of knowledge and understanding of TB, as well as their motivation and attitude toward taking medication.

Regarding TB-related knowledge, patients' basic knowledge of TB will be collected, including how TB is transmitted, symptoms, and diagnostic methods. By assessing patients' knowledge of this knowledge, we can assess their awareness of TB and further analyze patients' needs and challenges in controlling and treating TB.

In terms of motivation to take medication, patients' motivation, and attitudes towards taking medication will be investigated. Understanding patients' motivations and attitudes toward taking medication is essential to promote good adherence to treatment. This is achieved by asking them about their expectations of medication and the difficulties and problems they may face in taking medication. The collection and analysis of this data will provide an understanding of patients' attitudes and motivations toward medication, and a basis for improving and optimizing treatment regimens.

In addition, information on patients' behavior in the integrated TB control mobile phone management system will be collected in the quantitative research. We will observe patients' behavior during the use of the system, including whether they take their medication on time and how often they use the system functions. By collecting and analyzing these data, it will be possible to understand the behavioral characteristics and habits of patients during their use of the system and provide recommendations and guidance for further improvement and optimization of the system.

In sum, the objectives of this study are:

(1) Explore the influencing factors and pathways of adherence of tuberculosis patients.

(2) Construct a theoretical integrated model based on information-motivation-behavioral skills to analyze the correlation and strength of the relationship between factors and medication adherence.

(3) Validate the constructed integration model proposed.

4.2 Research object

In the quantitative research part, active TB patients in Huizhou city, Guangdong province, China, managed by "integrated mobile phone management system for TB prevention and control" are selected as the research objects. The sample size is calculated according to the sample size calculation formula of cross-sectional survey counting data.

$$N=\mu 2\partial/2*p*(1-p)/\delta 2 \quad (4.1)$$

N is the target sample size, α is the inspection level, P is the sample rate, and δ is the allowable error. In this case, α=0.05, then μ/2 = 1.96. The non-adherence of TB patients with medication is about 30%, that is, p=0.30, and the allowable error δ = 0.2p.

Referring to the sample size calculation formula, the minimum sample size is finally calculated to be 224, and the final survey sample size is 247 considering the 10% lost follow-up.

The inclusion criteria are as follows:

(1) Newly diagnosed pulmonary TB patients who have been taking medicine for more than two weeks.

(2) Those who have clear consciousness, can communicate normally, and understand the contents of the questionnaire.

(3) Patients who are not accompanied by serious diseases such as AIDS, cancer, chronic obstructive pneumonia and need surgical treatment or special management.

(4) Informed consent and voluntary participation in this research.

For the exclusion criteria we consider:

(1) Failure to meet diagnostic criteria: only patients who meet the diagnostic criteria for tuberculosis can be used as research participants.

(2) Duration of medication is not met, and participants need to take anti-tuberculosis medication for at least 2 weeks or more to ensure the stability of patient comparison.

(3) Age restriction: patients below 18 years old, or above 70 years old.

(4) Serious co-morbidities: co-morbidities with serious diseases (e.g., AIDS, cancer) can

interfere with the assessment of TB treatment.

(5) Consciousness limitations: patients need to have a clear state of consciousness and the ability to communicate and understand the questionnaire effectively.

(6) Surgical treatment or special treatment needs: patients requiring surgical treatment or with special treatment needs may be excluded to ensure consistency of research results.

(7) Lack of informed consent: participants must accept informed consent and participate in the research voluntarily to ensure compliance with ethical norms.

4.3 Questionnaire design

In this study, a self-designed questionnaire was used to conduct an on-the-spot investigation on TB patients, in the form of a questionnaire, according to the research question and objectives, to understand the contents, including the general social population economics information, behavior habits, access to health services, social support, knowledge related to TB, motivation for taking medicine, behavior skills, adherence with medication and evaluation of treatment effect.

The survey was conducted by filling in the questionnaire on the spot. Before the official start of the research, the investigators were given centralized and unified on-site training, and two researchers who had passed the training and examination conducted a one-on-one investigation on the TB patients who met the inclusion and exclusion criteria in Huizhou TB Prevention and Treatment Institute at the research site to obtain relevant information.

In the process of the questionnaire development and design, the survey content was divided into three aspects: external factors, internal factors, and treatment effect evaluation.

The measurement of external factors mainly includes general social demographic information, such as gender, age, occupation, education level, marital status, behavior habits. Health service acquisition mainly investigates the convenience of health service acquisition; Social support was measured by Social Support Rating Scale (SSRS) to measure TB patients' social/family support.

The measurement of internal factors is a questionnaire item designed by researchers based on the information-motivation-behavior skill model, in which the information includes the knowledge about TB, the necessity of taking medicine, and the adverse consequences of irregularly taking medicine. The motivation for taking medicine includes the perception of benefits and obstacles of adherence to medication, the perception of the severity of non-adherence with medication, and behavioral clues; Medication behavior skills are expressed by

self-efficacy.

The evaluation of treatment effect includes the self-rated health status of patients and the medication adherence of patients assessed according to the Morisky adherence Scale (the adherence is judged to be moderate or good with a score of 6 or above, otherwise it is poor). The above three aspects together form the questionnaire of this research - see Table 4.1 for specific measurement indicators; see Annex A for the questionnaire developed (Morisky, 2008). After testing, the validity KMO (Kaiser-Meyer-Olkin) value of the scale is 0.734, which indicates that the research data is more suitable for extracting information. The reliability Cronbach alpha coefficient is 0.652, which indicates that the quality of reliability of the research data (considering all the items in the scale) is acceptable.

Table 4.1 Main measurement indicators

Research contents	Measurement field	Leading indicator
External factor	External environment	General demographic information and behavior habits Health service provision and access Social support: access to social/family support.
Internal factor	Information	Knowledge related to medication adherence: knowledge related to TB, necessity of medication, consequences of irregular medication.
	Medication motivation	Perception of benefits of adherence with medication Perception of medication adherence disorder Perceived from the seriousness of medication failure Obtaining clues of medication behaviors given by different social roles
	Medication behavior skill	Self-efficacy: the ability of self-management and control of medicine -taking behavior. External supervision: get reminders of medication behaviors of doctors and family members.
Therapeutic effect evaluation	Medication adherence	Morisky scale
	Treatment results	Self-rated health status

As a special note, the design and use of the scale has been authorized by Dr. Morisky's permission, which can be found in the Appendix section. (See Annex F for proof authorization).

Measurement tools and Research method: The Medication Adherence Scale uses the MMAS 8-item version to investigate patients' medication adherence. The scale consists of 8 questions in the following order: (1) Do you sometimes forget to take your medication; (2) Have you forgotten to take your medication on any day or days in the past two weeks; (3) Have you ever reduced or stopped taking your medication without telling your doctor when you felt your symptoms worsened or when you had other symptoms during treatment; (4) Do you sometimes forget to take your medication with you when you go out; (5) Did you take your anti-tuberculosis medication yesterday? (6) Did you stop taking your medication when you felt

that your symptoms were getting better or had disappeared? (7) Do you think sticking to the treatment plan is troublesome? (8) Did you find it difficult to stick to your anti-tuberculosis treatment program?

"No" and "Yes" for questions 1, 2, 3, 4, 5, 6 and 7 where "No" is scored 1 mark and "Yes" is scored 0 marks. Likert 5 scale i.e. "never", "occasionally", "sometimes", "often" and "all the time"; "all the time" scored as 1, 0.75, 0.50, 0.25 and 0 in that order. The scale was scored out of 8 with a score of <6 as low adherence, 6-7 as moderate adherence, and =8 as high adherence.

The Follow-up Adherence Scale consists of two questions in the following order: (1) During the treatment period, have you had regular TB follow-up appointments as prescribed by your doctor? (2) Have you missed any appointments in the last three months? (For patients who have been on treatment for three months, "No" is worth 0 points and "Yes" is worth 1 point. A score of 2 indicates high adherence, a score of 1 indicates moderate adherence, and a score of 0 indicates low adherence.

4.4 Quantitative data analysis

The quantitative data were statistically analyzed by SPSS 25.0 and software R 4.1.0.

Descriptive analysis: the general situation, medication adherence, knowledge related to TB, medication motivation and behavioral skills of the investigated respondents were described and counted. The quantitative data that obey the normal distribution are described by mean, and standard deviation, the data that do not obey the normal distribution are described by median and interquartile spacing.

The comparison between groups is made by t-test, variance analysis or nonparametric test. Qualitative data were described by frequency and composition ratio, and the chi-square test was used to compare groups.

Regression analysis: Single-factor analysis and multi-factor analysis were used to analyze the correlations between external and internal factors and medication adherence, and the strength of the relationship.

4.5 Quality control of the questionnaire

To ensure the quality of the investigation, researchers will receive unified scientific research training before starting the investigation and will formally carry out the investigation after passing the examination.

To ensure the quality, the data obtained from the questionnaire will be entered into Epidata software by double input on the survey day.

4.6 Findings - Demographic characteristics

In this study, a total of 337 TB patients in Huizhou answered to the questionnaire. Among them, 68 patients who did not meet the inclusion criteria were excluded – according to the exclusion criteria – namely, because they had an age < 18 years old, relapse, and medicine resistance. Finally, 269 patients were included.

Among 269 respondents, 171 (63.6%) were male, accounting for a relatively high proportion. Most patients were married, accounting for 74.0%; Most patients with education levels below junior high school education accounted for 56.5%, of which 36.1% had junior high school education. In terms of living habits during treatment, non-smokers accounted for 84.4%, and non-drinkers accounted for 61.3%; At present, the number of people without income is the highest, accounting for 39.4%, but 94.1% of patients have purchased medical insurance; Medical distance of 3-10km and 10-40km are common, accounting for 34.9% and 32.2% respectively. See Table 4.2.

Table 4.2 Socio-demographic characteristics of respondents

	Quantity/mean standard deviation	Proportion (%)
Marital status		
Married	199	74.0
Unmarried/divorced/widowed	70	26.0
Education background		
Primary school and below	55	20.4
Junior school	97	36.1
High school or technical secondary school	69	25.7
College degree or above	48	17.8
Are you currently drinking?		
Yes	104	38.7
No	165	61.3
Are you currently smoking?		
Yes	forty-two	15.6
No	227	84.4
Monthly income		
< 3000	140	52.0
[3000...6000]	87	32.3
[6000...10000]	32	11.9
>= 10000	10	3.7
Medical insurance		
Yes	253	94.1
No	16	5.9
Medical service distance		

< 3 km	48	17.8
[3…10] km	94	34.9
[10…40] km	87	32.2
>= 40 km	40	14.9

4.7 Findings - Analysis of the treatment adherence

Among the 269 participants, 98.1% of them can have regular follow-ups, and the adherence of follow-up visits is generally good. In terms of medication adherence, most patients had moderate or good adherence, accounting for 74.7%, while those with poor adherence accounted for 25.3%. In the past two weeks, 36 patients had missed medication, accounting for 13.4%.

Most patients have fewer medicine leakage times, of which 61.1% have less than five medicine leakage times, followed by 5-10 medicine leakage times, accounting for 27.8%. See Table 4.3 for details.

Table 4.3 Review and medication adherence of pulmonary TB patients

Items and sub items	Average/number of cases	Standard deviation/proportion (%)
Medication adherence	6.6	1.4
Missed any medicine in the past two weeks?		
Yes	36	13.4
No	233	86.6
Number of medicine leakage in the past two weeks		
<5	22	61.1
5-9	10	27.8
≥10	4	11.1

4.8 Findings - Analysis of IMB score

4.8.1 Scores of TB-related knowledge

A total of 269 participants were assessed for their TB-related knowledge. According to the assessment results, the participants scored 28.8±6.3 in the knowledge related to TB. This score reflects the overall knowledge of the participants about TB.

In terms of TB knowledge, participants had a better understanding of “most TB diseases can be cured with standardized treatment” and “TB can be prevented and treated” with scores of (4.2±1.2) and (4.1±1.3), respectively. This indicates that most of the participants had a good understanding of the treatment potential and preventive measures for TB. However, the understanding of “patient assistance policies” was low with a score of (3.3±1.6). This may

indicate that the participants were not sufficiently aware of the relevant policies and benefits, and further information and education is needed.

In terms of treatment part of knowledge, participants had the highest understanding of "the need for regular medication" and "the need for standardized review" with a score of 4.8±0.6. This indicates that the participants had a high level of understanding of the importance of medication and review during TB treatment. In addition, all knowledge-related items scored greater than 3, indicating that most of the participants were knowledgeable about various aspects of TB. See Table 4.4 for details.

The assessment of TB-related knowledge allows researchers to understand the level of knowledge of patients regarding TB and helps to develop targeted health education and awareness campaigns. In addition, the results of the assessment can be used to evaluate the effectiveness of health education and awareness campaigns, which can further improve patients' knowledge of TB and promote their active participation in treatment and preventive measures. By continuously enhancing the knowledge and education of TB patients, their health literacy can be improved, and the risk of disease spread, and recurrence can be reduced, thus contributing to the development of public health.

Table 4.4 Scores of related knowledge of pulmonary TB patients

Items and sub items	Mean	SD
Disease knowledge		
After treatment, most TB can be cured.	4.2	1.2
TB is preventable and treatable.	4.1	1.3
Patient subsidy policy	3.3	1.6
Therapeutic knowledge		
The necessity of regular medication	4.8	0.6
Harm of irregular medication	3.9	1.6
The necessity of normative review	4.8	0.6
Harm of non-standard reexamination	3.8	1.6
Aggregate score	28.8	6.3

4.8.2 Scores of medicine motivation of pulmonary TB

Patients' medication motivation is divided into four parts: benefit perception, obstacle perception, disease severity perception and behavioral clues. The higher the score, the better the medication motivation. Of 269 respondents, the overall score of patients' medication motivation was 65.9±8.2. The higher the score, the more the patients agree with the content, regarding benefits perception, severity perception and behavioral clues of regular medication. Among them, the overall scores of four items are similar, and all of them are higher than 4.5 points in terms of the perception of the benefits of regular medication in the whole process.

The scores of the items perceived to the severity of the disease were all higher than 4.1 points, with the highest score of "TB is very harmful to my health" being 4.6±0.8 points. In terms of behavioral clues, "the doctor advises you to take medicine according to the doctor's advice" scored the highest, which was 4.9±0.4; Secondly, "your family suggested that you take medicine according to the doctor's advice", with a score of 4.1±1.6; The other two items are all less than 3 points, indicating that the behavioral clues of patients' adherence with medication are less affected by the other two factors.

The higher the score, the more patients disagree with this content. The scores of "I often do not take medicine on time because I forget", "I am too busy to make regular follow-up visits and get medicine", and "I am worried that the medicine used is not as effective as expected" are all higher than 4 points, indicating that the motivation of patients to take medicine is less affected by these three factors, "If others know that I use the medicine for TB, it will make me feel embarrassed" and "The medicine used often makes me feel unwell and unbearable". See Table 4.5 for details.

Table 4.5 Scores of motivations of taking medicine in patients with pulmonary TB

Items and sub-items	Mean	SD
Benefit perception		
Regular medication can control my illness.	4.6	0.7
Taking medicine regularly all the way, I am more satisfied with my physical and psychological condition.	4.5	0.8
Taking medicine regularly throughout the course can make me do more things I want to do.	4.6	0.8
The therapeutic effect of the medicine used is greater than its side effects.	4.5	0.8
Perception barrier		
If others know that I use medicine for TB, it will make me feel embarrassed.	3.4	1.7
I often forget to take my medicine on time.	4.6	1.0
I'm so busy that I do not have time to make regular follow-up visits and get medicine.	4.9	0.5
I'm worried that the treatment medicine used are not as effective as expected.	4.2	1.4
The medicine used often make me feel unwell and unbearable.	3.7	1.4
Severity perception		
TB is very harmful to my health	4.6	0.8
Irregular medication will lead to recurrence of TB.	4.1	1.4
Irregular medication will lead to medicine resistance.	4.1	1.4
Behavioral clues		
The doctor advises you to take the medicine according to the doctor's advice.	4.9	0.4
The propaganda of the news media suggests that you take the medicine according to the doctor's advice.	2.8	1.9
Your family advises you to take the medicine according to the doctor's.	4.1	1.6

Your friend suggested that you take the medicine according to the doctor's advice.	2.5	1.9
Aggregate score	65.9	8.2

4.8.3 Scores of behavioral skills evaluation of TB patients

Patients' behavioral skills are represented by self-efficacy, and the higher the score, the higher the score of patients' behavioral skills evaluation. Among the 269 investigated respondents, the self-efficacy evaluation item "taking medicine regularly all the way, completely under my own control" scored 4.8±0.5.

4.9 Findings - Analysis of influencing factors of tuberculosis knowledge score

This research conducted a multiple linear regression analysis of the relevant knowledge scores of 269 TB patients with the aim of exploring the factors that may influence patients' knowledge scores. By analyzing the results, the researchers found that the following factors were positively associated with patient knowledge scores: access to information, availability of health insurance, ease of access to health services, and social support received. The specific results are shown in Table 4.6.

Table 4.6 Multivariate analysis of scores of knowledges related to TB (N = 269)

	B	β	t	p	F	Adjust R^2
Gender (male=1, female =0)	-0.468	-0.036	-0.709	0.479	11.948***	0.364
Age						
30-44	-0.687	-0.053	-1.027	0.305		
45-59	1.073	0.074	1.094	0.275		
≥60	-0.223	-0.017	-0.219	0.827		
Education background						
Junior high school	-1.631	-0.108	-1.404	0.162		
High School/Technical Secondary School	-0.627	-0.048	-0.671	0.503		
College or above	1.038	0.072	0.983	0.327		
Access to information	1.603	0.098	1.327	0.186		
Internet (yes =1, no =0)	11.033	0.639	7.465	**<0.001**		
Medical staff (yes =1, no =0)	9.496	0.676	7.763	**<0.001**		
Informed by friends and relatives (yes =1, no =0)	8.279	0.273	4.425	**<0.001**		
Medical insurance (yes =1, no =0)	5.199	0.196	3.841	**<0.001**		
Other diseases (yes =1, no =0)	-1.114	-0.081	-1.482	0.139		
Health service access convenience score	0.544	0.123	2.406	**0.017**		
Social support score	0.09	0.113	2.167	**0.031**		

Note: Age ≤29 is the reference group; Take primary school and below as the reference group. * * * means p<0.001.

In terms of access to information, patients who obtained relevant knowledge through the Internet scored higher (β=0.639, p<0.001). The Internet provides a wide range of information resources and can be accessed anytime and anywhere; therefore, access to relevant knowledge via the Internet may positively influence patients' knowledge scores. In addition, notification of relevant knowledge by medical personnel (β=0.676, p<0.001) and notification of relevant knowledge by relatives and friends (β=0.273, p<0.001) were also positively associated with patients' knowledge scores. This suggests that information transfer from medical personnel and relatives and friends has an important role in the improvement of patient knowledge. Therefore, acquiring relevant knowledge through multiple means would help improve patients' knowledge about TB.

In addition, it was found that patients with medical insurance had higher knowledge scores (β=0.196, p<0.001). Medical insurance can reduce the burden on patients and provide better access to medical services and drug resources, thus increasing patients' access and opportunity to TB-related knowledge. Thus, the presence of health insurance has a positive impact on patients' knowledge scores.

