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ORIGINAL PAPER

Improvement of outpatient service processes: a case study of the university of Hong Kong-Shenzhen hospital

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Abstract

Purpose This work presents a case study of the University of Hong Kong-Shenzhen Hospital (HKU-SZH), which was the first to implement an outpatient appointments registration system. The research question is to determine which factors influence patient satisfaction most.

Methods The study provides an anatomy of the hospital outpatient process through various methods and theories, including a literature review, field research, expert consultation, business process improvement (BPI) theory and information technology, with the aim of identifying the objectives and strategies of the hospital for improving its outpatient process. A quantitative analysis was performed using a questionnaire survey to identify the defects and weaknesses of the current model. The principles, methods and techniques of BPI theory are used to analyse various problems existing in the outpatient process and the extent of their influence. A structural equation model has been established for scientific and quantitative analysis, which can help identify the goals of optimization and measure improvement in the outpatient process and patient satisfaction.

Results It was determined the source of inefficiency of the current outpatient service process. By means of outpatient process improvement, the study aims to increase the hospital's efficiency and raise the level of patient satisfaction so that it may enhance its comprehensive competence. In addition, an effective and operable methodology will be generated, which is expected to serve as a reference for other hospitals to improve their operation and management.

Conclusions It was found that service attitude, service value and waiting time have a significant influence on patient satisfaction.

Keywords Outpatient process · Business process reengineering · Information Technology · Local adaptation · Hospitals · China

1 Introduction

Given the increasing competition between major hospitals, patients tend to seek higher quality medical services. In the past, hospitals used to adopt a hierarchical management system driven by power, and a functional management pattern based on division of labour. However, this pattern has been failing to address the need for competition in the socialist economy over time. If a hospital wants to have a sustained competitive edge, it should make an ongoing commitment to raising the level of its medical services. At the same time, it should also foster a service philosophy of "treating patients like customers" and establish a strategic business process to respond to the changing internal and external environment. By renewing operational and management methods and rebuilding outpatient processes, a hospital can build a process management model that serves the interests of its patients.

After 30 years of development, there have been remarkable advances in China's economy. In addition, people's living standards and purchasing power have also improved significantly. As people become increasingly rich, they start to attach greater importance to their health. However, with such a large population, coupled with intensifying

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urbanization, the urban population in China has increased dramatically. These urban residents are in urgent need of high-quality services from hospitals and medical personnel. In China, large and medium-sized hospitals are mainly concentrated in cities and the scale of these hospitals is determined by the registered population of these cities. As a result, medical resources in cities are inadequate and this situation is unlikely to be reversed in the short term. Currently, as the appointment registration model has not yet been widely implemented in large and medium-sized hospitals, large crowds rush to see physicians in the morning. Consequently, patients have to spend longer on registration, payment and drug dispensing, while they have far less time for the critical diagnosis by the doctor. In order to allocate medical resources in a reasonable way and reduce the waiting times to ensure sufficient time for treatment, optimising the outpatient process management model has become inevitable. Introducing the appointment mechanism enables patients to arrange their schedule to see a doctor in advance, which saves unnecessary queuing time and minimizes conflicts between doctors and patients.

Waiting time is a key driver of patient satisfaction, together with medical expertise, specialist availability, hospital location, cost, success rate, clinical care and confidentiality [1]. Long waiting lists in outpatient clinics are a widely recognized problem [2]. Physician time is one of the scarcest resources in healthcare and there can be several reasons why a doctor does not spend enough time with patients [3]. Due to uncertainty in the demand for appointments, it is difficult to provide an exact match between planned physician availability and appointment requests [4].

Chen (2003) found that currently most domestic hospitals still adopt the traditional outpatient process model [5], namely: queue for registration → wait to see the doctor → see the doctor (doctor issues a checklist or prescription) → queue to pay fees → queue for examination/tests (or drug dispensing) → further consultation with the doctor (doctor issues a treatment list or prescription) → queue to pay fees → queue for treatment (or drug dispensing). This traditional model is very common in major hospitals, but has many shortcomings, particularly in large, overcrowded hospitals since only a small part of the patient's time in the hospital is reserved for treatment and this is severely detrimental to the social and economic benefits of the hospital.

Strategic and tactical capacity planning are critical issues that hospitals must face. While these problems have received significant attention, the current queueing-based approaches do not address realistic healthcare constraints such as blocking, transient arrivals, transient capacity assignments and surge capacities [6].

This study uses BPI Theory, Queuing Theory and System Theory with information technology at its core to analyse the process management model for outpatient appointments in the University of Hong Kong-Shenzhen Hospital (HKU-SZH). As far as we know, these theories have never been combined before to study patient satisfaction in a hospital, hence this is the gap that we intend to fill.

The research question is to know which factors influence patient satisfaction most. A quantitative analysis was performed using a questionnaire survey to identify the defects and weaknesses of the current model. The principles, methods and techniques of BPI theory are used to analyse various problems existing in the outpatient process and the extent of their influence. A structural equation model has been established for scientific and quantitative analysis, which can help identify the goals of optimization and measure improvement in the outpatient process and patient satisfaction. The aim is to maximize the existing resources in outpatient departments, optimize the management model and hospital operation service model, reduce unnecessary waiting time for patients, increase the effective hospital visit rate per unit of time, eliminate the phenomenon of "three longs and one short', build a social image for hospitals as providers of efficient, convenient and premium medical services, and enable patients to have easy access to medical services. In the literature review section, BPI Theory, Queuing Theory and Six Sigma Theory are reviewed and discussed. These theories served as a conceptual framework for the construction of the questionnaire. In the case study, a questionnaire survey was conducted on the outpatient appointment process management model in HKU-SZH. By establishing a structural equation model for the current outpatient process, the study analyses the influence of factors in the outpatient process on patient satisfaction, so that objective improvement measures can be identified. Thus, three hypotheses were defined:

H1: Service attitude influences patient satisfaction.

H2: Service value influences patient satisfaction.

H3: Waiting time influences patient satisfaction.

2 Literature review

2.1 Process management theory

Process management, as an important management method in modern enterprise management, has been playing an increasing role in enhancing business performance and raising customer satisfaction levels. It has attracted widespread attention from management specialists in business circles. Its successful application in enterprise management has also attracted great attention from hospital management scholars.

In the Taylor and Ford eras, maximization of operational efficiency was the primary target. As a result, the idea of process management gradually developed into a formal management theory. The management master Taylor first proposed the idea of job analysis, followed by the idea of process management, in 1920. In 1980, the idea of quality management became very popular. In 1984, the US-based International Business Corporation, abbreviated as IBM, proposed the Quality Focus Business Process (QFBP) and listed "quality" as the core element of process. In 1988, IBM officially changed QFBP into Business Process Management (BPM). In 1990, the American management theorists Michael Hammer and James Champy first proposed the idea of 'business process reengineering" in their best-seller Reengineering the Corporation [7]. This idea fitted the economic development requirements of the new period, since Hammer and Champy both agreed that enterprises should adapt to the changing external environment, gradually establish the customer-oriented operating principle, and reengineer the business processes to suit the external business development. In response to business process reengineering, IBM formally proposed the idea of Process Management (PM).

In 1995, Michael Hammer and Steven Stanton jointly published another book entitled The Reengineering Revolution Handbook [8], which led to an upsurge in "organizational reengineering" in Western countries. At the time, some scholars maintained that 'organizational reengineering' was the latest advance in management science and would definitely bring about a brand-new management revolution with business process re-engineering at its core.

In another study, also conducted in the same hospital (HKU-SZH), apart from assessing resistance related to human factors, it was concluded that rethinking the business process was also important, with the findings suggesting that process reengineering and innovation is a complicated and difficult organizational change [9].

In the healthcare sector, management scholars have always maintained a positive attitude towards successful management theories and methods in the business world. While findings on the application of management theories such as Business Process Reengineering, Business Process Management, and Process Management have been published in documentary research, empirical studies on other aspects of their application have also appeared in various academic journals. Wong, Doyle and Straus, for example, published an explanation of process management in 1975 [10].

Process management approaches (such as TQM, lean and six sigma) originally intended for manufacturing settings are increasingly being applied in the healthcare sector [11, 12]. In fact, these process management approaches have created an awareness of the operational organizational aspects of care treatments [13].

2.2 Business process improvement theory

Business Process Improvement (BPI) is a methodology which aims to maintain the competitive edge of an enterprise by constantly perfecting and optimizing the business process. The design and implementation of the process must be continuously improved in order to achieve the best result. BPI means doing the right thing in the right way. Its aim is to increase service time and improve the efficiency of valuable services, while minimizing the time spent on non-value-added services. Usually there are three stages in BPI: firstly, a description of the business process, which includes a clear definition of the business or operation process of the target company through field research in the enterprise; secondly, analysis of the business process, which means looking into the current process of the target company to identify the major causes of existing problems; thirdly, the formulation and implementation of improvement plans, in which redundant or overlapping processes are redesigned and optimized on the basis of the identified problems and their causes.

According to Ding and Sun (2010), most Chinese hospitals follow a serial working mode, which means the work is divided step by step, and only after one step finishes can the next start [14]. Such a process is rarely value-added since it leads to an unreasonable distribution of medical resources, a low information sharing capacity and low operating efficiency. Zhao (2006) suggests that the effective treatment time of outpatients represents only 10% of their stay in a hospital, as patients have to queue up for treatment and payment. If the percentage can be raised to 30%, then the patients' stay in hospitals will be cut by two thirds, and if raised to 50%, it will be reduced by four fifths [15]. However, some hospitals have faced great difficulties in implementing BPI projects, due to their system and structure. Improving patient service satisfaction in these hospitals is particularly difficult. Lin and Yang (2004) insists that Hospital Business Process Management (HBPM) should be applied [16].

A great deal has been achieved with respect to the use of BPI in the healthcare domain. However, there is still a need for more efficient and effective methods to support and overcome the shortfalls of existing methods. The complex nature of the healthcare domain requires comprehensive BPI that is able to deal with its common problems and challenges [17].

2.3 Queuing theory

According to Li and Xu (2003), Queuing Theory, or Stochastic Service System Theory, is an important branch of Operations Research [18]. It studies the probabilistic properties of queuing in various service systems, with a view to achieving optimal service system efficiency. In 1909, Agner

Krarup Erlang, a Danish engineer, published The Theory of Probabilities and Telephone Conversations, the first paper on Queuing Theory, which mainly calculates and studies service time and queuing efficiency. Lu (1994) found in his research that Queuing Theory has been constantly improved and enriched by the rapid development of IT technology and has been applied extensively in various sectors such as transportation, health care, shopping and banking [19]. In the healthcare industry, queuing theory has been implemented mainly through the use of distributed systems, which can be applied to achieve lean and flexible architectures that facilitate healthcare structure interoperability. Systems used in healthcare structures are characterized by proprietary data flow formats and encoding systems, which hinder the possibility of sharing data in a standard format and extracting atomic data for further analysis [20].

The queuing theory model can be used to measure the service efficiency of different departments in public hospitals, which can improve both service efficiency and patient satisfaction [21].

2.4 Six sigma theory

According to Liu and Ma (2005), the Greek letter sigma (σ) represents the level of the process or operation. Sometimes the process capability is denoted by Z: for example, $Z=6$ means that the process or operation has a process capability of 6σ [22]. The analysis of process capability usually focuses on whether the level of a process or operation can meet the expectation and to what extent it is met. Usually, Critical to Quality (CTQ) is employed as an indicator for analysis.

Chen (2010) finds in his research that in 2009 the Taizhou Hospital in Zhejiang Province reduced the defect rate from 39.6 to 12.9% by using the Six Sigma Theory management method to define, measure, analyse, improve and control the defect in the dripping speed of outpatient venous transfusion [23].

Six Sigma in itself does not address the cultural or interpersonal aspects of quality improvement and is limited further as it looks at individual processes rather than taking a system-wide approach. Moreover, poorly developed care processes are inevitably revealed when attempts are made to apply a Six Sigma program in a hospital [24]. To be effective, Six Sigma is dependent on high quality data and statistical expertise. Front line clinicians must therefore have access to appropriate systems and support (both technical and statistical), so that they can easily collect robust appropriate data for analysis [17].

2.5 Information technology

In terms of individuals, Information Technology (IT) has changed the way people communicate with each other. As to enterprises, IT has changed the distribution of power within organizations, altered corporate structure and reduced management hierarchies. As a result, corporate structure has become more and more flattening, which puts enterprises in a better position in market competition. IT has opened up space for process improvement, and to some extent, pushed forward process management reform. However, IT, in itself, is not characterized by the thoughts and ideas of "Process Management". Therefore, debates on medical process arose right when IT was first applied in the medical industry. For example, Shen (2003) proposes several questions, such as "whether information technology should be used to reengineer hospital management or information technology should accommodate hospital management model; and whether information technology should be used to simulate traditional manual work or new ways of work should be redefined." [5]. These questions can all be boiled down to the collisions between modern management technologies and traditional management ideas. For instance, the IT-based "One-Card" can integrate all medical processes, including outpatient registration, triage and payment. Using the "One-Card", patients can finish all the aforementioned processes at one time and significantly reduce the length of waiting; in comparison, outpatient doctor workstation has given rise to the management model where "patients choose doctors"; application of PACS and electronic medical records has reduced the storage time of medical records and accelerated the information transfer of medical records; information system can also further shorten the time required for completion of discharge procedures; besides, internet technologies also make online consultation, booking and registration possible. Therefore, it is believed that full use of IT is necessary for process optimization so as to enable HIS to bring about outpatient services with high quality and efficiency.

2.6 Summary

Table 1 shows the main constructs that result from the theories studied and are the main items related to the hospital environment in the outpatient service, which were used to construct the questionnaire.

Table 1 Main constructs and items in the outpatient service

Theory	Main constructs	Outpatient service
Process Management	Business performance Service attitude Customer satisfaction	Diagnosis an treatment Medical guidance Sign and guidance system Attending doctor Registration system
Business Process Improvement	Results Efficiency Service value Customer satisfaction	Environment Sanitary conditions Technical level Payment Treatment outcome Cost
Queuing	Waiting time Customer satisfaction	
Six Sigma	Quality improvement Customer satisfaction	

3 Informatization in the university of Hong Kong-Shenzhen hospital

Up to now, most of the hardware and software in the University of Hong Kong-Shenzhen Hospital are cutting-edge, thus enabling the hospital to base its clinic services on information technology as far as possible. To reduce manual operations, work that can be done by computers is now finished with the help of software.