In addition to this, convenience scores (β=0.123, p=0.017) and social support scores (β=0.113, p=0.031) were also positively associated with patients' knowledge scores. Both ease of access to health care and social support improves patients' acquisition and understanding of TB-related knowledge. Access to convenient medical services ensures that patients receive timely diagnosis and treatment, while support from society provides patients with some psychological and emotional support and encouragement, thus facilitating their learning and understanding of TB knowledge.

Multiple linear regression analysis showed that the above factors had a positive effect on the knowledge scores of TB patients. These findings can help guide the development of targeted health education and promotion strategies to improves patients' knowledge of TB.

4.10 Findings - Multivariate analysis of medication motivation score

Researchers conducted a multiple linear regression analysis of the medication motivation scores of 269 TB patients to explore the factors that influence the drug motivation of patients. The results of the analysis showed that education level, co-morbidity of other diseases, convenience of access to medical services, social support score and TB-related knowledge score all had an impact on TB patients' motivation to take medication. The specific results are shown in Table 4.7.

Table 4.7 Multivariate analysis of the medicine-taking motivation of TB patients (N = 269)

	B	β	t	p	F	Adjust R^2
Gender (male =1, female =0)	0.373	0.022	0.447	0.656	14.205 ***	0.426
Age						
30-44	-0.347	-0.018	-0.283	0.777		
45-59	-0.435	-0.025	-0.344	0.731		
≥60	0.073	0.004	0.05	0.960		
Education background						
Junior high school	-0.352	-0.021	-0.302	0.763		
Secondary school l	-3.418	-0.181	-2.592	**0.010**		
College or above	-4.627	-0.215	-3.064	**0.002**		
Access to information						
Internet (yes =1, no =0)	-1.455	-0.064	-0.715	0.475		
Medical staff (yes =1, no =0)	-2.85	-0.155	-1.681	0.094		
Informed by friends and relatives (yes =1, no =0)	-2.083	-0.052	-0.861	0.390		
Medical insurance (yes =1, no =0)	-1.624	-0.047	-0.936	0.350		
Other diseases (yes =1, no =0)	-2.851	-0.157	-3.032	**0.003**		
Health service access convenience score	0.583	0.101	2.048	**0.042**		
Social support score	0.253	0.241	4.811	**<0.001**		
TB-related knowledge score	0.806	0.614	10.304	**<0.001**		

Note: Age ≤29 is the reference group; Take primary school and below as the reference group. * * * means p<0.001.

In terms of education, it was found that patients with high school/polytechnic school and junior college or above education had lower motivation to take medication scores compared to those with elementary school and below education (β=-0.181, p=0.010; β=-0.215, p=0.002). This may be because patients with higher education are more aware and knowledgeable about medication and are more rational and cautious, and therefore may be more cautious about medication use, resulting in relatively lower medication motivation scores.

In addition, patients with other diseases had lower medication motivation scores (β = -0.157, p = 0.003). Comorbidity with other diseases may distract patients' attention and energy, leading to lower attention and adherence to TB medication, which affects the medication motivation score.

The scores of conveniences of receiving treatment to access medical services (β=0.101, p=0.042), social support score (β=0.241, p<0.001) and TB-related knowledge score (β=0.614, p<0.001) were positively correlated with patients' medication motivation scores. Patients with high accessibility to health care, a good social support system, and better knowledge about TB-related knowledge were more likely to maintain good motivation for medication use.

In summary, education level, co-morbidity of other diseases, ease of access to health services score, social support score, and TB-related knowledge score all had an impact on TB patients' motivation to use medication. These findings provide an important reference for the

development of targeted health education and promotion strategies.

4.11 Findings - Multivariate analysis of behavioral skill scores

We also aimed to investigate the factors that influence patients' medication behavior skills by performing multiple linear regression analysis on medication behavior skill scores of 269 patients with tuberculosis. The results of the analysis showed that age, other diseases, and motivation scores were associated with patients' medication behavior skill scores. The specific results are shown in Table 4.8.

Table 4.8 Multivariate analysis of scores of medicine-taking behavior skills of TB patients (N = 269)

	B	β	t	p	F	Adjust R^2
Gender (male =1, female =0)	0.07	-0.044	-0.714	0.476	2.477**	0.081
age						
30-44	0.103	0.179	2.207	**0.028**		
45-59	0.106	0.206	2.213	**0.028**		
≥60	0.122	0.139	1.507	0.133		
Education background						
Junior high school	0.098	-0.029	-0.338	0.736		
Secondary school	0.112	-0.13	-1.451	0.148		
College or above	0.129	-0.098	-1.087	0.278		
Access to information						
Internet (yes =1, no =0)	0.171	0.012	0.108	0.914		
Medical staff (yes =1, no =0)	0.143	-0.027	-0.232	0.817		
Informed by friends and relatives (yes =1, no =0)	0.203	0.037	0.48	0.631		
Medical insurance (yes =1, no =0)	0.146	0.024	0.384	0.701		
Other diseases (yes =1, no =0)	0.08	-0.134	-2.006	**0.046**		
Convenience of access to health services	0.024	0.033	0.53	0.597		
Social support score	0.005	0.064	0.971	0.332		
TB-related knowledge score	0.008	-0.092	-1.022	0.308		
Medication motivation score	0.005	0.295	3.706	**<0.001**		

Note: Age ≤29 is the reference group; Take primary school and below as the reference group. * * means p<0.01.

Regarding age, the findings showed that medication behavior skill scores increased with age in patients aged 30-44 years and 45-59 years compared to those aged 29 years and younger (β=0.179, P=0.028; β=0.206, p=0.028). This may be because with increasing age, patients have more experience and knowledge of medication therapy and are more aware of proper medication use and adherence.

In addition, patients with other diseases had lower medication behavior skill scores (β=-0.134, p=0.046). The combination of other diseases may cause more physical discomfort and psychological burden to patients, which in turn affects their ability to value and use TB medication correctly, resulting in a relatively lower medication behavior skill score. In addition,

the higher the motivation score (β=0.295, p<0.001), the higher the patients' medication behavior skill scores.

This implies that the more motivated and willing patients are to take medication, the better their medication adherence will be. Having strong motivation can motivate patients to maintain consistent medication behavior and place more emphasis on the correctness and regularity of medication administration.

4.12 Findings - Analysis of influencing factors of medication compliance

Medication adherence scores of 269 patients were categorized and analyzed by binary logistic regression with the aim of investigating the factors influencing patients' medication adherence. The results of the research showed that age, ease of access to health services, TB-related knowledge score, medication motivation score and behavioral skills score were protective factors for medication adherence. The specific results are shown in Table 4.9.

Table 4.9 Multivariate analysis of medication adherence of pulmonary TB patients (N = 269)

	β	p	OR (95%CI)
Gender (male =1, female =0)	-0.222	0.539	0.801(0.394,1.627)
age			
30-44 years old	-0.961	0.070	0.383(0.135,1.083)
45-59 years old	-1.279	**0.018**	0.278(0.097,0.800)
60 years old and above	-2.306	**<0.001**	0.100(0.027,0.363)
Education background			
Junior high school	0.338	0.554	1.402(0.457,4.300)
Secondary school	0.627	0.323	1.872(0.540,6.493)
College or above	0.403	0.572	1.496(0.370,6.041)
Access to information			
Internet (yes =1, no =0)	0.113	0.897	1.120(0.201,6.250)
Medical staff (yes =1, no =0)	0.67	0.350	1.954(0.479,7.969)
Informed by friends and relatives (yes =1, no =0)	-0.713	0.614	0.490(0.031,7.850)
Medical insurance (yes =1, no =0)	0.414	0.570	1.513(0.363,6.310)
Other diseases (yes =1, no =0)	0.164	0.707	1.178(0.502,2.763)
Health service access convenience score	-0.297	**0.012**	0.743(0.589,0.938)
Social support score	0.016	0.512	1.016(0.969,1.065)
TB-related knowledge score	-0.108	**0.007**	0.898(0.831,0.971)
Medication motivation score	-0.071	**0.010**	0.931(0.883,0.983)
Skill score	-0.926	**0.004**	0.396(0.210,0.747)

Note: Age ≤29 is the reference group; Take primary school and below as the reference group.

Regarding the age of participants, the results of the research showed that patients in the age groups of 45-59 and 60 years and above performed better in terms of medication adherence, and they had higher medication adherence scores compared to patients aged 30-44 years (β=-1.279, P=0.018; β=-2.306, p<0.001). This may be since as patients' health importance and

knowledge of medication increased with age, they became more aware of the importance of medication for disease control and recovery, and therefore more actively cooperated with physicians' orders for medication.

In addition, ease of access to health services, TB-related knowledge score, medication motivation score and behavioral skills score were also found to be associated with patients' medication adherence. The results of the research showed that the higher the convenience of access to health care score, the better the medication adherence of the patients (β=-0.297, p=0.012). This may be because convenient access to health care reduces inconvenience and distress during medication administration and makes patients more willing to adhere to the prescribed medication regimen.

Patients' TB-related knowledge scores were also strongly associated with medication adherence (β=-0.108, P=0.007). The higher the level of knowledge about TB, the more patients were able to understand and recognize the importance of drug therapy and thus were more motivated to adhere to the treatment regimen.

The medication motivation score and the behavioral skills score also contributed positively to patients' medication adherence. The higher the motivation score, the more motivated patients were to continue medication use (β=-0.071, p=0.010); the higher the behavioral skills score, the more patients were able to use medication correctly (β=-0.926, p=0.004). This suggests that improving patients' motivation and behavioral skills towards medication can effectively improve patients' medication adherence.

In summary, age, ease of access to health care, TB-related knowledge score, medication motivation score, and behavioral skills score were found to be associated with patients' medication adherence in a multiple logistic regression analysis.

These results provide an important basis for the development of effective interventions and health education strategies. For patients aged 45-59 years and 60 years and older, health care providers can further improve the accessibility of health care services, enhance education on TB-related knowledge and motivation for medication use, and develop patients' behavioral skills for medication use, thereby improving patients' medication adherence. In addition, social support and family support need to be strengthened to provide patients with physical and psychological support to encourage them to face medication positively, overcome difficulties, and adhere to treatment.

4.13 Factors influencing medication adherence in pulmonary tuberculosis patients' model

In this research, through the convergence of quantitative research and qualitative interviews, we developed a model of factors influencing medication adherence in pulmonary tuberculosis patients. This model is consistent with the Information-Motivation-Behavioral Skills theory, specifically focusing on the influence of relevant information, motivation, and behavioral skills on medication adherence in tuberculosis patients under the context of information management technology.

(1) Understanding of Relevant Information

The understanding of relevant information directly impacts patients' medication adherence. This includes knowledge of healthcare-seeking methods, health insurance policies, and social support. Firstly, knowledge and choice of healthcare-seeking pathways influence whether patients can timely access medical services and standardized treatment. Secondly, understanding and comprehension of health insurance policies also affect patients' attitudes and behaviors towards treatment. Lastly, social support plays a crucial role in patients' emotions and behaviors. Receiving support from family, friends, and the community can enhance medication adherence.

(2) Influence of Demographic Data on Motivation for Medication Adherence

Demographic data such as educational background, comorbidities, and accessibility to healthcare services can influence patients' motivation for medication adherence. Firstly, different educational backgrounds may lead to variations in patients' understanding and attitudes towards treatment, with higher-educated patients more likely to comprehend the importance and necessity of treatment. Secondly, comorbidities may increase patients' demand for treatment and awareness of adherence. Additionally, the convenience of accessing healthcare services can impact patients' motivation for adherence. If patients can easily access medical services and medications, they are more likely to actively cooperate with the treatment.

(3) Influence of Age and Disease on Medication Skills

Age and disease characteristics can influence patients' medication skills. Age-related factors primarily manifest in older patients having lower acceptance of new technologies and being more accustomed to traditional medication methods, such as medication box recording Different types of diseases may require specific medication skills, thus patients may need specific education and guidance to adapt to their disease characteristics.

(4) Direct Influence of Accessibility to Healthcare Services and Age on Medication Adherence

We found that the accessibility to healthcare services and age have a direct impact on patients' medication adherence. Accessibility to healthcare services refers to patients' convenience in accessing medical institutions and medication supplies.

Through multivariate analysis, we constructed a model of factors influencing medication adherence in pulmonary tuberculosis patients, as shown in Figure 4.2. This model considers multiple factors, including relevant information, motivation, and behavioral skills, providing a theoretical basis for understanding and intervening in patients' medication adherence.

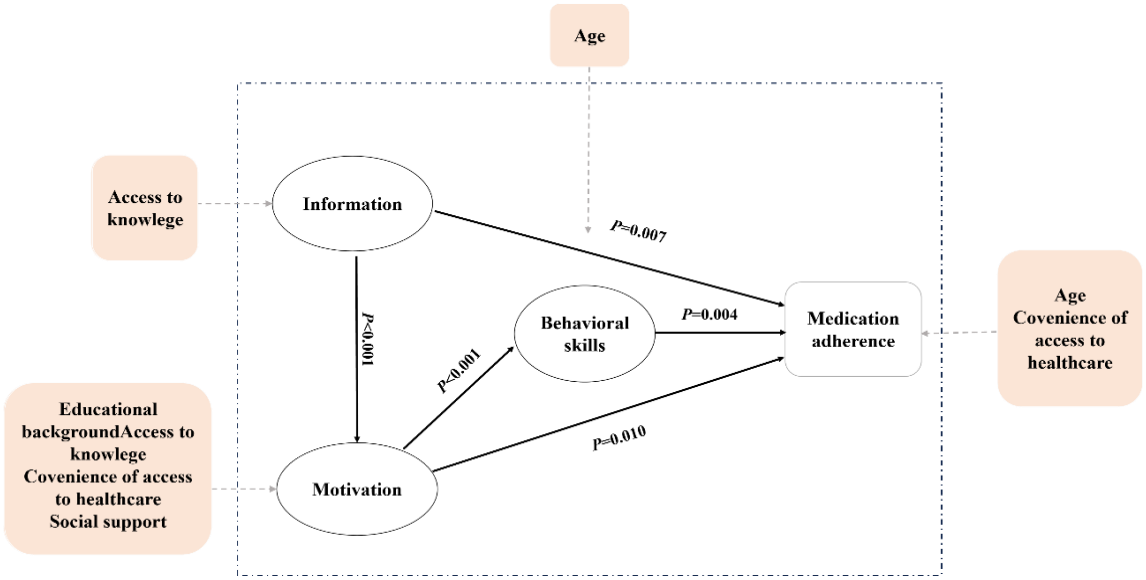

Figure 4.2 Results of multivariate analysis on medication adherence of pulmonary TB patients

By establishing this model, we gain a more comprehensive understanding of the factors influencing medication adherence in pulmonary TB patients and develop corresponding intervention measures for different factors. For example, strengthening patients' understanding of relevant information through education and awareness campaigns enhance their awareness and attitudes towards treatment. Additionally, establishing support systems, including social support and convenient healthcare services, can promote medication adherence among patients.

In conclusion, medication adherence in pulmonary tuberculosis patients is influenced by multiple factors, including understanding of relevant information, the influence of demographic data on motivation for medication adherence, the influence of age and disease on medication skills, and the direct impact of accessibility to healthcare services and age on medication adherence. Establishing a model covering all influencing factors helps understand and intervene in patients' medication adherence, improving the effectiveness and prognosis of tuberculosis treatment.

4.14 Summary of this chapter

Based on the results of the study1, it was found that out of 269 participating TB patients, most patients had moderate or good adherence (74.7%), while 25.3% had poor adherence. The results of the study showed that age, access to health services, TB knowledge score, motivation to take medication score and behavioral skills score had an impact on medication adherence. Specific analyzes showed that adherence was better among patients aged 45-59 years and 60 years and older, probably because ageing makes patients more aware of the importance of health and medication. Ease of access to health services, TB-related knowledge score, motivation to take medication score and behavioral skills score were also associated with adherence. Easy access to health services reduces inconvenience and distress during drug administration and improves patient adherence.

The higher the patient's level of knowledge about TB, the more he or she understands the importance of drug treatment, thus increasing adherence. Similarly, the higher the scores for motivation to take medication and behavioral skills, the better the adherence of patients. Associations between age, access to health services, TB knowledge scores, motivation to take medication and behavioral skills scores and adherence were identified in multivariate logistic regression analyzes. These results provide an important basis for the development of interventions and health education strategies.

Based on these results, we developed a model of factors influencing adherence in TB patients, which is consistent with the information-motivation-behavioral skills theory and considers several factors such as relevant information, motivation, and behavioral skills explicitly. By developing this model, we can better understand the factors influencing adherence in TB patients and develop appropriate interventions for different factors.

Chapter 5: Study 2 – Qualitative Study, with Interviews

5.1 Objectives of qualitative study

Based on qualitative research, this study aims to explore and analyze the key aspects and role of information management technology in patients' medication adherence. By coding and analyzing the interview data using text analysis methods, we will further refine and construct a model of the factors that influence medication adherence among TB patients using information management technology. The goal of the qualitative research is to understand and describe the phenomenon more comprehensively and to reveal the motivational and behavioral mechanisms behind patients' medication adherence through in-depth interviews and data analysis. This study will explore the application of information management technology in the TB treatment process, including the role and contribution of Tuberculosis Control Institute, Designated hospitals, and clinicians in patients' medication adherence.

In sum, the objectives of study 2 are:

(1) Clarify the mechanisms influencing adherence of TB patients.

(2) Analyze the effect of the current technology (E-TBPMS) on TB patients through the validated mechanisms.

(3) Propose strategies for further optimization (E-TBPMS).

5.2 Interview participants

The participants of the qualitative research will include TB patients who have been treated and managed at the Huizhou Tuberculosis Control Institute, clinicians, and TB management executives at the designated hospitals in Huizhou.

Interviews with these three categories of research participants will allow us to gain a multi perspectives and experience and to gain a comprehensive understanding of the practical use and effectiveness of information management technologies in TB treatment. The interviews with patients, clinicians, and management supervisors will help us to develop theoretical models of relevant key factors that can better guide and improve the treatment and management of TB patients.

5.3 Outline of the interview

To protect the privacy of the respondents and to consider the actual situation in the field, one-on-one online in-depth interviews were chosen as the data collection method in this research. The interview time for each respondent is expected to be 30-60 minutes. Before the interview begins, the patient supervisor will communicate with the interviewee in advance to confirm the interview time and provide an outline of the interview questions so that the interviewee has a general understanding of the interview content.

To ensure the accuracy and integrity of the interview, the interviewer will use an electronic recording device to record the interview process and content during the interview with the informed consent of the interviewee. This will ensure that the interview content is accurately recorded and facilitate subsequent coding and analysis. In addition, to ensure the quality of the recordings, a dedicated sound engineer will be assigned to each interview to avoid unclear or incomplete recordings due to any technical problems. In addition to recording, the interviewers also pay close attention to the emotions and reactions of the interviewees during the interviews.

Although audio recording can record the content of the conversation, human emotions and expressions often cannot be fully expressed through words. Therefore, interviewers proactively record changes in the interviewees' emotions and expressions, as well as their nonverbal behaviors during the interview. These observations can provide more comprehensive and accurate data that can help provide insight into the interviewees' experiences and perspectives. For the interview outline, the researcher will prepare a series of questions related to the research objectives and questions. These questions will be designed according to the research framework and theoretical model, covering various aspects of information management technology in patient medication adherence.

The interview outline will also be adapted and modified accordingly depending on the identity and role of the interviewee. For example, the outline for patients may focus on their understanding and acceptance, while the outline for physicians and management executives may focus on their practice experiences and perspectives.