Currently, Hong Kong- Shenzhen Hospital possesses seven buildings, a Logistic Service Building with seven floors (for the accommodation of canteen staff, interns and operators on duty), a Science and Education Administration Building with seven floors (for scientific and educational business and various trainings), three General Hospital Buildings with seven floors (the charge standard is governed by government), a VIP Hospital Building with five floors (the charge standard is higher and governed by hospital itself) and an Outpatient and Medical Technology Building with four floors (for outpatients and examination of medical laboratories). The two-floor basements of seven buildings are connected (which are mainly parking lots and a portion of warehouses). The hospital has adopted the internationally accepted Hierarchical Internetworking Model, which consists of access, convergence and core layers. Its buildings are connected by ten-gigabit armored fiber cables, which can be used outdoors. The network speed of computer terminals can reach gigabits. Besides, the whole hospital is covered by wireless network. In the four-floor Outpatient Medical Technology Building and the Hospital Building, wireless nursing, wireless ward rounds of doctors and wireless transmission of vital signs data are realized. Buildings and floors are connected by optical fibers. The Operation Room, Medical Imaging Department and Clinical Laboratory are connected to computer rooms through optical fibers. There are altogether three computer rooms in the hospital. The one on the first basement floor is for external lines and CCTV equipment, while those on the third floor of the Outpatient Medical Technology Building and the fourth floor of the Science and Education Administration Building are used to guarantee the operation of the medical software system in the hospital.

Network in the University of Hong Kong-Shenzhen Hospital is divided into internal and external networks due to network security concerns. The two networks are physically separated, and the Internet/email uses the external network while the medical software operates with the internal network. The hospital medical software structure is as follows (Fig. 1):

Adopting HL7 international standards, those seven systems transfer data on the data exchange platform developed by Orion New Zealand Limited. As there is no direct communication among the systems, their interdependence will be reduced to the lowest level. If one system doesn't function well, the others will not be affected. The hospital needs only to follow the HL7 interface standard when replacing the malfunctioning system and it is the same when some small functional software is connected to the medical software system. The hospital has two main computer rooms: the Main Data Center on the fourth floor of the Science

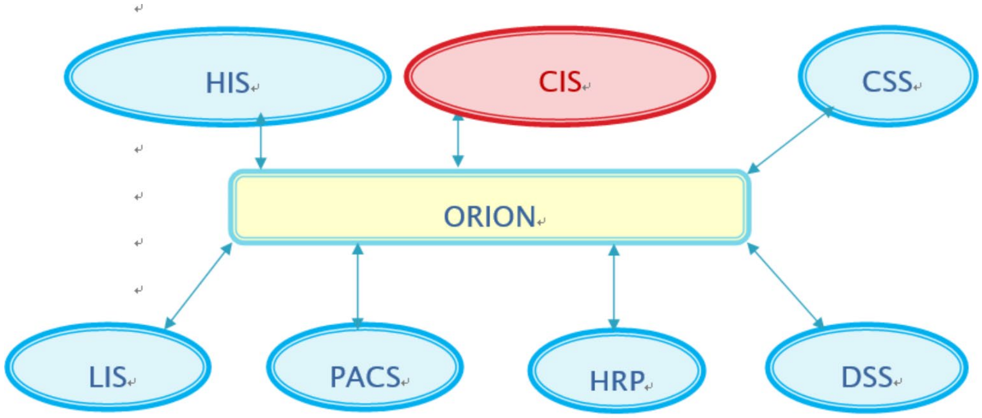

Fig. 1 Hospital Medical Software Structure

and Education Administration Building, and the Disaster Recovery Center on the third floor of the Outpatient Medical Technology Building (Fig. 2).

Currently the hospital has 30 PC servers, 20 of which have been equipped with the VMWARE virtualization software to provide the virtual environment for software operation. Systems such as LIS, PACS, CSS and HRP are installed in PC servers. There are also two IBM minicomputers and two supporting storages, in which HIS and CIS are installed. Besides, the hospital has two blade servers and two supporting storages. Equipped with CTRIX virtualization software, they can provide the installation environment for programs purchased from small companies, including the reproductive system, dental system, central lab system, tumor center system, maternity and child care system, birth certificate management system, knowledge management system, infant anti-theft system and examination management and training system. The blade servers also provide the software testing environment for the hospital.

Additionally, due to the considerable image data, a 300T storage is attached to the PACS system. Each day the hospital produces data of 35G, and it is estimated that the number will reach 80G per day after the hospital is fully opened.

The University of Hong Kong-Shenzhen Hospital has almost completely achieved electronic operation. As the whole treatment process is recorded by electronic medical records, and there are electronic results of various examinations such as biochemical test, imaging examination and pathological examination. Doctors can check the results on computers, and paper records will be abandoned. The hospital is also testing the CA system, an electronic authentication system. According to the plan, the CA system will first of all be applied to PACS and LIS. After it is stabilized, it will be applied to all software systems in the hospital. At that time, the hospital will truly realize electronization while paper-based medical records will be abandoned completely. The CA system has national legal force. It consists of two parts: personal identification and real time data. The system can show clearly who conducts what operation at what time, since all traces of modifications are recorded.

All those measures will significantly enhance the standardized management in the hospital and enable the medical staff to examine various materials in accordance with rules and regulations. It will also promote the development of medical research through data mining.

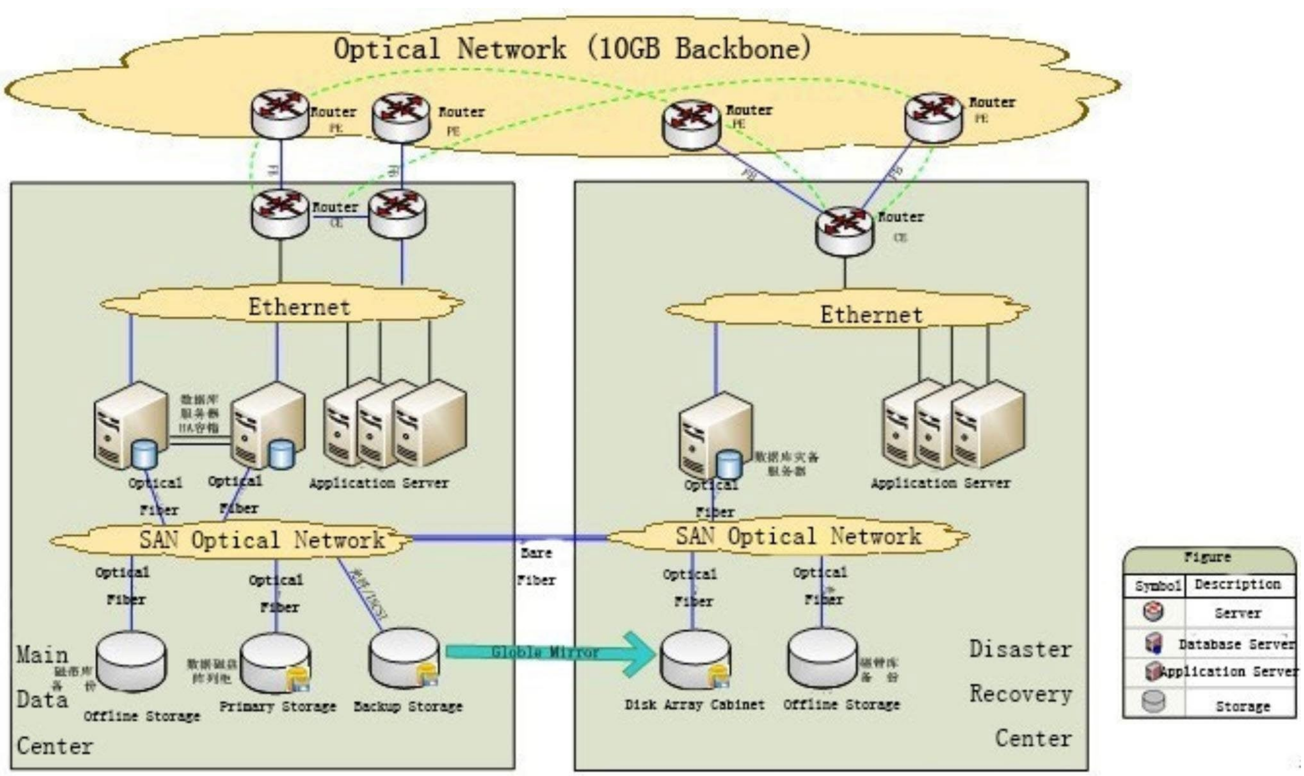

Fig. 2 Allocation of Computer Rooms in the Hospital

4 Methods

4.1 Satisfaction measurement for the outpatient service

Based on the literature review, on-the-spot convenience sampling was used to conduct an on-the-spot questionnaire survey that lasted for a month in the hospital. The survey collects basic information, general patient satisfaction with the outpatient process, and scores for each survey item. The structural equation modelling is then established to analyse the effects of basic factors on the degree of patient satisfaction with the outpatient process. In order to ensure that the model can fit the data better, it was optimized and revised and a standardized coefficient path graph was drawn. From an analysis of the direct and indirect effect of key variables on the degree of satisfaction, the current 'bottleneck problem' in the hospital's outpatient process was finally found and reasons for the obstacles in the present outpatient process were summarized.

In order to determine the needs of patients and the status quo of the outpatient business process, a convenience sampling of questionnaires was conducted in April and May 2014 among patients attending the hospital for treatment. This was an on-the-spot questionnaire survey, meaning that the patients anonymously completed a self-administered questionnaire on the premises. Clerks from the IT department gave questionnaires to patients who had finished treatment, who were ready to leave the hospital or who were waiting in the waiting room, injection room or clinical laboratory. The questionnaires were collected when the patients had completed them.

Out of 1,500 questionnaires distributed, 1,132 were collected, representing an effective rate of 88.3%. According to the statistical validity and reliability tests, the survey data is valid.

The questionnaire consists of three parts. The first part deals with basic information, including the respondent's sex, age, marital status, profession, level of education, place of residence, payment category, and monthly family income, for the purposes of classification and comparison. The second part comprises 24 items, including appointment registration, communication between doctors and patients, medical costs, medical effect, hospital signage, service attitude, hospital environment, hospital hygiene, and waiting time in each phase of the treatment. Based on a survey of variables of satisfaction, it is designed to enable patients to respond to each item and obtain a score for each patient's attitude, using a cumulating method. The average score of all the patients provides the researchers with an indication of the overall attitude. Each item adopts the Likert-type six-level scale method ranging from negative to positive, in which the numbers 1, 2, 3, 4, 5 and 6 correspond, respectively, to *very dissatisfied*, *not very satisfied*, *a little dissatisfied*, *a little satisfied*, *quite satisfied* and *very satisfied*. Hence, the answer to each item is not confined to "Yes" or "No" but is divided into several types, ranging from "satisfied" to "dissatisfied", with the medium term representing a neutral attitude. Due to the greater range of options, it can fully embody the differences in patient attitudes. The third part contains open questions which patients need to answer to make suggestions for the hospital's outpatient work and recommendations for improvement. Table 2 shows the scores for outpatient service items.

A total of 1,322 valid questionnaires were obtained from this survey. On the basis of the statistical validity test and reliability test, the data proved to be valid. After calculating the statistics, the overall degree of patient satisfaction with the hospital is 83.13 points.

The data from the collected questionnaires was introduced via the Epidata platform, issued by EpiData Association from Denmark, and analysed by SPSS 15.0, while AMOS7.0 was used to analyse the variables using structural equation modelling. Statistical approaches such as descriptive statistics analysis and the Wilcoxon rank sum test were also used.

Generally, questionnaires are analysed using the following methods:

4.1.1 Descriptive statistics analysis

The description of the basic information is included, as well as the frequency distribution and percentage analysis, in order to understand the distribution of the sample. Usually, a descriptive analysis of the data is conducted first, to find the inner law, and then a further analysis approach is adopted. Descriptive analysis can be used to analyse all the relevant data of variables in the survey population, mainly including frequency analysis, central tendency analysis, dispersion degree analysis and distribution of data, as well as statistical graphics. Common indicators include mean value, median, mode, variance, and standard deviation.

4.1.2 Cronbach's reliability coefficient analysis

Reliability refers to the consistency, stability, and dependability of test results. In general, the level of reliability is indicated by inner consistency: the higher the reliability coefficient, the more consistent, stable and dependable the result is. In addition, analysing measured items of variables can shed light on the inner consistency of the measurement dimension. Furthermore, when Cronbach's is higher than 0.7, its reliability is high, and when it is lower than 0.7, its

Table 2 Scores of the Outpatient Service Items

No.	Name for Variables	Items of Satisfaction Survey	Mean	Variance
1	B23	Will you choose our hospital for treatment again?	4.56	0.86
2	B20	Are you satisfied with the environment of the hospital and feel comfortable in the hospital?	4.48	0.66
3	B19	Are you satisfied with the sanitary conditions of the hospital?	4.31	0.74
4	B5	Are you satisfied with the technical level for general practitioners in our hospital?	4.21	0.62
5	B6	Are you satisfied with the diagnosis and treatment of the attending doctor?	4.09	0.71
6	B2	Are you satisfied with the patience shown by medical guidance personnel when they answer your questions?	3.96	0.79
7	B21	Are you satisfied with the sign and guidance system of our hospital?	3.91	0.78
8	B7	Are you satisfied with the attitude when the attending doctor asks about your illness, examines and treats you?	3.78	0.73
9	B1	Are you satisfied with the service of the registration system of our hospital?	3.72	0.6
10	B15	What do you think of the one-time charge which contains the entire fee for general practice?	3.69	0.91
11	B12	Are you satisfied with the service of the personnel in the clinical laboratory?	3.64	0.72
12	B14	Are you satisfied with the service of the personnel in the pharmacy?	3.58	0.65
13	B9	Are you satisfied with the privacy protection of our hospital for you?	3.52	0.77
14	B16	Are you satisfied with the waiting time to go to the dispensary?	3.47	0.64
15	B3	Are you satisfied with the waiting time n front of the triage station?	3.36	0.74
16	B18	Are you satisfied with the treatment outcome?	3.24	0.8
17	B4	Can you choose your doctor according to your own will?	3.16	0.79
18	B8	Does the doctor respect your opinion when choosing the therapeutic schedule?	3.05	0.67
19	B22	Do you think that the cost you paid can do justice to the medical treatment you get?	2.94	0.84
20	B17	Are you satisfied with the service of the personnel in the cashier?	2.92	0.91
21	B10	Are you satisfied with the waiting time to have a test (such as routine urine test and blood routine examination)?	2.9	0.83
22	B11	Are you satisfied with the waiting time to have a test (such as B ultrasonic and CT)?	2.72	1.09
23	B13	Are you satisfied with the waiting time to take medicine?	2.51	1.16

reliability is low. The lowest acceptable reliability level is 0.5.