(1) Basic background information about the interviewee, including age, occupation, and education level.

(2) Experience with the diagnosis and treatment of TB.

(3) Experience in using the "E-TBPMS", including the time and habits of use.

(4) Participants' doctor-patient information exchange, motivation and preference based on the (E-TBPMS).

Factors affecting medication adherence behavior, as well as key aspects and management functions that influence medication behavior (see Appendix B for an outline of the interviews).

5.4 Inclusion criteria and exclusion criteria

Inclusion criteria for patients with active pulmonary tuberculosis:

(1) Be clinically diagnosed with active tuberculosis, have received standardized anti-tuberculosis treatment within the last 2 weeks, and have relevant diagnostic and treatment records;

(2) Be able to effectively understand and use E-TBPMS;

(3) Ability to accurately and clearly express personal views, opinions, and perceptions of TB issues, including disease perception, treatment response, complication prevention;

(4) Voluntary and signed informed consent and willingness to actively participate in this research, including participating in interviews, providing relevant information and data.

Exclusion criteria for patients with active tuberculosis:

(1) Who has never used E-TBPMS;

(2) Have a speech, visual, hearing, or mental impairment that prevents them from effectively understanding and using E-TBPMS or from accurately expressing their personal views and opinions;

(3) Suffering from other serious illnesses or deteriorating conditions that prevent normal participation in research activities.

Inclusion criteria for Physicians:

(1) Have a professional background in diagnosing and treating tuberculosis, have relevant qualifications and extensive clinical experience.

(2) Be familiar with and proficient in the operation of E-TBPMS, including functions such as data entry, disease tracking, and treatment plan development.

(3) Be able to objectively and comprehensively express views and opinions on TB-related issues, including disease assessment, choice of treatment strategy, and determination of risk of infection.

(4) Voluntarily sign the informed consent for participation and be willing to actively participate in the research process, including providing case data, participating in discussions and sharing experiences.

Exclusion criteria for Physicians:

(1) Medical personnel not specialized in TB, without relevant professional background and

experience;

(2) Retired or stopped TB diagnosis and treatment workers.

Inclusion criteria for tuberculosis management supervisors:

(1) Staff who have supervised TB patients as a full-time or part-time position with relevant management and supervision experience.

(2) Be able to accurately and comprehensively express views and opinions on TB issues, including epidemic control, patient education, and supervision measures.

(3) Voluntary and signed informed consent and willing to actively participate in research activities, including being interviewed.

Exclusion criteria for tuberculosis management supervisors:

(1) Retired or stopped supervision workers of tuberculosis patients.

5.5 Sample collection

To ensure the integrity and representativeness of the research, the researchers adopted purposive sampling. In the sampling, the researchers followed the principle of maximum difference and selected the research participants based on differences in elements such as gender, age, and education level. Also, differences in gender, age, education level, and working hours were considered for the sampling of TB clinicians and management supervisors.

After collecting and organizing the relevant information, the researchers will select patients with large differences in gender, age, and literacy in a targeted manner. The purpose of this design is to obtain the perspectives and experiences of different groups of patients to gain a comprehensive understanding of the factors influencing the use of information management technology in medication adherence among TB patients. By selecting research participants with variability, we can gain insight into the acceptance and effectiveness of the application of information management technology in different populations.

5.6 Data collection

First, relevant literature was reviewed for previous research findings and theoretical models on TB treatment, information management techniques and qualitative research areas. Second, TB control and qualitative research experts were consulted to obtain their opinions and suggestions to ensure the soundness and accuracy of the research methodology and interview outlines. Finally, appropriate interview outlines were designed for the three types of research participants

(patients, clinicians, and management supervisors), and revised and improved according to the experts' opinions to form the final semi-structured interview outlines.（See the guidelines or outlines of the interviews in Annex B, Annex C and Annex D).

Through the data collection efforts, we will obtain detailed information on the perceptions and experiences of TB patients, physicians, and management supervisors on using information management technology in patients' medication adherence. These data will provide strong support and a basis for developing a reliable model of influencing factors, contributing to a deeper understanding of the key factors and mechanisms of patients' medication adherence. Through the qualitative research approach, we can obtain more in-depth and comprehensive information, which will provide valuable references and lessons for the improvement and optimization of information management techniques.

5.7 Qualitative data analysis

Qualitative data analysis was carried out by the Chinese version of NVivo 11 plus software. Qualitative research techniques were used to code and analyze the interview data:

Interviewers transcribe and review the interview recordings within 24 hours after the end of the interview to obtain the original data.

The original data collected in the interview are coded word by word and statistically analyzed. Taking the research purpose as the core, the interviewees' statements are repeatedly considered, and the specific categories and concepts are summarized and refined.

Based on open coding, the initial category is further summarized, and the relationship between nodes is established according to the correlation, causality, and structural relationship among concepts. Specifically, it includes merging keywords with the same or similar conceptual expressions, integrating them into a higher-level category, and developing the main category by constructing logical links.

Repeated comparative analysis and extraction of the concepts of main categories, analysis of the connection between main categories, finding out the logical relationship between main categories, presenting the behavioral relationship between main categories, establishing the action path, and finally forming a complete theoretical model obtained through interviews in this research (Chen et al., 2017; Liu et al., 2010).

To ensure the reliability and validity of the research and confirm that the theory obtained has reached saturation, after the data analysis, the interview data of four new interviewees are added for coding analysis again according to the three-level coding process. When no new

categories and relationships appear, the research is judged to be relatively saturated (Shi, 2021).

5.8 Basic information about the interviewees/participants

A total of 14 TB patients, 8 TB doctors, and 7 TB management supervisors participated in this study. The following analysis will be divided into the perspectives of patients and medical staff (TB clinicians and TB management supervisors). See Table 5.1, Table 5.2, Table 5.3.

Table 5.1 Disease information of pulmonary tuberculosis patients（N=14）

Code	Gender	Age	Education level	Job	Marital status	Treatment time (m)
a	Male	50	Middle school	Self-employed	Married	1
b	Female	26	Middle school	Unemployed	Married	1
c	Male	40	Middle school	Worker	Not married	1
d	Male	43	Middle school	Worker	Married	1
e	Male	41	Middle school	Worker	Married	2
f	Male	18	High school	Student	Not married	2
g	Male	58	High school	Unemployed	Married	2
h	Male	33	Bachelor	Worker	Married	4
i	Female	20	Vocational school	Student	Not married	4
j	Female	63	Primary school	Unemployed	Married	4
k	Male	36	Secondary school	Worker	Married	4
l	Male	31	High school	Self-employed	Married	4
m	Male	49	Primary school	Unemployed	Married	4
n	Female	20	Vocational school	Business services	Not married	4

Table 5.2 Basic information on tuberculosis diagnosis and treatment physicians（N=8）

Code	Gender	Age	Education level	Major	Job title	Working tenure (year)
A_1	Male	47	Bachelor	TB Medicine	Deputy director doctor	19
B_1	Male	52	Vocational school	Clinics	Clinic doctor	26
C_1	Female	48	Vocational school	Clinics	Attending physician	27
D_1	Female	34	Bachelor	Clinics	Attending physician	9
E_1	Female	51	Vocational school	Clinics	Deputy director doctor	16
F_1	Male	55	Bachelor	Clinics	Attending physician	30
G_1	Female	50	Bachelor	Clinics	Deputy director doctor	9
H_1	Male	53	Bachelor	Clinics	Deputy director doctor	30

Table 5.3 Information of tuberculosis management supervisors（N=7）

Code	Gender	Age	Education level	Major	Job title	Management Working tenure (year)
A_2	Male	37	Bachelor	Clinics	Attending physician	8
B_2	Male	46	Secondary school	Clinics	Clinic doctor	7
C_2	Female	32	Vocational school	Nursing	Nurse	2
B_2	Male	46	Secondary school	Clinics	Clinic doctor	7
C_2	Female	32	Vocational school	Nursing	Nurse	2
D_2	Female	42	Bachelor	Clinics	Attending physician	3
E_2	Female	33	Bachelor	TCM clinics	Attending physician	1
F_2	Male	31	Bachelor	Public healthcare	Attending physician	7
G_2	Female	43	Vocational school	Nursing	Primary nurse	4

5.9 Analysis topic from patient's perspective

5.9.1 Open coding

Open coding is the first level of coding in this research. In this stage, the researchers coded the original data of the first 10 patients verbatim and performed statistical analysis. Guided by the purpose of the research, specific categories and concepts are summarized and summarized from the participants' original words, and the remaining interview data from the last four patients were retained for theoretical saturation testing (Bulmer, 1969; John, 2009).

First, the researchers conceptualized the interview material through in-depth reading of the material and research purposes. Then, the concepts were gradually refined and clustered to obtain preliminary concepts. In coding the 10 interview transcripts, due to the large and complex initial concepts and related expressions, the researchers eliminated the initial concepts with low frequency and inconsistent expression. Through open coding and group discussion, 14 practical initial concepts were compiled and further analyzed.

The results of the open coding are presented in Table 5.4. Researchers extracted a range of initial concepts related to treatment requirements, relevant relief policies, perceived benefits, perceived barriers, perceived severity, self-efficacy, behavioral cues, instrumental support, financial support, emotional support, informational support, and access to health care services.

For example, the participants' raw data reflected treatment requirements, such as taking medication on time, paying attention to diet, and increasing exercise.

Table 5.4 Open coding

Serial number	Original data (excerpt)	Initial concept
1	If you get sick, you must take your medicine on time anyway, then take your medicine on time according to the doctor's instructions, and then take more exercise yourself. Then you should pay attention to your diet and take more exercise anyway.	Treatment requirements
2	TB can be cured, but it only means that his medication cycle is a little longer.	
3	Anyway, I think there is a discount on taking medicine. We people are like this, I think.	Relevant relief policies
4	Yes, it seems that he specializes in anti-TB. Those medicine are free.	
5	Knowing just a little, it seems that only some medicines are free.	
6	I know the benefits. It may control the disease.	
7	The advantage is that I do not have anything at present. The whole person didn't say anything like that, nothing.	
8	At least this disease can be cured by taking medicine. This is a benefit.	Perceived benefits
9	It's definitely good. Just treat the disease. It's easy to cure it, that's all.	
10	Then try to take that medicine to reduce the infectivity.	
11	This kind of medicine is no good.	
12	It's just that it's too difficult to take medicine. I feel a little disgusted and nauseous every time I eat it. I threw up after several times, and I often felt sick.	
13	Just like the old man in the family said, it must be three points of poison, and it will definitely be harmful to the health.	
14	I just said that I didn't want to take it, because after all, all the medicine are harmful to my health.	Perception disorder
15	Anyway, if you take too many medicines, you will be afraid of this.	
16	Taking medicine is very painful.	
17	I have time, I take medicine, I just I am afraid that others will have different eyes.	
	If you are troubled, you can only be troubled. The only thing is that the medication cycle is a little longer.	
18	Medication leakage can lead to medicine resistance.	
19	Definitely. If you become multi- medicine -resistant, it will be very troublesome. You have to take a lot of medicine s. Very expensive.	
20	It will definitely have an impact, resulting in medicine resistance, increasing the treatment time, prolonging the cure, or there will be minor complications.	Perceived severity
21	It will definitely be contagious or very strong. If you haven't eaten for a week or two or a few days, it will definitely still be no good.	
	It will infect others.	
22	Will remind at home, will often say to take medicine.	
23	Yes, my wife does every day.	
24	There are also doctors who specially dock with me every day, and they will remind me to take my medicine on time.	Behavioral clues
25	I also checked online Baidu. There are videos on Baidu, and there are videos in Tik Tok. They all said that we should stick to taking medicine.	

26	Yes, he will remind me to take medicine every day, and he will list what medicine I take.	Self-efficacy
27	I insist on having breakfast at work in the morning, taking medicine after breakfast, taking medicine after lunch, and taking medicine after dinner.	
28	Yourself, now you are yourself, and you do not need to be reminded. I am used to the present.	
29	I know. It would be better if someone reminded me.	
30	Everyone is familiar with it. They often come to see me, but it seems that when they are sick, they all come over.	Instrumental support
31	I am still concerned about nutrition.	
32	Our street here, if we go there to draw blood, he doesn't need money. It's like this.	Economic support
33	This is really necessary, because my wife works alone, and I have to take five or six thousand pills every month.	
34	They will enlighten me and tell me not to think about it. It's easy to take a medicine. Okay, it's nothing.	Emotional support
'36	As far as I'm concerned, the doctor seems to say that it will take nine months. He said that he would check it regularly anyway. Anyway, he said that he would cure it once. If you do not take medicine resistance in the future, it will be very difficult to treat it in the future.	Information support
37	It won't be far. Anyway, I think the traffic is quite convenient. OK.	Access to health services
38	Because my home is close, I usually go there by electric car.	
39	I felt uncomfortable on the sixth day of the year, that is, I was hospitalized. When I was hospitalized, I was found to have diabetes syndrome, then anemia, and then I was hospitalized. After living for three days, I was diagnosed with TB, and I started taking medicine after I was discharged.	Complicating diseases
40	I insist on taking medicine every day, and this one of mine is unbroken.	Medication behavior
41	He gave me a doctor's prescription for TB, which I took every day.	
42	It won't leak. I won't miss it. Take this medicine. I am very sorry for that. Ah, I also pay attention to these problems of taking medicine.	

Also, participants mentioned relevant relief policies, such as free TB medication. In addition, some participants talked about the benefits they perceived, such as controlling the disease and the possibility of a cure. However, there were also some perceived barriers, such as side effects and nausea and regurgitation during taking the medication.

Participants also expressed perceptions of the perceived severity, including concerns about the development of resistance and contagiousness. They also mentioned behavioral cues, such as reminders from family members and physicians. In addition, participants talked about their needs and experiences with instrumental support, financial support, emotional support, information support, and access to medical care.

5.9.2 Spindle coding

Based on the open coding, the subcategories induced, combined with the IMB theoretical model, the researchers determined the correlations between these subcategories and further summarized seven main categories such as information, motivation, behavioral skills, social support, access to health services, disease, and medication adherence.

The main categories and dimensions of spindle coding are shown in Table 5.5. This helps to provide a more comprehensive understanding of factors such as patients' perceptions, motivation, behavioral skills, and social support for TB treatment. Also, considering factors such as access to health care and co-morbidities can have a positive impact on promoting patients' medication adherence and treatment outcomes.

Table 5.5 Main categories and dimensions of spindle coding

Main category	subcategory	Connotation
Information	Treatment requirements	Patients' knowledge of standard treatment requirements for pulmonary tuberculosis
	Relevant relief policies	Patients' understanding of treatment-related relief policies for pulmonary tuberculosis patients
Motive	Perceived benefits	Patients perceived the benefits of regular medication for disease control.
	Perception disorder	Patients perceive obstacles encountered in regular medication.
	Perceived severity	Patients perceive the possible serious consequences of irregular medication.
Behavioral skills	Behavioral clues	Factors that promote patients' regular medication behavior
	Self-efficacy	The degree of self-control of patients in taking medicine regularly.
Social support	Instrumental support	Tangible material support and substantive services obtained by patients during regular medication.
	Economic support	The financial help patients get during regular medication.
	Emotional support	Patients get care, comfort, and security from others during regular medication, and make them believe that they are respected and loved.
Access to health services	Convenience	How convenient it is for patients to get health services related to TB treatment.
Complicating diseases	Other comorbidities	Do patients suffer from other diseases when they are suffering from TB?
Medication adherence	Medication behavior	Can patients insist on regular medication?

5.9.3 Qualitative interpretation of IMB models for E-TBPMS Patients

Based on the theoretical foundation of the IMB model, this study used qualitative research analysis to synthesize the factors influencing medication adherence in TB patients, including information, motivation, behavioral skills, social support, complex disease, and access to health

services. Based on this, the researchers constructed a theoretical model and refined the "Theoretical Model of Factors Influencing Medication Adherence in E-TBPMS Patients" to systematically understand and explain how these factors affect medication adherence in TB patients. Through this model, the researchers were able to identify the key dimensions of patient adherence, which provided guidance for the development of intervention strategies. Such a research approach provides an important theoretical reference for further improving medication adherence in TB patients.

(1) Information: TB patients' perceptions of TB treatment requirements. This includes the extent to which the patient is aware of the treatment plan, how to use the medication, and what to expect during treatment.

(2) Motivation: motivative factors for TB patients' medication adherence. This includes the patient's perception of the benefits of regular drug therapy, perceived barriers to drug use and side effects, and perceptions of the potential serious consequences of irregular drug use.

(3) Behavioral skills: The level of behavioral skills in medication uses among TB patients. This relates to the patient's self-efficacy to take medication regularly, i.e., the patient's confidence in his or her ability to control the behavior of taking medication regularly.

(4) Social support: The level of social support received by TB patients. This includes aspects such as instrumental support (e.g., tangible material support and substantive services), financial support (e.g., receiving financial help), and emotional support (e.g., receiving care, comfort, and a sense of security from others) received during regular drug taking.

(5) Complex diseases: whether the TB patient has other co-morbidities. The consideration here is that the complexity of TB treatment may be influenced by other co-morbidities.

(6) Access to health services: ease of access by patients to health services related to TB treatment. This relates to the extent to which patients can easily access health services related to TB treatment.

5.9.4 Selective coding

Selective coding is commonly used in qualitative research. It involves the process of integrating core categories and their relationships to form a comprehensive theory that explains the main concern of the research participants. During selective coding, the focus is on refining the core category or categories identified during the earlier phases of open coding and axial coding. The researcher identifies the relationships between the core category (or categories) and the main categories and encodes them into prototypical relationship structures to reflect the process of the entire behavioral phenomenon of the research participants. This process leads to the

development of a coherent and well-integrated theory that explains the phenomenon under study. In addition, during selective coding, the researcher may conduct theoretical saturation tests using the remaining data to determine if new categories or relationships emerge. If no new category or relationship can be drawn from the remaining data, it suggests that the research is saturated, meaning that the theory has been sufficiently developed and further data collection is unlikely to yield new insights (Vollstedt & Rezat, 2019).

In the selective encoding phase, based on the previous analysis results and the actual situation, this research identified the relationships between the core category (medication adherence) and the main categories, and encoded them in the form of prototypical relationship structures to reflect the process of the entire behavioral phenomenon of the research participants. These prototypical relationship structures are summarized in Table 5.6. Using the original data of the remaining four patients for theoretical saturation test, no new category and new relationship can be drawn, so it can be concluded that the research is saturated.

Table 5.6 Typical relationship structure formed by selective coding

Typical relational structure	The connotation of relationship	*Representative statement*
Information → Motivation	Patients' knowledge of TB-related information affects their motivation to take medicine.	*Is to get treatment. Just accept it for six months. This disease is from yourself, and you must accept it.*
Information → Medication adherence	Patients' knowledge of TB-related information directly affects medication adherence.	*Because I heard it because the doctor stressed that I couldn't stop, so I always remembered it. Be sure to eat when you are busy.*
Motivation → Behavioral skills	Patients' medication motivation affects medication behavior skills.	*Because, after all, I also want to take the medicine regularly during the critical period, at the initial stage, as much as possible, right? As a client, if you do not improve your own consciousness, that is, we do not control and supervise ourselves, and you do not eat. Who can prove what you said? That is to say, this thing of yours, after all, mainly depends on your own meaning.*
Motivation → medication adherence	Patients' medication motivation directly affects their medication behavior.	*Yes, I definitely want to eat it. It doesn't matter if I eat it for a year, as long as it can be cured, but I am afraid I'll become medicine resistant. When I arrive, I'll feel quite that way.*
Skills → Medication adherence	Patients' behavior skills directly affect their medication behavior.	*Because I am more careful myself. Take these things. My health is my own business, and I am more nervous than anyone else.*
Social support → information	The social support received by patients affects the	*The doctor told me that he meant that if I interrupted for a day, it would be difficult to cure, and it would increase the difficulty.*

	understanding of TB-related information.	*What would happen? medicine resistance. That's what he said.*
Social support → motivation	The social support received by patients affects their motivation to take medicine.	*They will enlighten me and tell me not to think about it. It's easy to take a medicine. Okay, it's nothing.*
Access to health services →adherence with medication	Access to health services directly affects patients' medication behavior.	*I was diagnosed in December, and I am going home for the New Year. Then my hometown is far away. My hometown is in Yunnan, and then I was diagnosed. Then I calculated the time when I came back. Then if I took it out at that time, I would be in a hurry to eat it. When I came back, I would have to stop taking medicine. Then I stopped for more than 10 days before taking it. After taking it, I came back and just picked it up.*
Diseases → Behavioral kills	Patients' complicated diseases affect their medication behavior skills.	*Because I think I am used to it, because I've been weak and sickly since I was a child, and my heart was uncomfortable before, and I took a lot of medicine at that time.*

(1) Information → Motivation: Patients' understanding of tuberculosis-related information influences their motivation to adhere to medication. When patients realize the seriousness of tuberculosis and the necessity of treatment, they are more motivated to comply with medication.

(2) Information → Adherence: Patients' understanding of tuberculosis-related information directly affects medication adherence. When patients understand the importance and rules of medication treatment, they are more likely to adhere to taking medication as prescribed.

(3) Motivation → Behavioral Skills: Patients' motivation for medication adherence influences their behavioral skills. The higher their motivation level, the more capable they are of adhering to medication schedules.

(4) Motivation → Medication Adherence: Patients' motivation for medication directly affects their medication behavior. If patients have positive expectations for the effectiveness of medication treatment, they are more likely to adhere to the prescribed medication.

(5) Behavioral Skills → Medication Adherence: Patients' behavioral skills directly influence their medication behavior. If patients possess the correct medication skills and self-control abilities, they are more likely to adhere to taking medication as prescribed.

(6) Social Support → Information: The social support patients receive influences their understanding of tuberculosis-related information. When patients receive support and explanations from family, friends, or healthcare providers, they have a more accurate understanding of tuberculosis treatment information.

(7) Social Support → Motivation: The social support patients receive influences their motivation for medication adherence. When patients feel care and encouragement from others,

they are more motivated to adhere to medication schedules.

(8) Access to Healthcare Services → Adherence: The opportunity for patients to access healthcare services directly affects their medication behavior. When patients can conveniently access healthcare services related to tuberculosis treatment, they are more likely to adhere to taking medication as prescribed.

(9) Disease → Behavioral Skills: Patients having other complex diseases influences their medication behavioral skills. If patients have concurrent health issues, they may need to deal with more medication treatments, which places higher demands on their medication behavioral skills.

Using selective encoding, the research integrated the previous analysis results and clarified the relationships between the core category and the main categories. These prototypical relationship structures reveal the complex associations among factors influencing medication adherence in tuberculosis patients. The formation of these relationship structures provides important clues for understanding medication adherence issues in tuberculosis patients.

After conducting theoretical saturation testing using the raw data of four additional patients, no new categories or relationships were identified, indicating that the research has reached the point of theoretical saturation, meaning that further encoding did not yield new information. Therefore, it can be concluded that the research has adequately explored the factors and relationships influencing medication adherence in tuberculosis patients.

5.9.5 Patient feedback on the use of information technology

(1) Current status of mobile supervision technology use

Of the 14 patients who participated in this research, 11 used the mobile supervision technology, and 3 had registered on WeChat but did not use it. The functions used by patients included medication reminders, popular science articles and communication functions, with the most frequently used function being medication reminders, while popular science articles and communication functions were seldom or not used. Patient i: “It (medication reminder) pops up every day, so I just click into read it and then exit.”; “No, it’s almost never clicked on (other functions).”

The survey found instances where a non-patient’s WeChat registration was tied to a family member using the technology instead of the patient. Patient n: “I have followed it, but it’s sent to my mum’s phone.”.

The results are shown in Table 5.7.

Table 5.7 Status of use of the information platform

Sub-topic	Main content	Refe-rence points	Frequency (%)	Original quote
Use of the platform	Some patients bind and do not use	1	1.12	Supervisor B2: "I've had a couple of patients, he was told by the doctor at the time to join up and go, add it in and he added it in, nothing was done (used)."
	Family members of elderly patients instead of using	3	3.37	Patient j: "(I) am not using this, it's always been (family)."
	Low number of users	12	13.48	Doctor F1: "The use of micro-supervision (of patients), it's about 40 per cent, less than 40 percent."
Platform Usage Functions	communication	1	1.12	Doctor C1: "There's a dialogue box where there are patients who have questions that are being fed back through micro-supervision."
	Popular Science Articles	7	7.87	Patient b: "Will push some articles, think I've read a few."
	Reminder function	19	21.35	Patient L: "Every day then every day I get the message that it's time to take my medication, and then every day it's pushed to me, and basically every day anyway it's also at the point where it's time to take my medication and it sends me a message."
	Check daily for medication reminders	8	8.99	Patient a: "It had messages just about every day anyway, telling me to take all my medication. "
Frequency of platform use	Fewer or no viewed science articles	17	19.10	Interviewer: "Have you read some of the articles pushed inside this service? "Patient K: "Then I haven't bothered to read them."
	Less or no use of communication functions	21	23.60	Interviewer: "The public number is available to go online and communicate with the doctor or supervisor, have you used it? "Patient c: "No."

(2) Factors affecting patients' use of mobile supervision technology

TB patients' own age, preference for communication methods, knowledge and awareness of the disease and the mobile supervision technique, forgetfulness and shame of the disease affect their use of the technique and their functioning. Elderly patients had difficulties in using the technology. Patient g: "I can't even use it when I'm old." Patients preferred to use other ways of contacting their doctors such as phone calls and text messages rather than the

communication and communication features of the mobile supervision technology. Patient: "Because there is also a phone number for the doctor, so I will also communicate with the doctor if there is anything." Lack of awareness about TB and mobile supervision technology led patients to use the technology less frequently. Patient f: "That one didn't pay attention, I was always focusing on taking the medication stuff and I just didn't pay attention to those other ones because I didn't know there were other functions." Forgetfulness and stigma can also cause patients to use the Mobile Supervision technique less. Patient m: "I sometimes remember to order it and sometimes I do not remember, and I do not order it to see it." Patient c: "Sometimes I am on my own on one side I dare to turn it over, sometimes when I am in public I don't dare to look at it."

External influences included the reminder settings of the mobile supervision technology, smartphone usage, and busy work schedules' The technology's pop-up reminders remind patients to use the Mobile Supervision technology, but inappropriate reminders can cause some patients to stop using the technology. Patient h: "It reminds me to take my medication every time at eight o'clock, it interferes with my rest and sometimes I switch it off." Patients who do not use their mobile phones frequently are less likely to use mobile supervision technology. Patient m: "Because it is not often to take the old mobile phone and use it, sometimes the mobile phone that goes out is left at home. "Busy work schedule causes patients to use the technology less frequently. Patient d: "Because I am quite busy sometimes, I do not have much time to look at it, I will look at it when I have time, but I do not usually look at it when I do not have time."

The results are shown in Table 5.8.

Table 5.8 Factors affecting patients' use of information platforms

Sub-topic	Main content	Refe-rence points	Frequency (%)	Original quote
Patient's own factors	oblivion	1	1.22	Patient m: "I sometimes remember to order it and sometimes I do not remember and I do not order it to see it."
	Sense of shame	3	3.66	Patient c: "Sometimes I am myself on one side I dare to turn it over, and sometimes I dare not look at it when I am in public."
	Drug-taking behavior	5	6.10	Doctor G1: "A lot of patients are just after two or three months, he is feeling all fine all taking medication, all unloaded after two or three months."

	Awareness and knowledge of the disease and the technology	16	19.51	Patient f: “That one didn’t pay attention, I kept focusing on taking the medication stuff and I just didn’t pay attention to those other ones because I didn’t know there were other features.”
	Demographic characteristics	27	32.93	Doctor G1: “A lot of patients, some rural or older patients, he doesn’t always use it.”
	Communication features are not a substitute for common communication methods	1	1.22	Patient d: “From time to time we have to communicate with the doctor, anything with the doctor, because there is a doctor’s phone number as well, and we communicate with the doctor about anything.”
objective factor	smartphone	10	12.20	Doctor B1: “Some people have mobile phones, some do not have mobile phones, do not have smartphones, all sorts of things.”
	Busy work	12	14.63	Patient d: “Because I am quite busy sometimes, I do not have much time to look at it, I look at it when I have time, and I do not usually look at it when I don't have time.”
	System network instability	1	1.22	Patient J: “I am at work and then all of a sudden I get a message, and then sometimes I do not know if it’s a card or what, I can’t click on it, and then it feels like too much of a hassle.”
Factors related to the technology	Reminders are not timed appropriately	2	2.44	Patient b: “Because the ones that are pushed over are taken at 8:00, and I usually get up at 10:00 or so to take my medication, so I usually do not, I don t see anything.”
	High frequency of information	4	4.88	Doctor G1: “It pops up messages to this patient every day to get him to take his medication. Some patients do not need to be too dense, he’ll get sick of it, he’ll think you’re a nuisance in his life, and he’ll delete it if you send it like that every day.”

(3) Effectiveness of the use of mobile supervision technology

The use of mobile supervision technology can raise patients’ awareness of TB and urge them to take medication regularly. The five TB patients who participated in this interview learnt about the basics of TB, the protection policy, and the consequences of not taking medication regularly by reading the popular science articles published by the technology. Interviewer:

"What did you learn about TB from the public articles? Can you tell us about it?". Patient h: "It's about how TB is transmitted, how TB has to be treated, and what to watch out for." Seven patients reported using the technology as an effective reminder to take their medication. Patient i: "At first I was sure I would forget (to take my medication), and it reminded me of it, and then I almost never forgot (to take my medication) at the back.". The results are shown in Table 5.9.

Table 5.9 Effects of the use of the platform

Sub-topic	Main content	Refe-rence points	Frequency (%)	Original quote
Promoting patient awareness of tuberculosis	Understanding the protection policy	2	4.65	Patient h: "Some of them are TB free kind of thing, some of the drugs are just reduced, but there are others that you have to pay for yourself as well."
	Understanding the consequences of irregular medication	5	11.63	Patient c: "It tells people with this condition to stick to their medication, otherwise they can develop resistance or cause adverse consequences that are not good for their health."
	Understanding the basics of tuberculosis	9	20.93	Patient h: "It means how is tuberculosis transmitted? What do you have to do to treat TB? What do I have to watch out for with the disease?"
Impact on patient adherence to treatment	No significant impact	8	18.60	Doctor H1: "And compliance now, most people are also better than before, but say it's not a big difference from the rest of us who do not use this supervisory system, and it's not say obviously a big difference is it?"
	Raising awareness of medication	19	44.19	Patient i: "At first I definitely forgot (to take my medication) and it reminded me of it, and by the end of the day I hardly ever forgot (to take my medication)."

(4) Evaluation of mobile supervision technology

The advantages of the mobile supervision technology include that it is suitable for patients who are unable to take medication on their own, provides authoritative information to help patients understand TB prevention and treatment, and is trusted by patients. The technology can play a good role in supervising patients who are unable to adhere to the full range of regular medication. Patient L: "I just think it's just really good anyway, especially for someone who can't discipline themselves." Patients felt that the information provided by the technology was consistent with that provided by their doctors, and that patients trusted the information provided by the technology more than other online media, and that it was useful to learn about TB

prevention and treatment through the technology. Patient e: “It is similar to the content of their own Baidu, what is posted on the public number is said to be more authoritative.”

Patients rated the shortcomings of the technology as still having instability in the system network, which caused inconvenience during patient use. Patient j: “I was at work, and then all of a sudden I received a message, and then sometimes I do not know if it's a card or something, how to point can’t go, and then it feels like it’s too much trouble.”

5.9.6 Correlation between quantitative and qualitative research findings

Based on the quantitative and qualitative research findings of this research, the correlation between the two approaches can be understood through Table 5.10.

Table 5.10 Correlation between results of quantitative and qualitative research

topic	Quantitative findings	Qualitative findings TB patient	medical worker
The use of information technology management techniques based on the WeChat platform	38.6 per cent of patients used the technique in their therapeutic life.	Eleven of the 14 TB patients who participated in the research used the technique, and three are not currently using it.	Fewer patients used the technique during treatment
The effect of the use of information management technology based on the WeChat platform	Effect of patient use: Medication adherence was significantly higher in patients who used the technique than in those who did not (90.70%, 78.83%, $p<0.05$); There was no significant difference in treatment outcomes between patients using the technique and those not using it.	Effectiveness of patient use: Promoting patient awareness of tuberculosis; (2) Opinions related to the effect of using the technology on patients’ medication adherence varied widely. Some patients and health workers felt that the technology was an effective reminder to take medication and that it could develop and improve patients’ awareness of medication taking. Some health workers had no significant impact or the impact was difficult to assess.	Effectiveness of use by health workers: (1) Solve the problems in once work; (2) Efficient transmission of information and close contact with three parties; (3) Assisting treatment management and improving work efficiency; (4) Increase in workload.

Factors affecting the use of information technology management techniques based on the WeChat platform	Whether patients used the technique was associated with patient age and population classification ($p<0.01$).	Factors affecting patient use: Patients' own factors: demographic factors of age, mobility, rural areas, work situation, education level, knowledge and awareness of the disease and the technology, forgetfulness, stigma and medication taking behavior; Objective factors: communication and exchange function cannot replace the usual communication methods, smartphone ownership and usage and busy work; Factors related to the technology: inappropriate reminder time, frequent messages, unstable system network.	Factors affecting use by health workers: (1) Medical workers' own factors: interest in using; (2) Objective factors: the need to use two work systems at the same time; (3) Factors related to the technology: the inadequacy of the functional settings of the technology.

5.10 Analysis topics from the perspective of medical workers

5.10.1 Topic 1: Use of E-TBPMS by medical staff and their perception of its use

The functions used by TB doctors include inputting patient information, pushing patient control notices, communicating, and checking patients' medication. Doctors use this technology to input patients' information on the first visit of tuberculosis patients and push the patient management notice to the tuberculosis management supervisor. The functions of TB management supervisor include receiver control notice, follow-up record, communication. The application of information management technology based on the WeChat platform can effectively assist the treatment and management of tuberculosis patients, improve the work efficiency of doctors and supervisors, and solve the problems existing in the previous treatment and management of tuberculosis patients, such as the inefficiency of pushing management notices by mail, the need to check the referral of patients for many times, and the difficulty for doctors to understand the treatment and management of tuberculosis patients.

Taking supervisors as an example, through this technology, management notices can be received in time for home visits, and at the same time, follow-up planning tasks can be received every day to facilitate daily follow-up work. This technology regularly sends medication

reminders and follow-up reminders, which also reduces the workload of supervisors. The use of this technology makes the relationship between patients, doctors, and supervisors closer and shortens the distance between patients and medical workers. Doctors and supervisors can push and receive control notices quickly and efficiently, and supervisors and patients can communicate and manage in time. Through this system, doctors can deeply understand the treatment and management of patients and master the medication situation of patients.

The negative impact of the implementation of this technology is mainly the increase of workload, especially the repeated entry of supervisor feedback in two work systems, which increases the workload (see Table 5.11).

Table 5.11 Status quo of medical staff's use

Sub-topic	Main content	Refe-rence points	Frequency (%)	Original quote
Doctor's function usage	Patient information record	2	6.45	Doctor F_1: "Then, that is to say, there is a doctor involved to get the relevant information needed by this patient."
	Patients medication check	4	12.90	Doctor E_1: "That is, I can see whether that patient has implemented it or not, and we can all see which patient has implemented it."
	Communication	6	19.35	Doctor H_1: "Yes, there is a consultation platform for communication."
	Notification of patients management information	6	19.35	Doctor F_1: "Mainly refer patients to community doctors. The main direction of use is to inform the patient and use a notification function."
Supervisors function usage	Notice of follow-up patients	1	3.23	Supervisor C_2: "It will remind how many patients need to visit again today."
	Communication	2	6.45	Supervisor D_2: "When we log on to the computer, he (the patient) can interact with us."
	Follow-up record	3	9.68	Supervisor D_2: "Then, that follow-up is done on it ... but on the E-TBPMS, that is, it was recorded."
	Upload materials like pictures	3	9.68	Supervisor F_2: "E-TBPMS can take a photo anytime and anywhere, and these are more real records as evidence."
Positive effect	Solutions to problems in previous job	15	22.06	Doctor E_1: "In the past, if we were paper-based, there would be many problems with paper-based referral forms. If it was a normal

	Efficiency in message convey, close connection among the three parties	20	29.41	diagnosis, some patients would be lost as a piece of waste paper." Doctor B_1: "I did this, and the supervisor of the town below received the message immediately, because we did that, and the message below him was received in synchronization. So I will catch up with the patient immediately, yes, I will meet and visit the facade."
	Support of treatment management with higher work efficiency	21	30.88	Supervisor G_2: "It can remind me, so I will make a face-to-face interview with my patients and do some work according to its reminder every day."
Negative effect	Higher workload	12	17.65	Supervisor B_2: "You said that if we had to input information for both sides, it would be unnecessary to do it twice, which would increase the workload, didn't you?"

5.10.2 Topic 2: Factors affecting the use of E-TBPMS by medical workers

Medical workers' use interests affect their use of information management technology based on the WeChat platform. A doctor said that the function of locating patients made him happy to use this technology, but the deletion of this function made him lose interest in using it anymore. The objective factor of using two working systems simultaneously affects medical workers' use of this technology. In addition to the information management technology based on the WeChat platform, supervisors must enter follow-up records in another system, and the two systems failed to share data, so some supervisors are reluctant to use this technology to enter follow-up records repeatedly.

The lack of function setting of this technology affects the use of this technology by medical workers. Supervisors' feedback that the communication function of the system is not as convenient as other communication methods (see Table 5.12).

Table 5.12 Factors affecting the use of medical workers

Sub-topic	Main content	Reference points	Frequency (%)	Original quote
Factors of medical staff themselves	Interest to use	1	14.28	Doctor A_1: "I can see my patients' location drifting on the Atlantic Ocean. Some patients are in Singapore, some patients are in Britain, some patients are in Canada, and some patients are in the United States. At this time, I am very interested in turning on the computer to

				see where my patients are."
Objective factors	Two working systems on spontaneous use	3	42.85	Supervisor F_2: "Then at the beginning, we used micro-supervision to enter, which was out of sync with the public health, and the assessment was mainly based on the public system."
Technical factors	Functions defects	3	42.85	Supervisor C_2: "If it communicates, it may not be as convenient as WeChat."