4.1.3 Exploratory factor analysis and confirmatory factor analysis

Exploratory factor analysis and confirmatory factor analysis are used to test the convergent validity and discriminant validity of measured items in each dimension. Reliability alone is not sufficient, since a high reliability measurement may turn out to be completely invalid or invalid to some degree. Therefore, a validity test is necessary. Validity refers to whether tools can produce the expected result for which they are designed. The convergent validity test is decided by the capacity of each item and measured concept factors, while the discriminant validity test calculates the correlation index of related concepts according to confirmatory factor analysis, to test whether 95% of the confidence interval of correlation index includes 1.0. If not, it can be regarded as discriminant valid.

4.1.4 Structural equation modelling analysis

Structural equation modelling combines factor analysis with path analysis and incorporates simultaneous equations in econometrics. Therefore, several variables can be dealt with simultaneously. Moreover, measurement errors in independent and dependent variables are allowed and the factor structure and factor relation can be estimated at the same time. A measurement model of greater flexibility is allowed and the fit degree of the overall model can be estimated so that it can be applied to the causal relationship of the overall model. Maximum likelihood (ML) estimation is adopted in the estimation of the model parameter. While testing the fit degree, indicators of preliminary fit criteria, overall model fit and fit of the model's internal structure are used as criteria. Regarding the overall model fit criteria, chi-square/df value, GFI, RMSR, and RMSEA are used as indicators to study whether the estimated parameters reach a significant level.

Basic information on the patients in the survey is shown in Table 3. According to data from A9, it was found that 34.3% of the patients had gone to the University of Hong Kong-Shenzhen Hospital for the first time and 65.7% had been there more than twice. Hence, the subjects in the survey are mainly patients who visit the hospital repeatedly and their evaluation of the hospital is therefore stable, with fewer errors in the data. According to the questionnaires, the main reason why the patients chose the hospital was its reputation and the advanced medical skills of the doctors, accounting for 53.8% and 33.7%, respectively, of all reasons given, followed by the simplified treatment process, advanced medical technology and equipment, and good attitude to service, which account for 22.4%, 16.5% and 12.7%, respectively.

4.2 Factors influencing patient satisfaction with the outpatient service

SEM can be divided into two models, namely Measurement Equation and Structural Equation.

(1) Measurement modelling is used to describe the relationship between measurement variables and latent variables. The mathematical expression is as follows.

Table 3 Basic Information of Surveyed Outpatients

Item	Percentage (%)	Item	Percentage (%)
A2. Gender		A6. Education degree	
Male	43.8	Master and above	9.6
Female	56.2	University and College diploma	58.3
A3. Age		Technical Secondary School, Secondary Technical School and Senior High School	10.9
Under 18	13.8	Junior High School	7.2
Between 18 and 25	10.9	Primary School and below	14
Between 26 and 35	14.1	**A7. Place of residence**	
Between 36 and 45	42.6	Districts Inside Shenzhen Special Economic Zone	68.2
Between 46 and 55	7.4	Districts Outside Shenzhen Special Economic Zone	26.4
Between 56 and 65	6.8	Districts Outside Shenzhen	5.4
66 and above	4.4	**A1. Clinical Departments**	
A4.Marital Status		General Practice Outpatient	21.7
Single	22.3	Internal Medicine Department	15.3
Married	74.8	Surgical Department	5.1
Divorced or Separated	2	Obstetrics and Gynecology Department	3.5
Widowed	0.9	Department of Pediatrics	19.4

$X = Ux\xi + \delta$.

$Y = Uy\eta + \varepsilon$.

The definitions for the above-mentioned mathematical expressions are as follows:

ξ represents exogenous latent variables. They serve as independent variables and remain unchanged regardless of influences from other variables in the model.

η represents endogenous latent variables. They change in accordance with changes in other variables in the model.

X represents vectors made up of exogenous measurement variables.

Y represents vectors made up of endogenous measurement variables.

Ux represents the rotated component matrix of exogenous measurement variables in exogenous latent variables.

Uy represents the rotated component matrix of endogenous measurement variables in endogenous latent variables.

δ is the error item, which is caused by exogenous measurement variable X.

ε is the error term, which is caused by endogenous measurement variable Y.

(2) Structural Modelling is used to reflect the relationship between latent variables. The mathematical expression is $\eta = B\eta + \Gamma\xi + \zeta$.

The definitions for the above-mentioned mathematical expressions are as follows:

B represents the interaction among endogenous latent variables.

Γ represents the effect and influence of exogenous latent variables on endogenous latent variables.

ζ is the error term of the structural equation.

The coefficient matrix composed of B and Γ, as well as the error vector ζ, serve as the link between endogenous latent variables and exogenous latent variables,

In this research, AMOS7.0 (Analysis of Moment Structures) is used to construct structural equation modelling and carry out parameter estimation and relevant test analysis. This software can utilize path graph to customize models and mapping tools to change path graph in order to change models. It can also graphically display parameter estimation and fitting measurement, as well as the degree of freedom at any point in the mapping in the path graph. In this software, the rectangle represents the measurement indicators, the oval represents latent variables that cannot be measured directly, and the circle represents residual error. A double arrow indicates correlation, while a single arrow represents cause and effect. Exogenous latent variables do not have residual errors whereas endogenous latent variables do.