5.10.3 Topic 3: Medical staff's perceptions of the benefits and barriers to using E-TBPMS

Medical workers have recognized the numerous benefits of utilizing information management technology based on the WeChat platform in the context of tuberculosis (TB) treatment. This technology has proven effective in reminding patients to take their medication, ensuring timely follow-up visits, and providing essential psychological support. By serving as a gateway to reliable information on TB prevention and treatment, it enables patients to enhance their understanding of the disease and improve their adherence to the prescribed treatment regimen.

The regular reminders and valuable information conveyed daily through the platform also contribute to making patients feel valued and cared for. Mental support emerged as a significant benefit of this technology, as medical workers observed that patients felt a sense of worthiness and appreciation due to the daily reminders they received. Patients acknowledged that this constant communication demonstrated the medical workers' dedication and concern for their health and well-being. Consequently, this perception of being valued played a vital role in motivating patients to actively participate in their own treatment journey. Moreover, the WeChat platform has proven instrumental in improving patients' comprehension of TB. Medical workers highlighted how this technology facilitates the delivery of extensive information regarding TB prevention and treatment.

Through accessible resources and informative content available on the platform, patients can broaden their knowledge and gain insights into the intricacies of managing their condition. This enhanced understanding enables patients to make informed decisions about their treatment options, reduce stigma associated with TB, and adopt beneficial health behaviors. Another notable advantage lies in the platform's ability to provide reminders for medication intake and schedule medical reviews. Medical workers readily acknowledged the positive impact of these reminders in fostering medication adherence and ensuring regular medical check-ups. Patients greatly benefited from the consistent prompts and notifications, which helped establish a structured routine for medication consumption. Consequently, treatment compliance significantly improved, ultimately leading to more favorable treatment outcomes.

Medical workers believe there are still four major kinds of obstacles in implementing

information management technology based on the WeChat platform. First, there are problems in the application process that can't reflect the actual medication situation. In the implementation process, the system cannot play the role of direct supervision and cannot truly give feedback on the patient's medication situation. Second, the proportion of tuberculosis patients using this system is still low, and it is not very feasible for the elderly population. Third, the communication and interaction mode among patients, doctors, and supervisors using the system could be insufficient, and the information flows in one direction, mainly reflected in the fact that the communication function is replaced by more familiar methods such as WeChat, telephone, and SMS. The lack of communication between doctors and supervisors about patients' follow-up visits and medication records leads to the lack of comprehensive understanding of patients' treatment process. Fourth, the system has technical defects, including unstable network, complicated operation, and unmet needs. The supervisor thinks that entering the follow-up record is inconvenient, and it is more difficult to quit and not save it during the entry process. Because the patient's treatment plan may change, the fixed template of the system does not meet the actual functional needs, and the supervisor needs to delete the original records and re-enter them when the patient's treatment plan changes, which may easily lead to errors in the list of patients who need daily follow-up received by the supervisor; The system regularly sends reminders for follow-up and review every month, but the actual time for follow-up and review of tuberculosis patients is not fixed, and receiving reminders for follow-up and assessment that are not in line with the actual situation will confuse patients. The results are shown in Table 5.13.

Table 5.13 Medical workers' perception of benefits

Sub-topic	Main content	Reference points	Frequency (%)	Original quote
Mental support	Patients feel valued	1	16.67	Doctor C_1: "The patient feels that he is valued by us, because we remind him every day, and he feels that we attach great importance to him."
Helpfulness	Patients' understanding of TB improved	2	33.33	Doctor F_1: "This is the advantage of our micro-supervision, which can provide patients with a lot of information on tuberculosis prevention and treatment."
	Remind of medication and medical review	3	50.00	Doctor F_1: "Now we can improve our performance to a certain extent through information supervision. The compliance of taking medicine is regularity."
Problems in actual use	Unable to show medication in real situation	1	3.03	Doctor A_1: "Because of the patient of mine, his son is doing this for him. As a result, he told me, 'Doctor, you didn't prescribe this medicine enough. How could I finish it in

				seven days with the dose for half a month?' But the micro-supervision showed that he was having it every day, but in fact he didn't." "Yes, I didn't really play a role in supervising medication under direct vision."
Applicable groups and numbers of people	Not applicable to elderly population	1	3.03	Doctor A_1: "Now maybe tuberculosis in the elderly is our key plan now. Therefore, it is ok to face customers or groups before micro-supervision, but now it is not suitable for use with aging. "
	Few patients choose to use this system	4	12.12	Doctor F_1: "About 40% of patients use micro-supervision and less than 40%."
Insufficiency of communication	Remote communication function of this technology is replaced	3	9.09	Doctor A_1: "Then some other aspects of communication, such as the direct communication between the attending doctor and the patient, and the communication between the patient and the supervisor, have been replaced by telephone and WeChat."
	Insufficient information interaction	4	12.12	Supervisor F_2: "We recorded it in the system as a supervisor, but the attending doctor didn't know that he (the patient) could get the medicine when he went back to the CDC, and we didn't know the information about the medicine he got there."
Technical defects	The system network is unstable	3	9.09	Doctor B1: "Sometimes there will be instability. When referring to the township below, the network was said to be unstable, which seems to be less in our county." Doctor B_1: "Sometimes there will be instability. When referring to the township below, the network was said to be unstable, which seems to be less in our county."
	Complicated operation	6	18.18	Supervisor D_2: "That is to say, as soon as you quit, you will lose all the records on it, and sometimes you will call."
	Do not meet the actual needs	11	33.33	Supervisor F_2: "Maybe the patient went ahead of time, or he didn't go at this time. He will be puzzled, 'I went for a blood test yesterday, but why did it remind me to go today?' He doesn't know whether to follow it."

5.10.4 Topic 4: Medical practitioners' needs and recommendations for the use of E-TBPMS

Medical staff put forward four opinions and suggestions on information management technology based on the WeChat platform, including strengthening information communication and connection, enriching popular science content, connecting, and integrating working systems, and adding and optimizing functions. By further enhancing the information exchange

of the system, patients can effectively use the communication function to communicate directly with doctors, and the doctors and supervisors can share information and cooperate.

It is suggested that various popular science methods should be provided for patients on an existing basis. Adding more popular science content is beneficial to the management of tuberculosis patients, such as displaying excellent missionary works and popular science tuberculosis treatment and management. This technology can also solve patients' troubles, answer patients' questions and provide more popular science ways and methods for patients' widespread science-related reduction and exemption policies. The supervisor suggested connecting and integrating various working systems to realize information synchronization.

The follow-up reminder needs to be adjusted individually according to the status of patients, which is consistent with the actual behavior of patients and plays a role in the treatment process; The doctor suggested that to supervise medication under direct vision, the system can add video supervision function; The supervisor thinks that the follow-up record template of the design should not be fixed, but can be adjusted to a more flexible template for the supervisor to record the follow-up according to the actual situation. At the same time, it is necessary to calibrate the follow-up reminder function to avoid mistakes in the list of patients who need to be followed up every day received by the supervisor. The results are shown in Table 5.14.

Table 5.14 Needs and suggestions from medical workers

Sub-topic	Main content	Reference points	Frequency (%)	Original quote
Enhance information sharing and connection	Direct communication between doctors and patients	1	6.67	Doctor H_1: "If he (the patient) has any questions, such as what's wrong with taking medicine, or when I want to come for a follow-up visit, or when you go to work, he must want to establish such a relationship and contact the doctor directly."
	Information sharing among three parties and cooperation	2	13.33	Supervisor F_2: "If we can feed back (follow-up) through this system, the next time he (patient) takes medicine, the doctor can see it, and he (doctor) can do ideological work in a targeted way. If he (patient) doesn't take medicine there, we can also track a situation of him (patient) in a targeted way."
Enrich education content	More healthcare knowledge	1	6.67	Supervisor F_2: "I think there are some good publicity cases on the March 24th TB Prevention Day every year. I think it would be a good education if these cases can be seen by patients."
Integrate working system	Integration of working	5	33.33	Supervisor D_2: "The best thing is that he should synchronize with the public

	system			system. For example, I recorded it on the computer, and this micro-supervision also has it. ”
Enhance and optimize function	Video supervision	1	6.67	Doctor A_1: “Now it’s very simple to turn on mobile video peer-to-peer, that is to say, direct supervision in DOTS, which was once out of reach, can now be realized very easily.”
	Correction function	5	33.33	Supervisor F_2: “His (patient’s) six-month course of treatment may be fixed, and it will remind you to take a blood test after 15 days, but the patient may go ahead of time, or not at this time, but he will be confused and say, I went for a blood test yesterday, but why did it remind me to go today? He doesn’t know whether to follow it. If we can adjust it more personally, it may be more in line with one of our work realities.”

5.11 Summary of this chapter

According to the results of study 2, E-TBPMS based on the WeChat platform was found to play an important role in the treatment management of TB patients. Using this technology, medical staff can remind patients to take their medication on time, ensure timely follow-up visits, and provide necessary psychological support.

E-TBPMS serves as a gateway to reliable information, enabling patients to improve their understanding of TB prevention and treatment and their adherence to prescribed treatment regimens. Regular reminders and valuable information sent daily also help patients feel valued and cared for. Psychological support, a key benefit of this technology, was observed by medical staff as patients felt valued by the daily. Patients recognized that this ongoing communication demonstrated the medical staff’s concern and commitment to their health and well-being. As a result, this feeling of being valued plays an essential role in motivating patients to take an active part in their own treatment process. In addition, the role of the E-TBPMS in reminding patients to take their medication and to attend medical reviews was very positive.

Healthcare professionals highlighted the positive impact of these reminders, which helped establish an orderly medication routine. As a result, medication adherence improved. These findings provide strong support for further improving adherence among TB patients.

However, medical staff also recognized that there were still some significant barriers to implementing E-TBPMS. Firstly, the problem is being unable to reflect a patient’s medication use during the application process. During implementation, the system cannot fulfil the role of

direct supervision and does not provide complete and genuine feedback on patients' medication use. Second, the proportion of TB patients using the system remains low, and implementation is not easy for the elderly population. Third, the system's modes of communication and interaction between patients, doctors and supervisors may be inadequate, with a one-way flow of information, mainly in the form of the system's communication function being replaced by more familiar methods (e.g. WeChat, phone calls and SMS). The lack of communication between doctors and supervisors regarding patient follow-up and medication records resulted in an incomplete understanding of the patient's treatment process. Fourth, there were technical shortcomings in the system, including unstable network, complexity of operation and lack of demand.

Supervisors found it less convenient to enter follow-up records; the system's fixed templates did not meet actual needs, as patients' treatment plans could change, and the need to delete the original record and re-enter it when a patient's treatment plan changed could easily lead to errors in the list of patients who needed daily follow-up; The system sent reminders for follow-up visits and assessments on a regular basis, but the actual follow-up visits and assessments for TB patients were not fixed in time, and receiving reminders for follow-up visits and assessments that did not correspond to the actual situation could be confusing for patients.

The medical staff have made several recommendations to address these issues. By further improving the system's information exchange, patients can effectively use the communication function to communicate directly with doctors, and doctors and supervisors can share information and work together. It is recommended that more scientific content be provided in addition to what is already available and that enriching the scientific content is beneficial to the management of TB patients, for example, by showing good missionary work and popular TB treatment and management. This technology can also address patients' concerns, answer their questions, and provide more ways and means of popularizing science for patients' broader TB control policies.

Supervisors suggested linking and integrating other related work systems to synchronize information. Follow-up reminders need to be individually adapted to the patient's situation to be consistent with the patient's actual behavior and to be helpful in the course of treatment; the supervisors felt that the template designed for recording follow-up visits should not be fixed but should be adapted to a more flexible template to facilitate the recording of follow-up visits according to the actual situation.

Chapter 6: Research Discussion

6.1 Medication adherence in tuberculosis patients using E-TBPMS

In the present research we found that most users of the Integrated Mobile Phone Management System (IMMS) for TB control felt benefited from using the system. Previous studies have shown that the proportion of patients receiving medication from E-TBPMS is higher than traditional supervision (Li et al, 2019). For those who can use the system proficiently, such as young, well-educated patients, the system can be fully utilized for treatment management to improve treatment adherence and efficacy.

E-TBPMS (Electronic Tuberculosis Patient Management System), plays an important role in improving TB patients' medication awareness, and health education, assisting medical staff in managing TB patients, and improving work efficiency:

(1) Enhance patients' medication awareness: With the medication reminder function, E-TBPMS can automatically send medication reminder notifications to patients to ensure that they take their medication on time. This reminder function can effectively remind patients to take medication on time and enhance their awareness of medication compliance. Patients can learn about the correct usage, dosage, and side effects of medication through the help of the system, further increasing their attention and understanding of medication. Provide personalized support: E-TBPMS can provide personalized support according to the patient's situation. The system can record the patient's medication history and treatment progress, and provide appropriate advice and feedback based on the patient's situation. This personalized support can help patients feel the care and attention of the healthcare team and motivate them to actively participate in their treatment.

(2) Health education: E-TBPMS can provide rich health education content, including knowledge about TB prevention, treatment, and management. Patients can learn the relevant knowledge systematically and understand the seriousness of TB and the importance of treatment. This kind of health education can improve patients' understanding of their own disease, enhance their willingness to actively participate in treatment, and further improve their awareness of medication. E-TBPMS provides real-time online communication and consultation functions, which allow patients to communicate and consult with medical staff through the

system. Patients can consult with medical staff at any time about disease treatment, side effects of medication, and other issues, and medical staff can provide timely guidance and support to help patients solve problems and promote their health.

(3) Assisting medical staff to manage patients: E-TBPMS can help medical staff to better manage TB patients. The system can record patients' medication records, health data, and treatment progress, and provide real-time monitoring and reporting. Medical staff can use the system to assess and track the patient's condition, identify problems, and take appropriate measures in time. This improves the effectiveness of the medical staff's patient management and enhances teamwork. E-TBPMS can provide timely feedback by monitoring patients' medication and health data in real-time. The system can record the time and dosage of a patient's medication and provide real-time reports to doctors or nurses. The healthcare team can assess the patient's medication use based on this data and provide guidance and support when needed. This real-time monitoring and feedback can increase the accountability of medical staff and the initiative of patients to take their medication.

(4) Improve work efficiency: E-TBPMS can improve the work efficiency of medical staff. The system can automatically record and organize patients' health data and medication information, reducing the manual recording and organizing work of medical staff Through the system's reporting and analysis functions, medical staff can analyze data and statistics, helping them to better understand the patient's condition and treatment effect. The system can generate a variety of reports and charts to show the patient's medication, treatment progress, health indicators, and other information. These analyzes and statistical results can help medical staff better assess the patient's condition, formulate appropriate treatment plans, and improve the efficiency and accuracy of their work. Medical staff can share and exchange patient-related data and medical record information, and this collaboration and communication mechanism can improve the efficiency of the team and reduce the time and error of information transmission.

6.2 Analysis of factors influencing patients' medication adherence based on IMB modeling

IMB theory is an acronym for Information-Motivation-Behavioral Skills (IMB) theory, which is a behavioral change theory model that has been introduced into quantitative research to construct models mainly based on its wide application and effectiveness in the fields of disease management and nursing interventions. The model organically combines the three elements of information transfer, motivational stimulation and behavioral skills intervention,

which helps to reveal patients' behavioral patterns and influencing factors in treatment adherence, so as to construct the corresponding quantitative research model. In the literature review, we have already compared the knowledge-belief behavior model, health-belief model, rational behavior theory and planned behavior theory, etc. These theoretical models either oversimplify the complexity of behavioral change, or neglect social and environmental factors, as well as the analysis of the influencing factors is not comprehensive enough, to sum up the above, we finally chose to introduce the "IMB We finally chose to introduce the "IMB" model.

6.2.1 Analysis of scores and factors influencing information, motivation, and behavioral skills

In this investigation, in study 1, multivariate analysis of the information score, medication motivation score, and behavioral skills score of 269 TB patients using E-TBPMS revealed that access information, health insurance, facilitated healthcare services and social support had a positive effect on patients' knowledge score. In addition, education level, other diseases, facilitated healthcare services score, social support score, and TB-related knowledge score affected patients' medication motivation score. For behavioral skills scores, age, other diseases, and medication motivation scores also showed significant associations. These results provide an important reference for improving management strategies and optimizing technical tools for TB patients. They are important for helping patients improve their medication adherence and thus, ultimately achieve the best treatment outcomes.

These results show that in terms of information score, most patients have some knowledge about TB, know that TB can be prevented and treated, and know that standardized treatment is necessary. Still, they need to learn more about the government protection policy. Patients need to know more about TB-related assistance and protection policies due to inadequate publicity, lack of awareness and protection, information mismatch caused by the unequal status between doctors and patients, and the complexity of reimbursement by health insurance (Liu et al., 2010).

Information technology can further eliminate these problems, which can disseminate and supplement information, provide counseling services, and guide patients through the relevant policy protection system and reimbursement procedures. Patients who were able to access TB-related knowledge through the Internet, medical personnel, relatives, and friends had relatively higher scores on TB-related knowledge. This is aligned with previous findings of other researchers (Liu et al., 2015).

The overall score of patients' motivation to use medication was high. Patients' perception of the benefits of full routine medication was high and most of the patients were able to realize

that full routine medication patients' perception of the severity of the disease was that TB was harmful. Doctors, followed by family members, had the greatest influence on patients' behavioral cues to comply with medication; the news media and friends were less influential. Increased education and other illnesses were risk factors for patient motivation to take medication. Convenient access to health services, higher social support scores, and knowledge related to TB were protective factors for motivation to take medication.

In this study, patients' behavioral competence scores were high and most of them felt that they were able to master and adhere to the regular medication throughout the course of treatment. Age and other diseases were risk factors for medication behavioral competence, while motivation to take medication score was a protective factor for medication behavioral competence. Older adults with other medical conditions are burdened and difficult to treat. It is difficult for them to keep track of their entire medication routine and they need to be reminded by others to take their medication on a daily basis. Information technology can provide this service and ensure their regular treatment (Li, 2022). Health education on knowledge related to tuberculosis should be strengthened to improve the cognitive level of patients, enhance the belief and motivation of patients for formal treatment, and ultimately achieve the purpose of improving patients' adherence to treatment.

6.2.2 Influence of information, motivation, and behavioral skills on medication adherence

6.2.2.1 The direct and indirect influence of information score on medication adherence

The multifactorial results we obtained suggest that information factors can directly influence medication adherence and that the higher the patients' knowledge of TB and its treatment, the better their medication adherence.

Previous studies have also shown that patients' understanding of the importance of treatment can facilitate their adherence (Jaiswal et al., 2003; Johansson et al., 1999). Interview findings from the studies also support this view. For example, some patients said, "Because I hear it and because my doctor emphasizes that I cannot stop taking my medication, I always remember. I must eat when I am busy", "I know the benefits, it controls the disease", "TB can be cured, but it takes a little longer to take the medication". This suggests that the treatment information patients receive directly affects their medication behavior.

In addition, we also found that information factors can also directly affect patients' motivation to take medication, i.e., the knowledge of disease acquired by patients can affect their motivation to take medication, which in turn affects their medication adherence behavior.

It has been pointed out that patients with adequate knowledge of health will also be more motivated to take treatment, and when patients have inaccurate information or lack of relevant information, their motivation to comply with medication will be poor, which is consistent with the results of previous studies (Amico et al., 2009; Starace et al., 2006). This also suggests that improving patients' understanding of TB and its treatment remains critical.

Based on the scores of each item of the information factor, patients had a high awareness of the curability of the disease and the need for regular medication and review, but low awareness of TB-related subsidy policies and the dangers of irregular medication. This may be related to the insufficient publicity of TB-related subsidy policies. Some patients do not know that the state has always had a fee waiver policy for TB treatment, and all fees are self-funded, resulting in certain financial burdens, some patients may not be able to withstand the financial pressure, which affects their confidence in adhering to treatment; irregular medication use generally occurs in patients who have obvious treatment effects at an early stage, and who are too cautious about the treatment because of Because of the rapid elimination of symptoms, and thus too optimistic estimate of the effect of treatment, not willing to continue to adhere to a long period of treatment, many of them appear to stop or omit medication. Both situations can be proactively disseminated to all patients by strengthening the popularization function of the E-TBPMS, informing patients about the government's subsidy policy, as well as emphasizing the importance and necessity of long-term TB treatment.

6.2.2.2 The direct and indirect influence of medication motivation score on medication adherence

Our findings showed that patients' motivation to use medication has a direct impact on medication adherence. Patients' motivation for medication use was divided into four components: benefit perceptions, barrier perceptions, disease severity perceptions, and behavioral cues. The higher the score, the better the motivation to take medication. The higher the scores indicating patients' perceptions of the benefits of taking medication on time, the severity of TB disease, the ease of reviewing medication, and behavioral cues, the better their medication adherence.

Previous studies have also shown that patients with more severe symptoms are more likely to adhere to treatment due to fear of deterioration (Menegoni, 1996). Similarly, the results of the multifactorial analysis of this project indicated that patients' motivation to take medication also directly affects behavioral skill factors, i.e., patients' perceptions of benefits, barriers, disease severity, and behavioral cues in this study directly affect patients' self-efficacy, and

consequently, their self-awareness of medication.

The results of the interviews also showed that increasing patients' motivation to use medication could further improve their ability to master medication behaviors and ensure their adherence to regular medication use. Education level is an important intermediate variable; patients with higher education levels tend to pay more attention to the correct use of medication and treatment adherence, and their medication motivation scores are likely to be higher, and high medication motivation scores imply that patients are more actively involved in medication therapy, which can indirectly promote their medication adherence.

Having other medical conditions is an intermediate variable that affects medication adherence, and patients with other medical conditions may face more medical challenges and difficulties with treatment, which can lower their motivation to use medication scores. However, by providing additional support and assistance, such as the use of information technology, it can be easier to communicate with one's supervising physician to help patients better cope with comorbidities and indirectly promote medication adherence. Convenient medical services can facilitate patients' access to medication and treatment information, and good social support can provide emotional support and encouragement' enhancing patients' belief in and motivation for medication and further improving medication motivation scores. The improvement of all these factors can indirectly promote patients' medication adherence. Some previous studies on how the IMB model affects patient health outcomes have also shown that motivation is an important factor influencing behavioral skills, and that the impact of motivational factors on ultimate health outcomes is moderated by behavioral skills (Mayberry & Osborn, 2014)..

6.2.2.3 The direct influence of behavioral skill score on medication adherence

Among the three factors of information, motivation, and behavioral skills in the IMB theoretical model, behavioral skills directly affect medication adherence. In this study, patients' behavioral skills were represented by self-efficacy, and the higher the score, the higher the patients' behavioral skills evaluation score. This means that patients with higher self-efficacy have better medication adherence.

Previous studies have also shown that patients with higher self-efficacy perceive themselves as more capable of self-management, so they strictly adhere to their physician's recommendations. In contrast, patients with low self-efficacy perceive themselves as less capable of self-management, and they may stop self-management at an early stage, thus decreasing medication adherence (Stajkovic & Luthans, 1998). The results of the qualitative interviews in this study further support this. Several patients stated in their interviews that the

behavior of taking medication regularly after illness depends largely on self-adherence and self-management. Only the higher the degree of self-control in taking regular medication, the longer the behavior of taking regular medication can be adhered to. This is consistent with the majority of current research findings, and many studies that have used the IMB model to explore relationships with adherence or other health outcomes have confirmed a strong correlation between behavioral skills and adherence (Alegria-Flores et al., 2017; Nelson et al., 2018).

6.2.3 Influence of health service accessibility, social support on medication adherence

The results we obtained from the multivariate analysis showed that among other factors related to patients' medication adherence, the most critical factor was convenience of healthcare services. The higher the score of ease of access to healthcare services, the better the patients' medication adherence. In addition, interviews provided further evidence of this. Many patients with good adherence said their homes were close to their healthcare providers. Follow-up appointments and taking medication were convenient, making it easier to comply with treatment.

Consistent with the results of this study, previous studies have found that the further the clinic is from the patient's home, the less adherent the patient is (Harper et al., 2003; Johansson et al., 1996). The social support that patients receive during post-disease treatment is also an important factor that indirectly affects their medication adherence. Interviews revealed that the social support received by patients facilitated their access to information about TB and treatment as well as their motivation to take medication one patient said, "My doctor told me that if I interrupt for a day, it will be difficult to cure and increase the difficulty. What happens? Drug resistance, that's what he said". This also suggests that patients' awareness of the need for regular medication and the potential harm from not taking it regularly is related to the social support they receive from their doctors.

Improving the convenience of patients' access to health services can be achieved by combining the TB patient management system with modern logistic means to provide regular and scheduled smart drug delivery services for patients approaching the drug-taking period, which facilitates the taking of medication by patients and solves the drawbacks caused by the objective conditions, thus improving the patients' adherence to taking medication and improving their health outcomes.

6.2.4 Correlation between quantitative and qualitative research findings

The research and improvement of digital TB adherence technology can be conducted through qualitative research to gain an in-depth understanding of patients' psychology, behavior and attitudes, and quantitative research to quantify the influencing factors and effects of adherence. Thus, conducting qualitative and quantitative research separately is conducive to a comprehensive and in-depth understanding of the effects of digital platforms for TB adherence management, as well as targeting for improvement and optimization. The conclusions of the quantitative study can be used to explain patient behavior and factors influencing TB treatment adherence by analyzing and quantifying the three elements of the IMB model: information, motivation and behavioral skills. The empirical study can quantify the effect of information delivery, the degree of motivation stimulation and the actual effect of behavioral skills interventions, thus drawing quantitative conclusions and data support, and providing a theoretical basis and empirical evidence for subsequent qualitative research.

The results of the quantitative study led to subsequent qualitative research because quantitative research focuses mainly on quantitative data and drawing conclusions. In contrast, qualitative research allows a more complete understanding of the reasons behind patients' psychology, attitudes and behaviors through in-depth interviews, observations and situational analysis. Qualitative research can further explore the intrinsic links and interactions between information, motivation and behavioral skills in the IMB model, thus providing a deeper understanding and recommendations for further improving and optimizing TB treatment adherence.

6.2.4.1 The direct and indirect influence of information score on medication adherence

Medication adherence was significantly higher in patients who participated in the quantitative study with the use of E-TBPMS than in those who did not use the technology (90.70% > 78.83%, $p<0.05$), which is consistent with the feedback from most patients who participated in the qualitative interviews. However, there was no significant variability in the treatment outcomes of patients whether they used or did not use E-TBPMS. There may be two reasons for this: (1) the sample size is relatively small and may be under-representative; (2) at present, for patients with common TB disease, anti-tuberculosis drugs are more effective, and if they can complete the course of treatment, the general cure effect is around 90%.

6.2.4.2 Factors influencing the use of E-TBPMS technology applications

The results of the qualitative interviews suggested that patients' individual, objective, and technology-related factors were significantly correlated with using E-TBPMS technology. Individual factors include patients' age, mobility, region of residence, work situation, and education level; objective factors: communication and communication functions that cannot replace regular communication, smartphone ownership and use, and busy work; technology-related factors: inappropriate reminder time that affects daily work life, too frequent reminder messages, and unstable system network. The results of the qualitative interviews are highly compatible and consistent with the analysis of the IMB model.

6.2.5 Influence mechanisms of the IMB model of medication adherence in TB patients

Based on the results of this study, the architecture of the IMB (Information-Motivation-Behavior) model of medication adherence among TB patients suggests that it includes the following influencing factors or mechanisms: information mechanism, motivation mechanism and behavior mechanism.

6.2.5.1 Information mechanism

Based on our research, we deduced that by providing patients with relevant information about TB disease, medication, and the importance of medication adherence, patients'' attention and understanding of the medication-taking process will be enhanced. The information includes knowledge about the causes, transmission routes, and symptoms of the disease, as well as detailed information about the name of the medication, its use, and its side effects. Through information delivery and education, patients could understand the severity of the disease, the importance of medication for recovery, and the correct methods and precautions for taking medication. The adopted model suggests that effective information delivery can improve patients' knowledge and understanding of medication adherence and prompt them to form correct health beliefs.

6.2.5.2 Motivation mechanism

It was also verified that stimulating patients' intrinsic motivation can improve their willingness and commitment to medication adherence. Intrinsic motivation may include the desire for recovery, concern for health status, and recognition of social roles. Information technology can stimulate patients' intrinsic motivation by providing personalized medication reminders, follow-up visits, health education and doctor-patient communication. In addition, external

motivational factors such as family support, physician and supervisor support, and community support positively influence patients' medication adherence.

6.2.5.3 Behavior mechanism

This model suggests that behavioral mechanism refers to taking actions to promote the actual medication-taking behavior of patients. With the support of information technology, various tools are used to promote patients' behavioral transformation. For example, sending regular medication reminders through mobile apps, providing personalized medication plans and instructions, and monitoring and recording patients' medication taking. Through the establishment of online doctor-patient communication, to help patients deal with the confusion and challenges in the process of taking medication, and to promote their actual adherence to the medication treatment in the behavior.

With the support of information technology, these mechanisms work more individually and precisely to improve TB patients' medication adherence, thus enhancing disease management and rehabilitation.

6.3 Impact of E-TBPMS on physicians and supervisors

6.3.1 Impact of E-TBPMS on physicians and supervisors

The use of the E-TBPMS system by medical staff is closely related to whether they are interested in information technology, whether it is easy to use, and whether the information technology is mature. Most doctors were satisfied with the WeChat monitoring system and recognized the WeChat diagnosis and treatment function in it. They believe the system can keep abreast of patients' information and improve the success rate of patient follow-up and review. The online communication function improved communication between doctors, supervisors, and patients to some extent and became an effective tool to assist in the management of TB patients. They felt that the system provided them with a more convenient means of patient management and could improve the efficiency and quality of TB management.

However, individual doctors questioned the effectiveness of the E-TBPMS system, saying that the system failed to supervise patients truly and that there were cases where some elderly patients did not take their medication, but their family members clicked to confirm the medication. Other doctors reflected that the reminders pushed by the system were inaccurate, and patients still received reminders when they were reviewed on time. In addition, the operation of the system requires extra time, which increases the daily workload of doctors,

leading some doctors to resist using the E-TBPMS system. In addition, a few doctors expressed a low level of cooperation with TB micro supervision in general hospitals, believing that its operation process was cumbersome.

6.3.2 Analysis of factors affecting supervisors

Supervisors were generally willing to use E-TBPMS and felt the system could assist them in their daily TB management tasks. They felt that patients could take their medication based on the daily medication reminders in the system, easing the supervisors' task of reminding patients to take their medication daily. Supervisors said that although E-TBPMS has some functional shortcomings, such as not being able to interoperate with provincial health systems, requiring multiple data entry not easy enough for data entry operations, not having a staging function, and having occasional network failures and lagging problems, it still greatly reduces their workload.

Supervisors said that patients currently preferred to communicate with doctors and supervisors by phone, WeChat and face-to-face, and needed more willingness to use the online communication function of the WeChat Supervisory System. This phenomenon may be related to patients' habit and trust in face-to-face communication, or it may be because patients are not familiar enough with technology or have some resistance. In response to this situation, the supervisors believe that their willingness to use the WeChat Supervision System can be improved by strengthening patient education and guidance.

6.3.3 Factors affecting the use of E-TBPMS by health workers and supervisors

Factors affecting the use of E-TBPMS (Electronic Tuberculosis Patient Management System) by health workers and supervisors may include the following:

(1) Technology acceptance: Health workers' and supervisors' technical acceptance of the electronic system is an important factor influencing their use of the E-TBPMS. If they are unfamiliar with the electronic system or need more confidence in the technology, they may resist using it.

(2) Training and support: Providing adequate training and technical support is important for the smooth use of E-TBPMS by health workers and supervisors. Lack of relevant training and support may affect their use of and trust in the system.

(3) Work environment and workflow: E-TBPMS must be compatible with the daily work environment and workflow of medical workers and supervisors. If introducing the system leads

to a disjointed workflow or adds extra workload, it may reduce the willingness to use it.

(4) Data privacy and security: Health workers and supervisors may have concerns about the privacy of personal data and the security of the system. If they are concerned about the disclosure of patients' personal information or the vulnerability of the system to security threats, they may be resistant to using E-TBPMS.

6.4 Benefits and drawbacks of applying E-TBPMS

6.4.1 The benefits of applying E-TBPMS

Doctors and management supervisors believe that the benefits of applying information management technology based on the WeChat platform include encouraging patients to take medication regularly, providing scientific and authoritative health education information, and providing psychological support. The application of the technology can urge patients to take medication and follow-up consultations, help patients understand TB prevention and control information, and raise their awareness of TB.

Technology can play a relevant role in reminding and urging patients who cannot fully grasp the whole process of routine medication. Medication reminders can encourage patients to take medication on time and improve their treatment compliance. The technology provides patients with channels to comprehensively understand TB-related information, including health education posters, quick search and query, and remote communication with health workers. Patients can access TB-related information, such as TB prevention knowledge and healthcare safety information, according to their needs.

Patients consider that through this technology, they can receive health education, increase their awareness of TB, improve their lifestyle and adherence behavior, and lay a good foundation for successful treatment. This technology gives patients easy and quick access to official, authoritative, and scientific information. Patients trust the information provided by this technology more than other online media. Patients feel valued when they receive treatment-related information daily. Patients who received mHealth interventions said that receiving information made them feel supported by their healthcare provider. A qualitative study by Shi et al(2021). found similar results. Patients who received adherence monitoring by phone had enhanced communication with health workers, which made them feel concerned about their health.

6.4.2 Insufficient benefits of applying E-TBPMS

Tuberculosis patients, doctors, and management and supervisory personnel identified the inability to reflect the real medication situation, low patient utilization, insufficient communication and interaction, and technological deficiencies as barriers to the application of information management technology based on the WeChat platform. After the medication reminder message pops up, the patient's click is regarded as completing the medication. In practical application, it is impossible to determine whether the patient takes medication regularly or not, and there is no real feedback on the patient's medication taking. The utilization rate of the technology is low, and the number of patients in the elderly population, migrant population, rural areas, and low-education population is low, which results in the technology not being able to play a full role in patient treatment management.

The frequency of communication between patients and medical workers utilizing the technology is low, with WeChat, phone calls, and SMS replacing this function. Doctors and supervisors do not communicate enough about patients' follow-up visits and medication records, and both parties do not have a comprehensive understanding of the patient's treatment process, which is not conducive to carrying out treatment management of TB patients. The network is unstable, the functions are inconvenient or do not meet the actual needs, and the early warning information is wrong or does not correspond to the actual situation, which increases the difficulty of operation and reduces the experience.

6.5 Measures to further improve E-TBPMS

6.5.1 Optimization of system functions

It is important to also discuss how to improve E-TBPMS through the optimization of system functions.

(1) Establishment of a user feedback mechanism: A user feedback mechanism has been established to encourage medical practitioners and supervisors to provide their comments and suggestions on system functions and processes. By collecting and analyzing user feedback, problems and room for improvement can be identified promptly.

(2) Optimize user interface: Optimize the user interface of E-TBPMS to make it more intuitive, and easy to navigate and use. Through user-friendly interface design, learning costs and operational difficulties can be reduced, and the acceptance and use efficiency of the system by medical workers and supervisors can be improved.

(3) Customized personalized functionality: Provide customizable functional options according to the needs of different users. For example, medical workers may need specific data entry and query functions, while supervisors may be more concerned about statistics and reporting functions. By allowing users to customize functions, personalized workflows are provided, enhancing the adaptability and flexibility of the system.

(4) Integration of intelligent analysis and decision support: The system utilizes artificial intelligence and data analysis technologies to provide medical practitioners and supervisors with more accurate and timely data analysis and decision support. Through intelligent algorithms, the system can provide personalized advice and alerts based on patient data and history, helping medical workers and supervisors better manage and guide patients.

6.5.2 Wider promotion and application

(1) Publicity and promotional activities: Publicity and promotional activities are organized to convey the advantages and value of E-TBPMS to medical practitioners, supervisors, and related institutions through various channels. This can be done through thematic seminars and training courses that demonstrate the system's functions and benefits to target users and share successful cases of practical application.

(2) Strengthen communication links with partners: Establish cooperative relationships with relevant medical institutions and health departments to promote the application and promotion of E-TBPMS jointly. By cooperating with these organizations, we can obtain more resource support, professional knowledge, and industry recognition and improve the credibility and promotion effect of the system.

(3) Case demonstration and word-of-mouth dissemination: Select some medical organizations or supervisors as demonstration points for case demonstration and sharing. Let other medical workers and supervisors witness the actual effect of the system and listen to recommendations and feedback from actual users. Through word-of-mouth spreading among users, more users will be attracted to use and promote the system.

(4) Provide training and support: Provide training and technical support for new users to help them quickly get up to speed and become proficient in using the E-TBPMS and answer any questions they may have. Provide regular updates and maintenance to ensure the stability and perfect function of the system and increase users’ trust and satisfaction.

The above measures can help to promote the application of E-TBPMS more widely and increase the visibility, acceptance, and effective utilization of the system, thus improving the effectiveness and quality of TB management.

6.5.3 Ensuring smooth operation

In the process of improving and promoting the system further, it needs to be ensured that it works well. As an essential information system, the privacy and security of users' health information data are prioritized, and various measures are taken to protect it. This includes establishing relevant data privacy policies and norms and ensuring that the system provides access to authorized personnel only.

In addition, various data analysis reports, resource statistics reports, and operation and maintenance analysis reports can be established to ensure the good operation of the system. Through multi-dimensional analysis of the system's operation and performance, problems and optimization requirements can be identified in time, and a scientific basis for system upgrading, transformation, and expansion can be provided. These reports can also help relevant personnel better grasp the system's operating conditions and make timely interventions and adjustments to ensure the stability and effectiveness of the system.

6.6 Research summary

To close the discussion of the research developed for the present thesis, and before presenting the conclusions' chapter, we recall the research design or plan (see Figure 1.1) and summarize what we may briefly conclude from the findings obtained in the two studies that were developed and presented.

Figure 6.1 shows the summary of the research, highlighting the main results.