The graphic interface provided by AMOS is used to map out the causal relationship path graph. In mapping, the corresponding factor for every latent variable in the measure indicator is supposed to be 1. In other words, the unit of

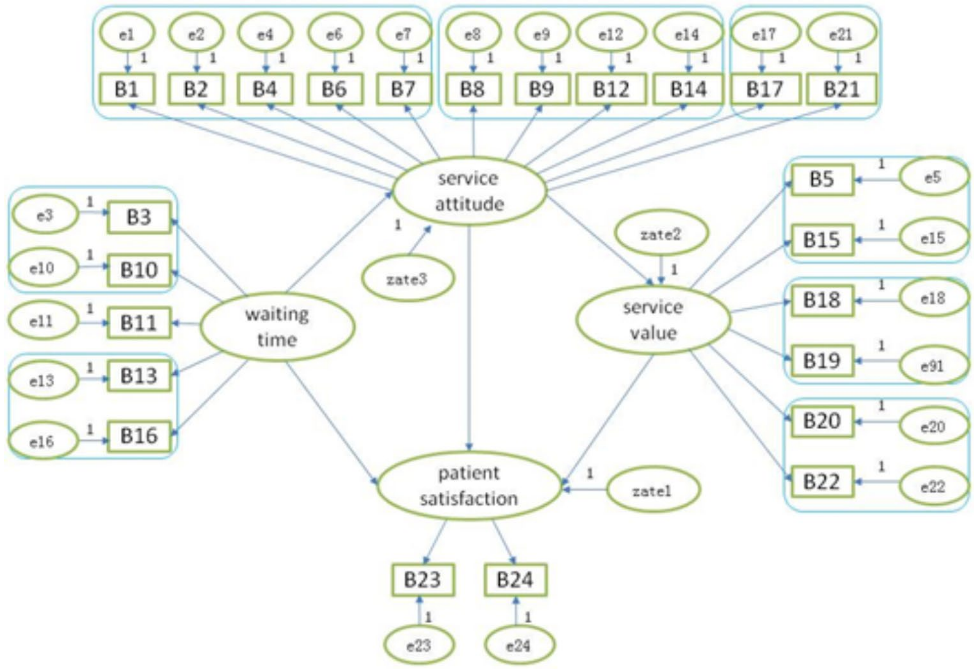

Fig. 3 Causal Relationship Path Graph

Table 4 Model Fit Measures

	CMIN	DF	P	RMR	GFI	AGFI	NFI	RFI	CFI	RMSEA
Default Model	367.194	149	0.000	0.079	0.81	0.786	0.859	0.832	0.897	0.105

measurement for latent variables and the corresponding measure indicators are the same. It is also supposed that the default value for the system error of observed variables is 1 and that at least one path coefficient for the measure indicators has 1 as its initial value. Furthermore, AMOS7.0 will automatically set 1 as the value of the path coefficient, which is one indicator of the measure of the same latent variables. (Fig. 3).

It is estimated that four latent variables exist in this model, namely, service attitude, service value, waiting time and patient satisfaction. The four variables can be explained and defined as follows:

(a) Service attitude is defined as the outpatient medical staff's level of patience, conscientiousness and respect for patients.
(b) Service value is defined as the expertise of medical workers, the curative effects of the treatment provided, the rationality of the medical service charge, and hospital hygiene.
(c) Waiting time is defined as the queuing time and organization of patients throughout the outpatient process.
(d) Patient satisfaction is defined as the overall patient satisfaction rate with the outpatient service in the hospital. The satisfaction rate is influenced by the three variables.

24 constructs from B1 to B24 were used to measure the above-mentioned four variables. Among them, the corresponding variables for patient satisfaction are patient loyalty and the overall evaluation score. The variables e1 to e24 represent the measurement errors caused by the measurement variables. The variables from zate1 to zate3 represent the error for endogenous latent variables.

The fitting situation for the model is shown in Table 4. The indicators of the fitting effect show that the P value which corresponds to the chi-square has a certain statistical significance. The degree of freedom is 1 and the probability value is 0.672, which is higher than the threshold value 0.05. As a result, a null hypothesis is accepted and the model is considered to be appropriate. The ratio of the chi-square to the degree of freedom is more than 2. The values for GFI, AGFI and CFI are all less than 0.9. The value for RMSEA is more than 0.08. Generally speaking, the GFI value should be more than 0.9 while the RMR value and the RMSEA value should be less than 0.05, and the smaller the value, the better. Therefore, this indicates that the fit between data and model is not ideal and this model should be revised. Usually the fitting indicator RMSEA (root mean square error of approximation), which is very sensitive to model errors, is an ideal indicator, particularly when its value is smaller. When its value is less than 0.08, it indicates good fitting. In comparison, it is better for the GFI (goodness of fit index) and AGFI (adjusted goodness of fit index) values to be high. The value of NFI (normed fit index) ranges from 0 to 1. When it surpasses 0.9 the model is acceptable, and the nearer the value is to 1, the better.

In the estimation of regression coefficient, although the regression coefficient P value for wait->satisfaction, attitude->B4, and wait->B3 does not have statistical significance, the other regression coefficient achieves more than 95% in the hypothesis testing of significance. Whether the non-standardized regression coefficient is meaningful is determined by whether the P value is significant (three asterisks indicate that it is significant). Insignificant path needs to be removed in the model revising process afterwards.

5 Results and discussion

The questionnaire and the theoretical model were created on the basis of the theories studied. The results demonstrate that these theories can be useful for the study of patient satisfaction, confirming previous studies. Following an analysis of the theoretical model, the relationship between measured variables and latent variables was found to be clear. After a check on the correction factors, the M.I value between e7 and e15 was found to be the largest, at 15.426. If the correlation between the two variables is strengthened, the chi-square value will decrease to at least 15.426. Therefore, it can be concluded that there is a strong relationship between these two variables. In the causal relationship path diagram, if the correlation of measurement errors between e7 and e15 is strengthened, a revised model can be obtained.

The fitting situation of the revised model is shown in Table 5, from which it can be seen that the new model is better matched to the data. Furthermore, the revised chi-square value of significance is $p = 0.00$. The ratio of the chi-square to the degree of freedom is 2.06, slightly larger than 2.0, but the RMSEA value is 0.057, far less than 0.08. The values for GFI, NFI, and CFI are all greater than 0.9, while the values for AGFI and RFI are all less than 0.9. This proves that the revised model matches its data, in comparison to the previous one. The reason why the chi-square value of significance is 0 is probably connected with the abnormal distribution of the data. Following a regression coefficient analysis, it was found that, except for the P value for attitude->B4, which does not have statistical significance, the other regression coefficients are all greater than 95% in the hypothesis testing of significance.

From the standardized coefficients of variables in the output model of AMOS7.0, the correction and degree of correlation between different variables can be found. In this way, it is easier to figure out which factors are the bottleneck that influences patient satisfaction and then help to make efficient improvement plans. In the software, the covariance between two variables can be shown in sample moments. The coefficients between different latent variables are shown in Fig. 4.

5.1 Correlation analysis of latent variables

The coefficient between latent variables means that a change in one variable will cause a change in another variable. This degree of influence is reflected in the correlation coefficient. It can be seen in Fig. 4 that:

a) The coefficient of influence between service value and patient satisfaction is 0.552. This shows that an addition or improvement of 1% in service value will directly lead to an increase of 0.552% in patient satisfaction.
b) The direct influence coefficient between service attitude and patient satisfaction is 0.499. The indirect influence coefficient caused by service value is $0.758 \times 0.552 = 0.418$. Therefore the total influence coefficient is $0.499 + 0.418 = 0.917$.
c) The direct influence coefficient between waiting time and patient satisfaction is 0.198. The indirect influence coefficient caused by service attitude is $0.413 \times 0.917 = 0.379$. Therefore the total influence coefficient is $0.198 + 0.379 = 0.577$.

As a result, the three variables of service attitude, service value and waiting time have a huge influence on patient satisfaction, leading to the verification of the three hypotheses, especially service attitude, given that its coefficient of influence reaches 0.917. Waiting time alone does not have a significant influence on patient satisfaction (its direct influence coefficient is only 0.198). However, if the indirect influence caused by service attitude is also taken into consideration, the influence coefficient will become 0.577, which deserves the attention of the hospital.

The scores for latent variables are shown in Table 6. It can be seen that patients gave the highest score to service attitude and the next highest score to service value, while giving the lowest score for waiting time. Therefore, reducing the waiting time is the key to making patients more satisfied.

Table 5 Revised Model Fit Measures

	CMIN	DF	P	RMR	GFI	AGFI	NFI	RFI	CFI	RMSEA
Default Model	288.163	128	0.00	0.067	0.903	0.853	0.914	0.856	0.909	0.057

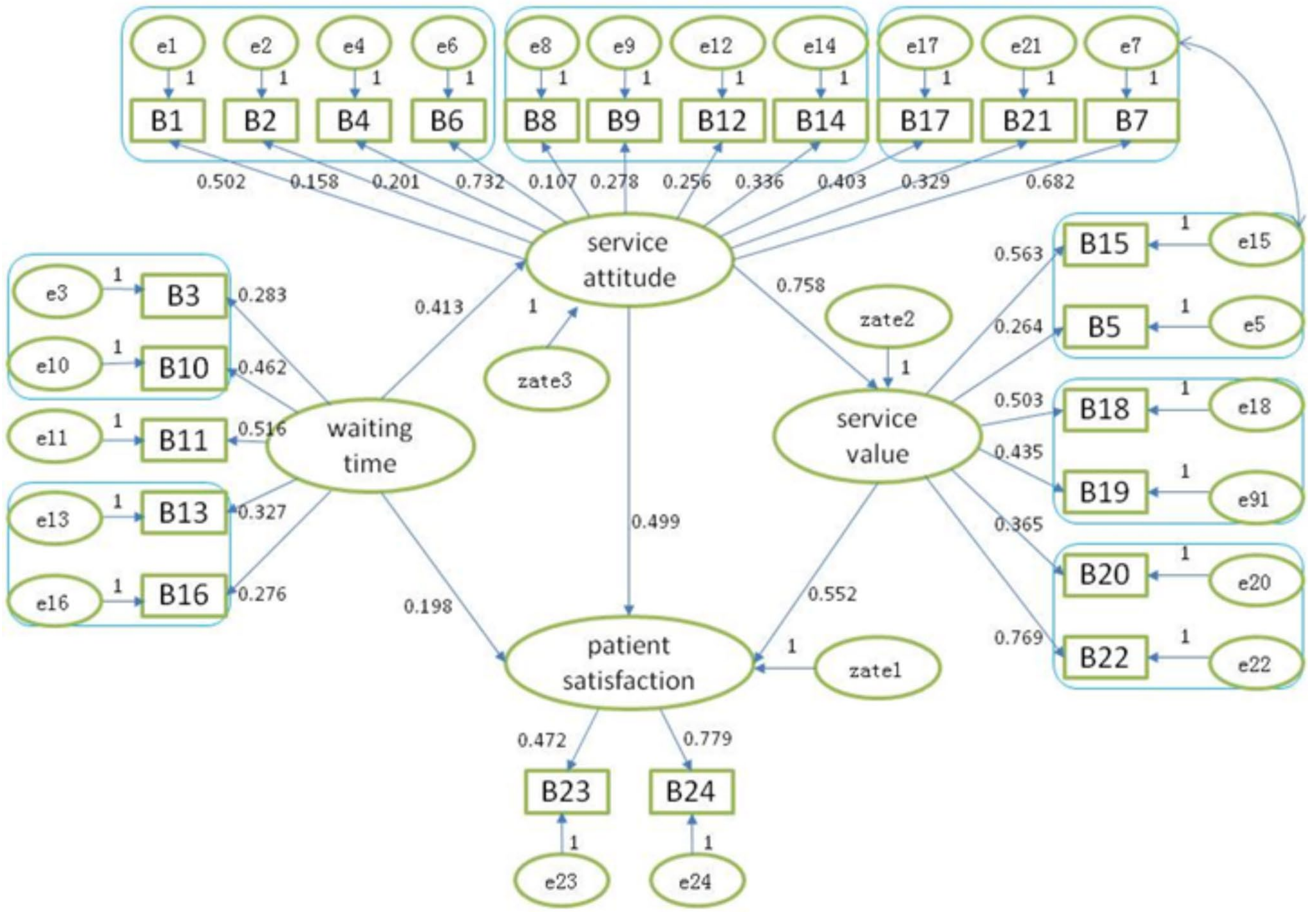

Fig. 4 Standardized Coefficient Distribution Map after Revision

Table 6 Scores for Latent Variables

Latent Variables	Measurement Variables	MEAN	SD
Service value	B5、B15、B18、B19、B20、B22	3.45	0.43
Service attitude	B1、B2、B4、B6、B7、B8、B9、B12、B14、B17、B21	3.68	0.40
Waiting time	B3、B10、B11、B13、B16	2.91	0.52

5.2 Analysing the correlation between measurement variables and latent variables

The correlation between "service value" and the price/performance ratio of medical service is the closest, with the correlation coefficient reaching 0.769. The next closest correlation is between inspection fees and therapy effectiveness. Although service value is also related to the general doctors' medical expertise as well as the hospital environment, comfort and sanitary conditions, the degree of correlation is not significant.

The correlation between service attitude and the physicians' diagnosis and treatment is the closest, with the correlation coefficient reaching 0.732. The degree of conscientiousness of doctors, namely their work attitude while examining and treating patients, has the second closest correlation with service attitude, with the correlation coefficient reaching 0.682. Furthermore, the patient satisfaction level with the appointment service, pharmacy staff service, hospital cashier service and hospital guidance system have the third closest correlation with service attitude, with each correlation coefficient reaching more than 0.3. The data shows that the attitude of hospital patient guides when answering questions, the patient's free choice of doctors, the respect for patients when choosing treatment protocols, the protection of patient privacy, and the attitude of the Medical Examination Department personnel are also correlated with service attitude. However, the degree of correlation is not significant, with the correlation coefficients all below 0.3.

Waiting time is most closely related to medical examinations, laboratory tests and queuing for drug dispensing, with the correlation coefficients reaching 0.516, 0.462 and 0.327 respectively. However, waiting time has a weak correlation with queuing and with waiting for triage and payment of fees, with the correlation coefficients both below 0.3. After comparing the values of all correlation coefficients, it can be seen that the waiting time for medical examinations, laboratory tests, and medicine dispensing is relatively long and can significantly influence patient satisfaction. This should be given priority in process optimization. Although patients have to wait for a long time to get treatment, it does not have a huge influence on patient satisfaction, which is probably because patients have the lowest expected value or the highest degree of tolerance towards waiting to be treated.