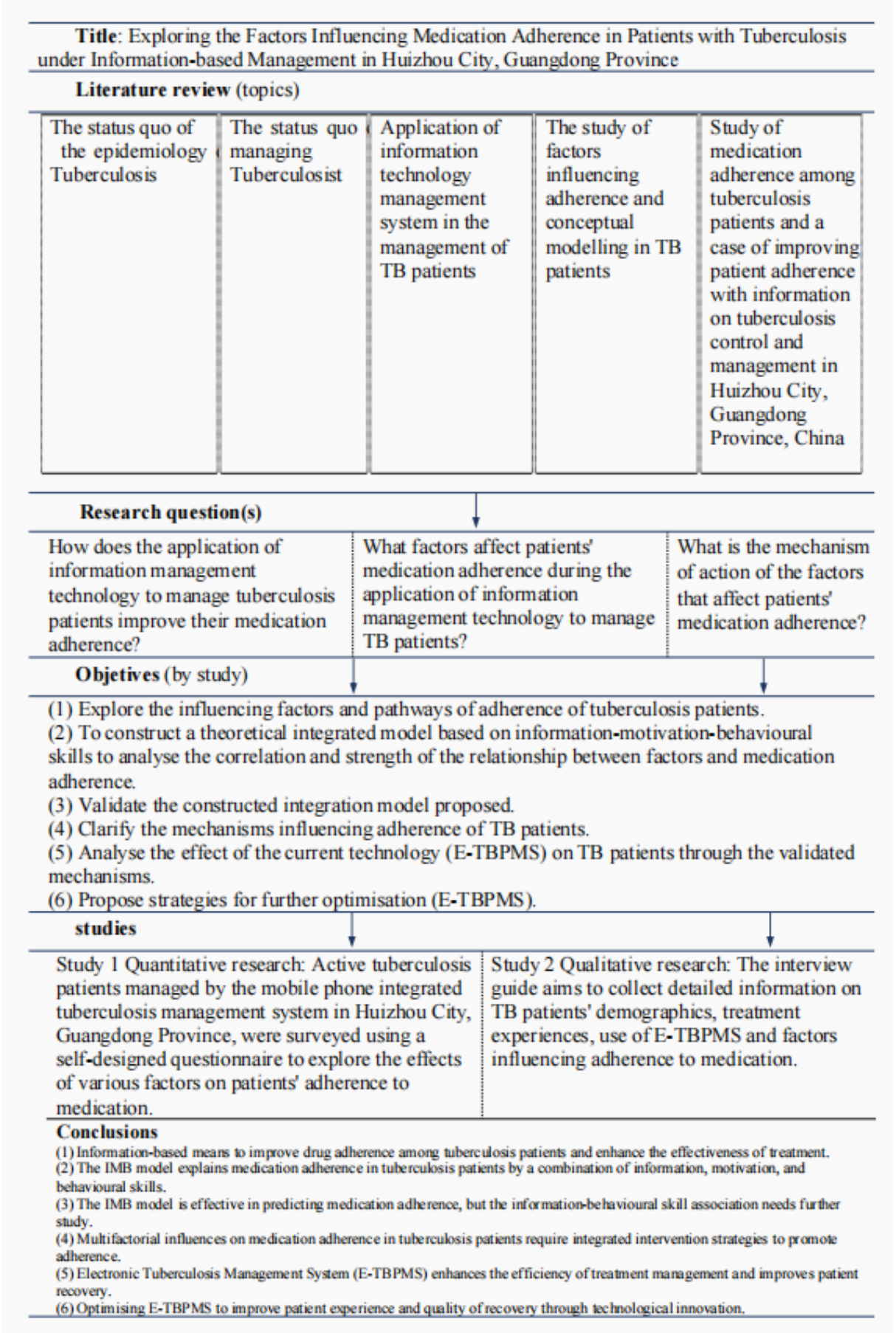

Figure 6.1 Summary of research

Chapter 7: Conclusions

7.1 Highlights

In the present research, we investigated the role of medication adherence in assessing the effectiveness of tuberculosis (TB) management. We used qualitative and quantitative methods to examine the factors that influence medication adherence among TB patients using the Electronic TB Patient Management System (E-TBPMS). Based on the Information-Motivation-Behavioral Skills (IMB) theory, we explored how the information management technology can improve medication adherence among TB patients. We aimed to provide insights into how information management technology can be used to improve medication adherence among tuberculosis patients.

We examined the factors influencing adherence to medication among tuberculosis patients in Huizhou City, Guangdong Province, China. The empirical research generated valuable data and insights, providing a localized perspective that contributes to understanding contextual factors influencing medication adherence behaviors. By exploring the role of technology and information management systems, our findings contribute to the understanding of the potential of these interventions to support adherence among TB patients. This main contribution is particularly important in the current era of digital healthcare solutions and provides insights into the use of information technology in TB management. By combining qualitative and quantitative methods, the research provides an example of mixed-methods research, demonstrating how to effectively cross-interpret the use of information management technologies in the management of TB patients. It also evidences the role of cross-disciplinary research methods.

(1) In terms of academic research, the results of a study exploring the factors influencing medication adherence among tuberculosis patients under information-based management in Huizhou City, Guangdong Province, provide valuable data and an analytical framework. This study provides insights into how information-based management affects the medication-taking behavior of TB patients through an empirical research approach, which is important for understanding and optimizing TB control strategies. The findings enrich academic research on

TB management, particularly in the area of medication adherence research in the context of informatics.

(2) In terms of practice, the results of this study are of great significance as a guide for TB control in Huizhou City, as well as in Guangdong Province and the country as a whole. The study reveals the potential role of information-based management in improving patients' medication adherence, which implies that by optimizing the design and implementation of the information system, it may be effective in enhancing the effectiveness of patients' treatment and management efficiency. For example, the study may find that e-reminders, online counselling, and remote management may enhance patients' knowledge of treatment and increase their willingness to take medication on their own, thereby improving medication adherence.

(3) At the same time, these research results can provide decision-making support to policy makers, helping them to better allocate resources, design interventions, and improve the overall effectiveness of the public health system through informatization. In addition, the research results also provide contributions and references for information technology management in other regions or similar diseases.

7.2 Limitations and future research suggestions

7.2.1 Limitations

Only newly diagnosed TB patients or patients with specific types of TB in Huizhou City, a Guangdong province, participated in this research, resulting in limited generalizability of the results. This research relied on patients' data recorded on the E-TBPMS system and their own stated outcomes to assess medication adherence, which may have the effect of memory bias or untrue system registration records. TB patients from different regions and cultural backgrounds may have different perceptions and behaviors regarding medication adherence, which may differ from the current situation.

7.2.2 Recommendations for further research

It is recommended that a long-term tracking be conducted in future studies to follow up on the adherence to medication of TB patients under information-based management. Through long-term observation, it will be possible to understand the influence of the various factors on medication adherence and the causal relationships between factors at different stages and time points. Future studies may consider a more comprehensive selection of participants, having

larger samples, including patients from different regions and classifications, to obtain more generalizable results.

7.3 Main conclusions

(1) In the context of information technology, medication adherence of tuberculosis patients is influenced by mechanisms such as information provision and health popularization, personalized medication and follow-up reminders and management, psychological support for doctor-patient communication and exchange, as well as real-time monitoring and feedback of medication data. These factors work together to improve patients' knowledge and understanding of anti-tuberculosis medication therapy, improve motivation and confidence in taking medication, and provide timely support and guidance, thus promoting good medication adherence and improving the effectiveness of tuberculosis treatment and control.

(2) In this research we constructed an IMB model of medication adherence in tuberculosis patients, with three elements or variables, namely information, motivation, and behavioral skills, that interact to determine patients' medication adherence. The information provides the basis for patients' knowledge and understanding of TB medication taking, motivation stimulates the intrinsic willingness and drives to adhere to medication taking, and behavioral skills provide the ability to adhere to the practical aspects of medication taking. The relevance and strength of the different factors to medication adherence depends on the patient’s performance and ability on these three elements.

(3) The IMB model of medication adherence constructed from our results is consistent with the classical IMB theoretical model. One difference is that our findings suggest that there is no significant correlation between information and behavioral skills, which may be related to the design of the questionnaire, the characteristics of the survey sample, or the potential mediating variables, which may have some influence on the results. In this research, we assessed whether patients possessed proper behavioral skills by investigating their access to information and their knowledge of relevant information, by investigating their motivational factors, and by observing their medication-taking behavior. The validation of these three aspects can be used to comprehensively assess the effectiveness of the IMB model in predicting and explaining medication adherence.

(4) According to our results, the mechanisms affecting medication adherence in tuberculosis patients are multifaceted and involve factors such as knowledge and cognition, motivation and attitudes, social support, management of side effects and adverse reactions,

forgetfulness, and difficulties. These mechanisms can help managers develop effective interventions to promote medication adherence among TB patients.

(5) The Electronic TB Management System (E-TBPMS) positively impacts TB patients by providing automatic access to TB patient diagnosis and treatment information, adjustment of individualized treatment regimens, reminders for timed medication taking and follow-up visits, a communication platform, and tracking of recovery progress. The system provides a comprehensive and personalized way to manage TB treatment and improve patient outcomes and recovery.

(6) The electronic TB management system (E-TBPMS) can be further optimized by improving user experience, enhancing personalization, introducing AI technology, strengthening social interaction features, and strengthening data security and privacy protection to provide better services and support and improve patient outcomes and quality of recovery.

In conclusion, this research identifies the impact of factors such as knowledge, motivation, social support, side-effect management, forgetfulness, and difficulties in medication adherence, highlighting the positive impact of an electronic tuberculosis patient management system (E-TBPMS) in improving patients' medication adherence. It also suggests strategies to optimize the E-TBPMS further.

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Annex A

Figure A1 shows the Developing process of Tuberculosis Control Management Information System in Huizhou City in Guangdong Province, China.

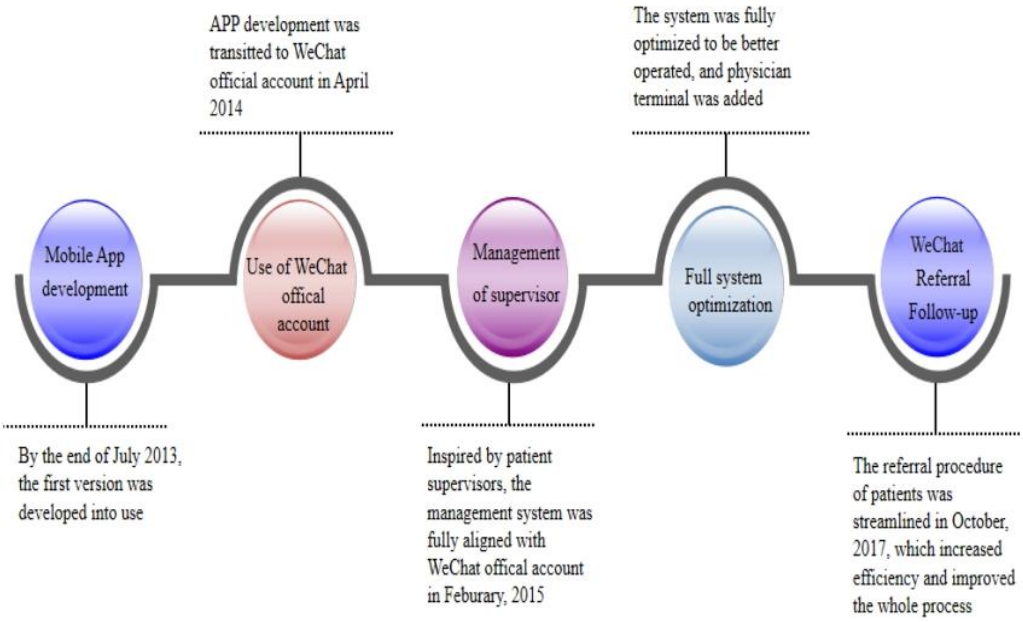

Figure A1 Development process of the information system for managing TB

Figure A2 shows the Core functions of the information system of managing TB.

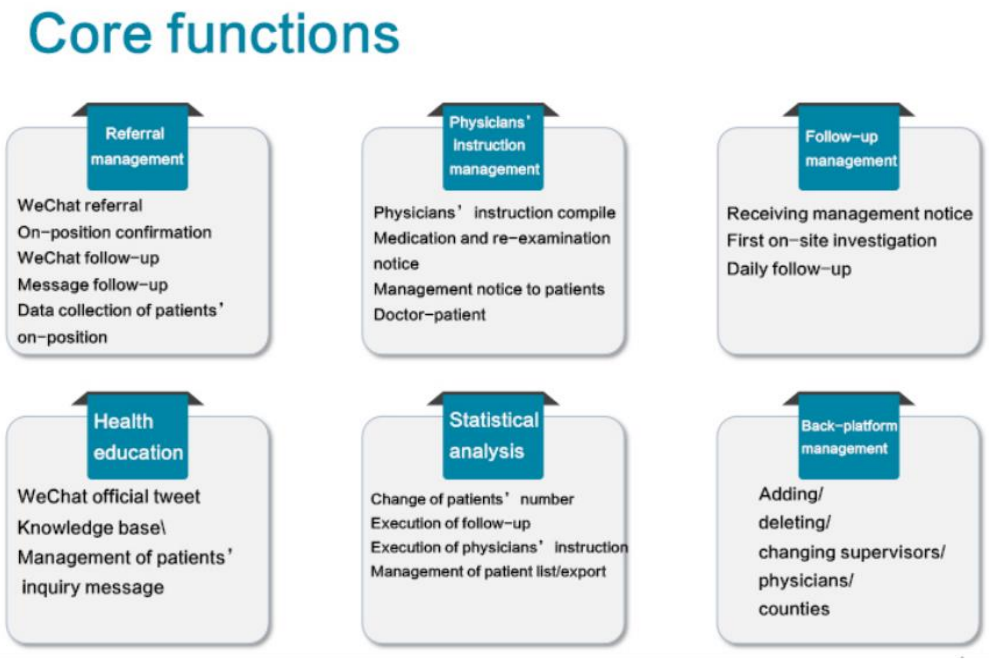

Figure A2 Core functions of the information system of managing TB

Figure A3 shows the Follow-up management of TB patients from the information management system.

Figure A3 Follow-up management of TB patients from the information management system

Figure A4 shows Breakdown of demographic social characteristics of respondents.

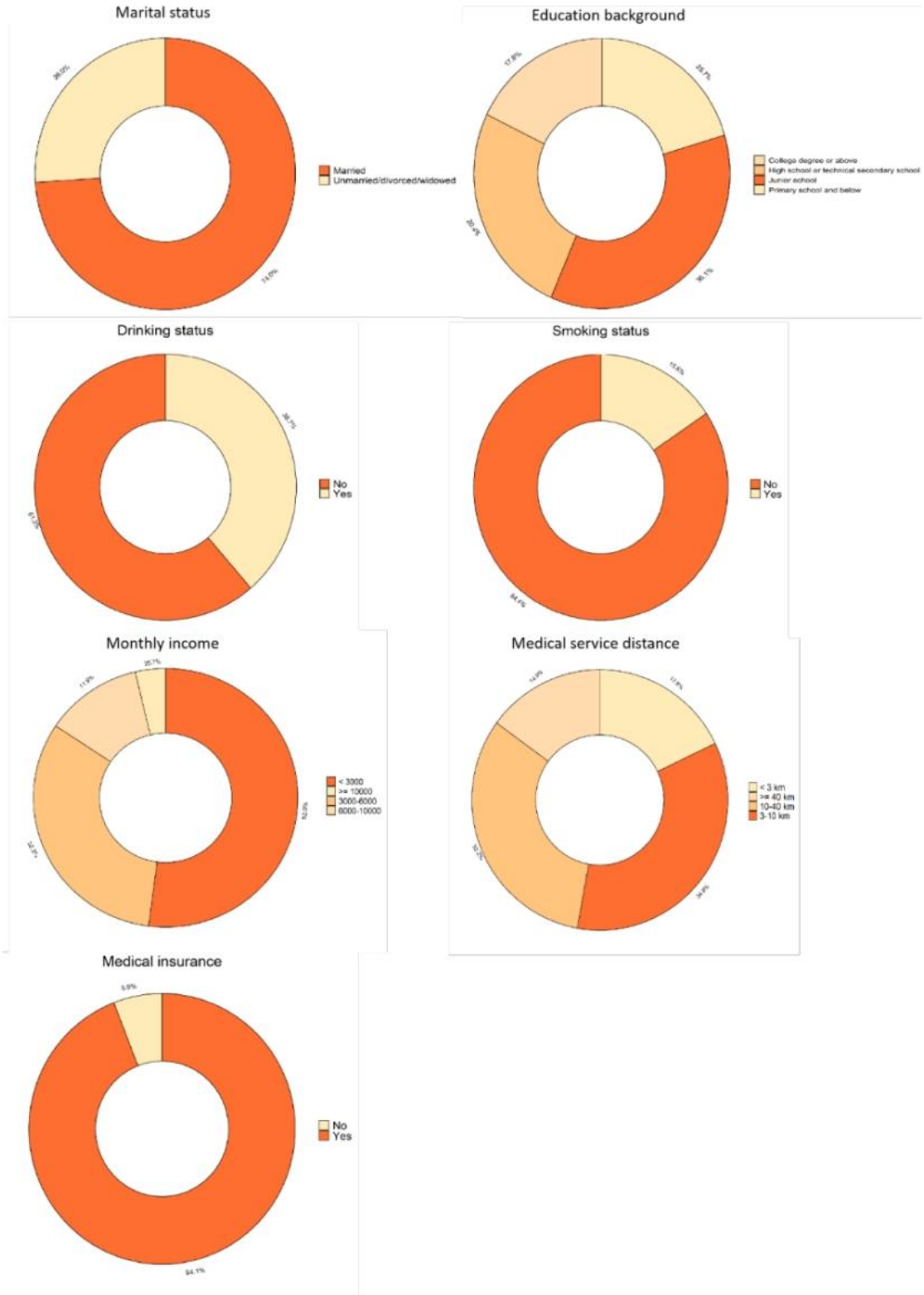

Figure A4 Breakdown of demographic social characteristics of respondents

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Annex B: Health Questionnaire for Treatment Adherence of Pulmonary Tuberculosis Patients

Hello, we are the investigators of Huizhou Tuberculosis Prevention and Treatment Institute. We are conducting research on the treatment adherence of tuberculosis patients, and the research results will help to optimize and improve the future treatment work. The survey will be conducted in the form of a questionnaire, which will take about 10 minutes to complete. All the information you provide is for research purposes only, and we will keep your information strictly confidential. Thank you for your support.

If you agree to participate in this research, please sign here:

Part I basic information

1.1 Your name: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

1.2 Your gender is:

A. Male B. Female

1.3 The last four digits of your mobile phone number are: _ _ _ _ _ _ _ _ _ _

1.4 Your current personal monthly income:

A. None B. < 1000 yuan C. 1000-3000 yuan

D. 3000-6000 yuan E. 600-10,000 yuan F. > 10,000 yuan

1.5 Alcohol consumption (during treatment)

1.5.1 How often do you drink alcoholic beverages?

A. Never B. Once a month or less C. Two to four times a month.

D. Two to three times a week. E. Four times a week or more

1.5.2 If you drink that day, how many glasses of wine do you usually drink that day? [One glass: for example, 250ml or half a bottle of beer, a small glass of white wine (15ml), a glass of wine or yellow wine]

A. 1 to 2 B. 3 to 4 C. 5 to 6

D. 7 to 9 E. 10 or more

1.5.3 In the previous year, how often did you drink six or more drinks at a time (if you were a woman); Or 8 or more glasses of wine (if male)? [One glass: for example, 250ml or half a bottle of beer, a small glass of white wine (15ml), a glass of wine or yellow wine]

A. Never B. Less than once a month C. Every month

D. Once a week E. Almost every day

1.6 Smoking situation

1.6.1 Do you smoke now?

A. Every day B. Yes, but not every day (answer 1.6.2a) C. No smoking (answer 1.6.2b)

1.6.2a Have you ever smoked every day before?