Given that the normality of the survey data could not be guaranteed, it was decided to conduct the Wilcoxon rank sum test to analyse the influence of some basic factors, such as gender, occupation and age, on outpatient service satisfaction. It was found that factors such as gender, age, payment method and clinical department significantly influence outpatient service satisfaction. The conclusions are as follows:

a) Male and female patients make quite different comments on service attitude and waiting time: the comments from men are much more positive than those from women.
b) Age also has a certain influence on the level of satisfaction with service attitude and waiting time. Individuals aged 36 to 45 made the most comments while those aged 46 to 55 produced the most negative ones. Furthermore, older people made more comments on waiting time.
c) The payment method also has a certain influence on customer loyalty. To be specific, patients with medical insurance that covers part of their medical costs rank first in terms of loyalty, while patients enjoying free treatment or medical insurance that covers all the costs rank second, with those who seek medical treatment at their own expense ranking last.
d) The clinical department is also a factor that has an influence on waiting time. It was found that the waiting time for treatment in the Gynaecology, Obstetrics and Paediatric departments is much longer than that in other departments. Therefore, the hospital should focus on the Gynaecology, Obstetrics and Paediatric departments when improving its process.

In terms of improving the outpatient hospital service process in the interests of patients, it can be expected that there are mainly three medical service processes which are closely related to the interests of patients, namely departmental treatment, tests and examinations, and diagnosis and treatment. Since the improvement of other processes such as registration, triage for treatment, payment and drug dispensing cannot bring significant benefits to patients, they are defined as non-value-added process. Therefore, the process can be optimized by reducing, integrating, and simplifying the non-value-added processes while ensuring the normal operation of the three above-mentioned processes. The theories studied made it possible to highlight these conclusions.

According to the revised Fig. 4 for standardized coefficient distribution, the waiting time required for different processes has different effects on patient satisfaction, which can be ranked from large to small as follows: examinations (B11), testing (B10), drug dispensing (B13), triage for treatment (B3) and payment (B16). The corresponding coefficients of relationship are 0.516, 0.462, 0.327, 0.283 and 0.276. Hence, reducing the waiting time for examinations, testing and drug dispensing can efficiently improve patient satisfaction.

Following an analysis of the current outpatient service process, the source of inefficiency was determined and can be summarized as follows.

(1) The overly subdivided departments and the lack of medical information sharing result in a poorly-organized and discontinuous outpatient process. Due to the excessive subdivision of functions, patients have to go back and forth between different departments, leading to high patient mobility within the hospital. Currently, some consulting rooms, the pharmacy, examination department, and testing department are even located on different floors. When a doctor asks his or her patient to have a laboratory test, the patient has to leave the consulting room, find the medical laboratory with the test report, and then undergo testing. After the test, the patient has to wait for the result, go back to the consulting room, ask the doctor to prescribe medication and pay for the fee. Only after these processes are completed can the patient receive the medicine. The outpatient process is even more complicated when the patient needs to be transferred to another hospital or needs to visit different departments. Additionally, the lack of information sharing also results in poor coordination and links between different departments. For example, since a doctor knows nothing about supplies of medicine when he or she writes a prescription, the patient may only learn the said medicine is out of stock when they reach the cashier. The patient then has to return to the consultation room to ask the doctor to change the prescription. This situation occurs from time to time in the hospital, not only adding to the flow of patients between the consulting room and cashier, but also affecting the orderliness and continuity of the process.

(2) The unreasonable architectural layout of the outpatient service leads to increased patient mobility and waiting time. In fact, the layout of the medical technology building and departments will directly influence the efficiency of the process. Moreover, the lack of signage in the hospital or the overly small font size of the characters used in signs will further increase patient mobility and waiting time in different service processes. Nurses serving as guides, who

know little about the categories of diseases due to their lack of training, cannot provide an efficient service for patients. Furthermore, the location of some departments, such as Orthopaedics and Obstetrics, is badly-designed. The Orthopaedics Department is located on the second floor, while the Obstetrics Department is on the third floor, which presents great difficulties for patients who need to move around.

(3) The medical and health resources are insufficient and unevenly distributed. Although a comprehensive outpatient appointment system has been established in the hospital for the consultation process, there is still not enough medical staff and examination equipment to meet the needs of patients, since the hospital has only been open for a short time. Given the increasing number of outpatients, a further expansion of the hospital is necessary. Moreover, the comparatively uneven distribution of medical resources to some extent leads to uneven patient mobility in different departments. As analysed, the Gynaecology and Obstetrics, the Paediatric departments receive the majority of patients, while there are relatively few dermatologists.

6 Conclusions

This research analyses the current situation regarding the outpatient service process. In addition, patient satisfaction with this hospital was measured by means of a field questionnaire and interviews. In total, 250 patients at the hospital took part in the survey anonymously and patient satisfaction was evaluated using the 6-grade scale. A validity test was also carried out on the reliability coefficient. The analysis of this survey mainly focuses on the basic situation, percentage of overall satisfaction and the scores of all outpatient service items, covering 24 factors, including sex, age, marital status, occupation, degree of education, address, payment category, family monthly income, reservation and registration, communication between doctors and patients, treatment effect, hospital signage, service attitude, hospital environment, hospital hygiene, and waiting time for each process.

In order to determine the specific process that has the greatest impact on patient satisfaction from the quantitative analysis method, which is also the bottleneck for the hospital outpatient process, a structural equation model was used. With this model, the interactive relationship between multiple variables and the relationship between multiple reasons and results, including some unobservable variables (latent variables), can be studied. It was assumed that there were four latent variables in the established model, namely service attitude, service value, waiting time, and patient satisfaction.

Through regression analysis and parameter estimation, the relationship between e7 and e15 was added, and it was found that service attitude, service value and waiting time have a significant influence on patient satisfaction. In particular, the influence coefficient of the service attitude reached 0.917. Meanwhile, the direct and indirect influence of waiting time on patient satisfaction cannot be neglected, since these factors might be the key to improving patient satisfaction.

In this study, the diagnoses and analyses of the HKU-SZH outpatient process were carried out by means of field investigation and measurement of patient satisfaction. Rather than regression analysis, correlation analysis or factor analysis, the measurement is based on a structural equation model, from which the influence of different processes on patient satisfaction can be accurately calculated. This method not only embodies the service philosophy of “putting patients first”, but also serves as an entry point for process reengineering. An in-depth analysis was carried out on deficiencies in the appointment registration system for the all-patients model. Information technology was used to reengineer the HKU-SZH outpatient process so that its medical resources are utilized rationally and efficiently. In this way, the difficulty of accessing medical services was solved to some extent. This empirical study is of practical significance, as it is in line with the Outline National Development Plan for Health Information.

The major limitations and suggestions for further study are as follows:

1. There is no quantitative analysis to evaluate the effects of process improvement. One method to improve and perfect the process improvement plan would involve devising a scientific measurement scale for patient satisfaction, for a more in-depth investigation of patients and hospital staff. The effects of hospital progress should be evaluated using the Cost-Benefit Analysis Method. Special attention should be paid to the changes in patient satisfaction, especially in the hospital process, before and after process reengineering.
2. With regard to sharing resources on treatment information, it is necessary to seek help from government departments such as the Shenzhen Health and Family Planning Commission. Only with their help can a medical information-sharing platform be built to ensure treatment information is shared between different hospitals.
3. Dialogue and negotiations with medical security institutions are recommended, for the purpose of proposing a functional integration of social security cards and co-branded cards. In this way, patients would only need one card for medical services, which is convenient and efficient.

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Availability of data and materials Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest Both authors declare that they have no competing interests.

Ethics approval Not applicable.

Consent to participate Informed consent was obtained from all individual participants included in the study. This study is not a clinical trial.

Consent to publish Not applicable.

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