A. Yes B. No C. No idea

1.6.2b Have you ever smoked before?

A. every day B. Yes, but not every day. C. No idea

1.7 How long has it been since you were diagnosed with tuberculosis: _ _ _ _ _ _ months

1.8 Your education level is:

A. Never been to school B. primary school C. junior school

D. High school or technical secondary school E. Vocational school F. Bachelor's degree or above

1.9 Your marital status:

A. Unmarried B. Married C. Divorced D. widowed

1.10 Type of your medical insurance: (multiple choices)

A. Medical insurance for urban workers B. Medical insurance for urban and rural residents C. Commercial medical insurance

D. No medical insurance E. Other _ _ _ _ _ _ _ _

1.11 What is your height? _____m; What is your weight? _____kg

The second part is the mastery of information related to tuberculosis.

How well do you know the following?	**No idea**	**Not familiar with**	**Generally understood**	**Partly understood**	**Well understood**
2.1.1 The vast majority of tuberculosis can be cured by standardized treatment as required by doctors.					
2.1.2 Tuberculosis is preventable and treatable. Nutrition and exercise should be strengthened to improve human resistance.					
2.1.3 The state has a reduction and exemption policy for the treatment of tuberculosis patients, and local governments also have preferential treatment measures.					

2.1.4 From which way did you learn the above information?

A. Internet B. Community/village Committee public C. Medical staff informed when seeing a doctor.

	ity
D. Friends and relatives inform	E. other

How well do you know the following?	No idea	Not familiar with	Generally understood	Partly understood	Well understood
2.2.1 Patients with pulmonary tuberculosis need to take regular medication throughout the treatment period.					
2.2.2 Irregular medication may lead to the disease not being completely cured or even relapse into medicine -resistant tuberculosis.					
2.3.1 Patients with pulmonary tuberculosis need regular reexamination during treatment.					
2.3.2 Irregular reexamination may lead to failure to observe the damage caused by medicine side effects (such as liver injury) in time.					

The third part is adherence behavior.

3.1.1 Do you sometimes forget to take medicine?	A. Yes, _ _ _ _ _ times	B. No
3.1.2 In the past two weeks, have you missed your medication?	A. Yes, _ _ _ _ _ times	B. No
3.1.3 Have you ever cut back or stopped taking medicine without telling your doctor because you felt unwell after taking medicine?	A. Yes, _ _ _ _ _ times	B. No
3.1.4 Have you ever forgotten your medicine when you are away from home or traveling?	A. Yes	B. No

3.1.5 Did you take all the medicines you should have taken yesterday?	A. Yes			B. No
3.1.6 Have you stopped taking medicine after you thought your condition was under control?	A. Yes			B. No
3.1.7 Do you think it is troublesome to stick to the treatment plan?	A. Yes			B. No
3.1.8 Is it difficult for you to remember to take the medicine you used?	A. never	B. barely	C. sometimes	
		D. often	E. always	
3.2.1 Will you regularly follow the doctor's advice for TB reexamination during treatment?	A. Yes			B. No
3.2.2 In the past three months, have you been absent from the clinic? (Patients who have been treated for three months)	A. Yes, _ _ _ _ times			B. No

The fourth part is subjective self-evaluation of treatment results.

Do you agree with the following views?	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
4.1 After taking the medicine, my symptoms have improved obviously.					
4.2 The side effects of medicine are obviously harmful to my health.					

The fifth part is the motivation of treatment adherence.

Do you agree with the following views?	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

5.1.1 Regular medication throughout the course can control my condition.					
5.1.2 Taking medicine regularly throughout the course, I am more satisfied with my physical and psychological condition.					
5.1.3 Regular medication throughout the course can make me do more things I want to do.					
5.1.4 The therapeutic effect of the medicine used is greater than its side effects.					
5.2.1 If others know that I use medicine for tuberculosis, it will make me feel embarrassed.					
5.2.2 I often do not take the medicine on time					

because I forget.					
5.2.3 I'm so busy that I do not have time to make regular follow-up visits and get medicines.					
5.2.4 I'm worried that the therapeutic medicine used are not as effective as expected.					
5.2.5 The therapeutic medicine used often make me feel unwell and unbearable.					
5.3.1 Tuberculosis is very harmful to my health.					
5.3.2 Irregular medication will lead to the recurrence of tuberculosis.					
5.3.3 Irregular medication will lead to medicine resistance.					
Do you agree with	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

the following views?					
5.4.1 The doctor advises you to take the medicine according to the doctor's advice.					
5.4.2 The propaganda of the news media suggests that you take the medicine according to the doctor's advice.					
5.4.3 Your family suggests that you take the medicine according to the doctor's advice.					
5.4.4 Your friend suggested that you take the medicine according to the doctor's advice.					

Part VI Behavior

Do you agree with the following views?	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

6.1.1 Adhere to regular medication throughout the course, which is completely under my own control.					

Part VII Social Support

When you need emotional support/material help (such as financial difficulties),

7.1 How much support can you get from your family?

0——1——2——3——4——5——6——7——8——9——10

Not at all. Very much

7.2 How much support can you get from your friends?

0——1——2——3——4——5——6——7——8——9——10

Not at all. Very much

7.3 How much support can you get from your colleagues/classmates?

0——1——2——3——4——5——6——7——8——9——10

Not at all. Very much

Part VIII Access to Medical Services

8.1 approximate distance between the health service institution where you take medicine/treat and your place of residence?

A. 3km-10km B. 10Km-40Km C. over 40Km

8.2 What is your mode of transportation to the institution?

A. Walking (_ _ _ hours _ _ minutes)

B. Urban vehicles (_ _ _ hours _ _ minutes)

D. Intercity trains/buses (_ _ _ hours _ _ minutes)

D. Self-driving (_ _ _ hours _ _ minutes)

E. Others: _ _ _ _ _ _(_ _ _ hours _ _ _ minutes)

8.3 Do you agree that it is convenient to take medicine/treat in this institution?	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

Part IX Other comorbidities

9.1 Have you ever been diagnosed with the following diseases

A Yes (answer 10.2) B No.

9.2 Which or several of the following diseases do you suffer from?

A hypertension B diabetes

C AIDS D myocardial infarction

E hypercholesterolemia F stroke

G renal insufficiency	H renal insufficiency
I osteoporosis	J chronic obstructive pulmonary disease (COPD)
K tumor/cancer	L hepatitis b
M hepatitis c	Others: _ _ _ _ _ _ _ _

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Annex C: Interview Outline of Tuberculosis Patients

1 General information

(1) Excuse me, are you XXX? Could you tell us something about yourself first?

(2) What changes have taken place in your life before and after your illness?

(3) Could you tell me something about the treatment and medication after getting sick? The whole treatment process from the beginning of your symptoms until now.

(4) Could you please talk about your medical treatment process?

2 Therapeutic effect evaluation

At present, how do you feel about your health?

3 IMB model factors

(1) Can you talk about your knowledge of tuberculosis?

(2) Could you please tell us in detail about your views on the benefits, obstacles and the possible severity of diseases caused by irregular medication?

(3) From whom or from what channels did you get the fact that you need to take medicine regularly all the time? Do these people/channels encourage you to keep taking your medicine? What do you think of the different reminders?

(4) Could you please talk about your own related factors in the matter of “taking medicine regularly throughout the course”?

4 Social support

Did you get any help and support after you got sick? What do you think of this help?

5 Requirements and suggestions:

Do you have any other suggestions?

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Annex D: Outline of A Physician Interview for A Clinical Consultation on Tuberculosis

1 Basic information:

Socio-demographic: name, title, professional background, work related: years of work, workload, specific scope of work.

2 Current status of the use of mobile supervision technology: modules used, frequency of use, scenarios of use

Please tell us which features of mobile supervision technology you use in your work? How often do you use them? In what situations do you use these functions?

3 Acceptance, satisfaction, strengths and weaknesses of all current supervision methods compared to mobile supervision technology.

(1) Do you think the functions and design of the technology are compatible with your workflow? What is the impact on work efficiency?

(2) Based on your work experience, how many patients are willing to use mobile supervision technology? What kind of patients are more/less likely to use the technology?

(3) In your opinion, what are the advantages and disadvantages of using this technology to manage patients' treatment?

4 Evaluation of the effectiveness of treatment management: communication with patients, factors influencing the taking of medication, follow-up and review of tuberculosis patients:

(1) Have you used the technology to communicate with patients online? What has been communicated? What do you think is the difference between face-to-face communication and online communication?

(2) Can you use the technology to detect patients missing medication, interrupting treatment, or having adverse reactions in a timely manner? How do you handle these problems when they occur?

(3) What do you think is the impact of using mobile supervision technology on patients' adherence to treatment? Why?

5 Needs and suggestions: interface, functions, operation, and training of mobile supervision technology:

(1) What measures or methods do you think can improve patients' treatment adherence?

(2) What functions and contents would you like to see improved or added to the mobile supervision technology?

(3) What other suggestions do you have?

Annex E: Tuberculosis Management Supervisor Interview Outline

1 Basic information: both sides introduce themselves to each other and establish a basis for communication:

(1) Are you XXX? Please briefly introduce your age, education, workplace, length of practice.

(2) How many TB patients are you managing now? What methods are used to manage them?

2 Current status of the use of mobile supervision technology: modules used in supervising drug administration, frequency of use, and scenarios of use:

When do you use mobile supervision technology in the management of TB patients? Which features of the mobile supervision technology are used? How often and for how long?

3 Willingness to use the mobile supervision technology and feelings: acceptance, satisfaction, strengths and weaknesses:

(1) Do the functions and design of using the technology fit your workflow? What is the impact on your work efficiency?

(2) What do you think are the advantages and disadvantages of using this technology to manage patient care?

(3) Based on your work experience, how many patients are willing to use mobile supervision technology? What are the main issues affecting the use of mobile supervision technology by patients?

4 Evaluation of the effectiveness of treatment management: communication with patients and their families, factors influencing the taking of medication, follow-up and review of tuberculosis patients:

(1) Have you used the technology to communicate with patients and their families online? What has been communicated? What do you think is the difference between face-to-face communication and online communication? Which do you prefer?

(2) Can you use the technology to detect patients missing medication, interrupting treatment, or having adverse reactions in a timely manner? How do you handle these problems when they occur?

(3) How do you think the use of mobile supervision technology affects patients' adherence

to treatment? Why?

5 Needs and suggestions: interface, functions, operation, of mobile supervision technology:

(1) What measures or methods do you think can improve patients' treatment adherence?

(2) What functions and contents would you like to see improved or added to the mobile supervision technology?

(3) What other suggestions do you have?

Annex F: Field Pictures

Figure F1 Field pictures

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system（2022）

In March 2022, a quantitative survey was conducted in Huizhou Institute for Tuberculosis Control and Prevention, and a questionnaire survey on the treatment compliance of tuberculosis patients was conducted among 269 patients.

In April, 2022, a field survey on the application of patient health management tools was conducted in Huizhou Tuberculosis Prevention and Control Institute and Huicheng Chronic Disease Prevention and Control Station, and local clinicians and supervisors were interviewed to deeply understand the functional modules, application status and use experience of health management tools.

(1) Notification of doctors' instructions

Figure F2

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system (2022)

(2) Customized notification service

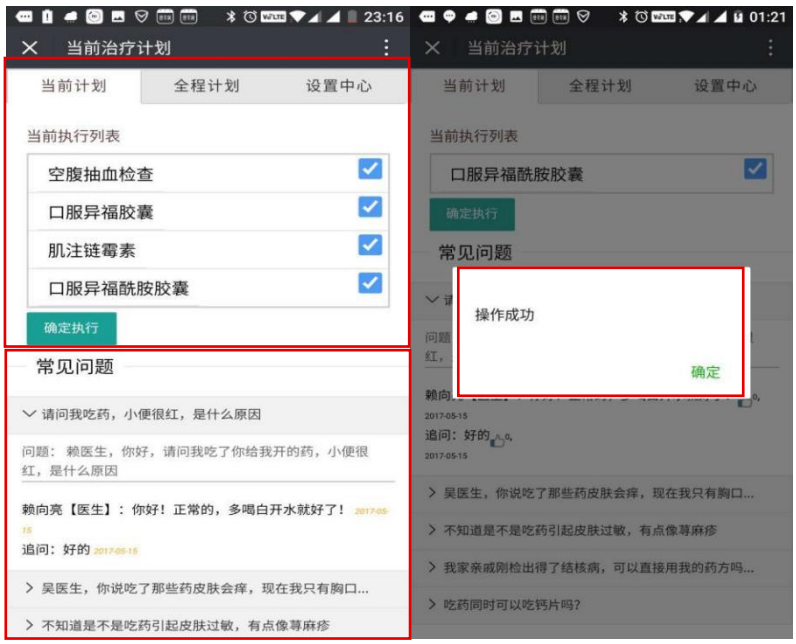

Figure F3

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system (2022)

Receive the supervisor's on-site supervision appointment prompt

Figure F4

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system (2022)

(3) Consultation service: chat between doctors and patients

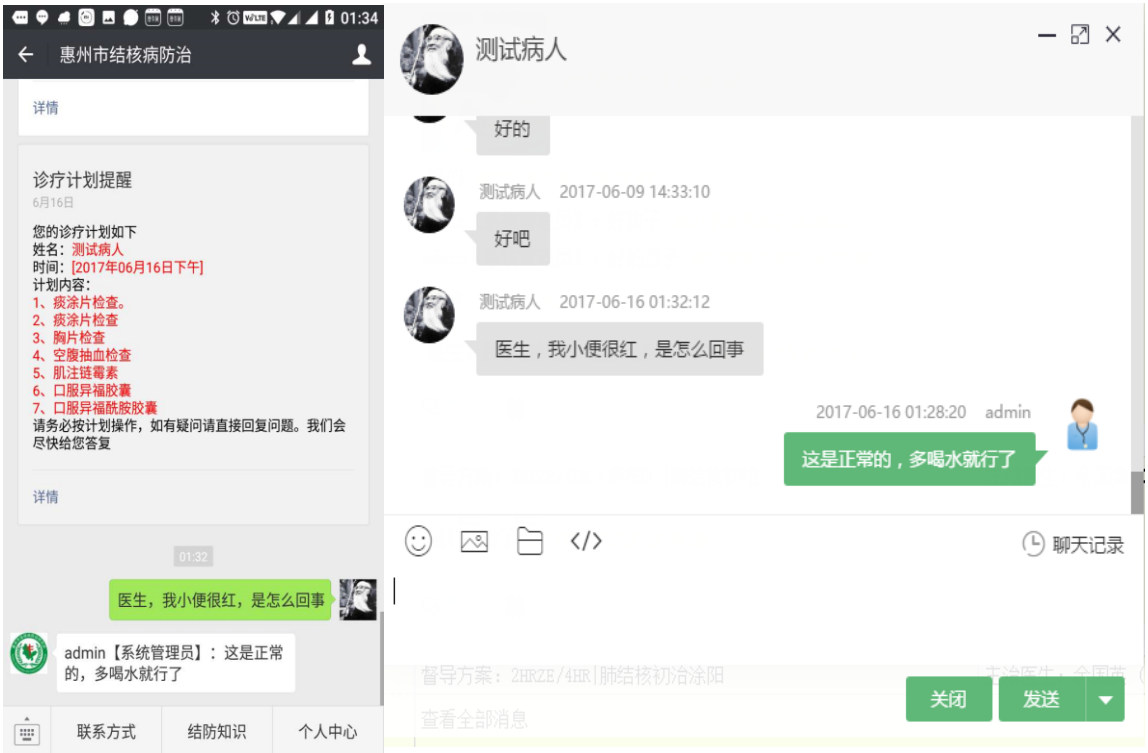

Figure F5

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system (2022)

(4) Enquiry service: quickly understand and learn the knowledge of tuberculosis prevention and treatment.

Figure F6

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system (2022)

(5) Service evaluation: Patients can evaluate the supervisor's service

Figure F7

Source: Screenshot of the mobile terminal of Huizhou tuberculosis management information system (2022)

Annex G: License for the Morisky Scale

mmar.
MORISKY MEDICATION ADHERENCE RESEARCH, LLC.

Certificate Number: 9158-5494-2974-9663-3542

To Whom It May Concern:

This is to inform you that Liang Chen from ISCTE University Institute of Lisbon has my permission to use the MMAS-8 (Morisky Medication Adherence Scale 8 item) in this research study:

"Exploring the Mechanism of Medication Adherence for Tuberculosis Patients under Information-based Management in Huizhou City, Guangdong Province"

The requirements to use this scale are to cite the following references in the document:

1. **Morisky DE, Ang A, Krousel-Wood M, Ward H. Predictive Validity of Medication Adherence Measure in an Outpatient Setting. Journal of CLinical Hypertension 2008; 10(5):348-354**
2. **Berlowitz DR, Foy CG, Kazis LE, Bolin L, Lonroy LB, Fitzpatrick P, et al. for the SPRINT Study Research Group. Ipact of Intensive Blood Pressure Therapy on Patient-Reported Outcomes:Outcomes Results from the SPRINT Study. N Engl J Med 2017; 377:733-44.**
3. **Bress AP, Bellows BK, King J, Hess R Beddhu S, Zhang Z, et al, for the SPRINT Research Group and the SPRINT Economics and Health Related Quality of Life Subcommittee. Cost-Effectiveness of Intensive versus Standard Blood Pressure Control. N Engl J Med 2017; 377:745-55.**

i. The following footnote is required in all articles, presentations, web postings, reports and submitted manuscripts, and on the first table or figure which present the MMAS-8 as well as in the Acknowledgment Section of manuscripts submitted for publication:

The MMAS-8 Scale, content, name, and trademarks are protected by US copyright and trademark laws. Permission for use of the scale and its coding is required. A license agreement is available from MMAR, LLC., www.moriskyscale.com.

ii. The MORISKY SCALE intellectual property legend must appear on the first page of all (Morisky) Questionnaires: **(© 2007 Donald E. Morisky)**

Donald E. Morisky, Sc.D., M.S.P.H., Sc.M. President
Morisky Medication Adherence Research, LLC

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Annex H: Relevant Papers Published During Studies

Chen, L., Wang, J. W., Feng, H. Y., Xiao, B., Chen, X. X., Wei, R., Liang, H. D., Liu, K. Y., Xiao, L. W., & Zhou, L. (2019). 广州市白云区初治涂阴肺结核患者治疗依从性研究 [Study on treatment adherence of first-treatment smear-negative tuberculosis patients in Baiyun District, Guangzhou City, China]. *Chinese Journal of Preventive Medicine*, *20*(3), 165-168.

Wang, J. W., Huang, S. S., Liu, K. Y., Liang, H. D., Feng, H. Y., Zhou, F. J., Liang, A. Q., Chen, L., & Zhou, L. (2019). 对结核病患者实施移动通信直接面视下短程督导化疗的效果评价[Evaluation of the effect of implementing short-course supervised chemotherapy under direct face-to-face vision with mobile communication for tuberculosis patients]. *Chinese Journal of Anti-Tuberculosis*, *41*(9), 946-950.

Peng, J. M., Liu, Z. D., Zhong, Q., Liu, L. H., Chen, L., Li, X. F., Weng, J. F., Huang, B. W., & Chen, W. J. (2018). 基于微信的多功能肺结核防治管理信息系统应用效果评价 [Evaluation of the application effect of multi-functional tuberculosis control management information system based on WeChat]. *Journal of Tuberculosis and Lung Health*, *7*(1), 74-76.