# Research on the design of household coagulation testing product service system

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## ABSTRACT

In this study, the product service system was introduced to study and design the postoperative health management of patients with coronary heart disease, aiming at solving the problems such as difficult medication guidance and high reexamination time cost for patients with coronary heart disease. The user journey map, which focuses on user experience, was used to identify the requirements and pain points of postoperative health management of patients with coronary heart disease. Combined with Kano model, the functions transformed from requirements and pain points were classified and prioritized to guide the design of product service system. Through the research, the framework of product service system is established, and the household coagulation testing product service system is visually displayed through the service blueprint. The design of household coagulation tester, interactive interface of mobile and computer software is produced, so as to improve the efficiency and effectiveness of health management for patients with coronary heart disease and realize a one-stop service platform integrating medical diagnosis, medication guidance and health management. The findings of this study propose a new noninfectious chronic disease (NCD) management mode taking coronary heart disease health management as an example, and provide a reference for the research of NCDs management system in China.

**Keywords:** Household coagulation test, product service system, Kano model

## 1. INTRODUCTION

NCDs, such as cardiovascular and circulatory diseases, diabetes mellitus and cancer, are the leading causes of death and disability worldwide[1]. In order to reduce the burden of NCDs on global mortality and economic resources, the UN set "25% reduction in premature deaths caused by NCDs by 2025" as a global goal at the 2011 High-Level Meeting on NCDs[2]. Under the goal of the UN to control NCDs, the requirements for NCDs management are particularly important. Among NCDs, cardiovascular disease is the leading cause of death in the world, accounting for 1/3 of the total number of deaths in the world[3]. Common cardiovascular diseases include coronary heart disease, stroke and hypertension. Relevant data from the WHO show that coronary heart disease (CHD) has become the main cause and disease leading to premature death of human beings worldwide[4]. Cardiovascular physicians said that patients with the degree of coronary artery stenosis exceeding 75% among patients with CHD are generally treated by coronary stent implantation, in China. Postoperative patients need to take anticoagulants for life, and the dosage should be determined according to coagulation. However, due to the high cost of reexamination time and the resistance of patients, it is difficult for patients to carry out a proper postoperative health management.

For NCDs, developed countries, led by the United States, have established personalized management systems through actively cooperation between patients and health management teams. This care mode can effectively control the progress of the disease[5]. However, in countries with high mortality rate of NCDs such as China and India, the professional health management system for NCDs is still vacant. Aiming at the vacancy of NCDs health management system in China and the requirements of patients with CHD, product service system (PPS) is an effective mode to fill this vacancy. The core idea of the product service system is that the enterprise changes from simply designing and selling material products to providing an integrated scheme of products and services to better meet the requirements of users[6]. This study takes the health management system for patients with CHD as an example, integrating "household medical products, professional medical services and the Internet" into the health management system, assisting patients with CHD in health management through technical and professional guidance.

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## 2. PROCESS AND METHOD

### 2.1 Research process

The PSS adheres to the design concept of taking user value as the core, user requirements as the leading factor and user experience as the focus. Based on the guidance of the above concept, this study's design of research process adheres to the user as the core, and combs the user requirements through Kano model (Figure 1). In the user research stage, patients with CHD and cardiovascular physicians were interviewed, and user journey map was established to gain insight into requirements and pain points. In the stage of function research, according to the requirements and pain points to identify the functions, and the functions were refined and prioritized by Kano model. In the design stage, the PSS scheme, software and hardware were designed and studied.

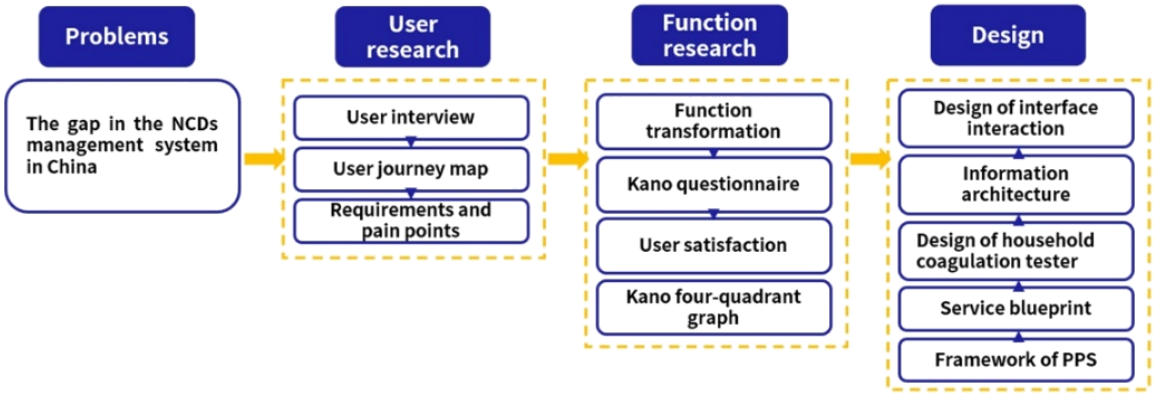


Figure 1. Research process.

### 2.2 Kano model

Kano model is a tool proposed by Professor Noriaki Kano. Based on analyzing the influence of different functions on user satisfaction, Kano model classifies and prioritizes user requirements, reflecting the nonlinear relationship between product functions and user satisfaction. Professor Noriaki Kano divided product quality characteristics of Kano model into must-be quality (M), one-dimensional quality (O), attractive quality (A), indifferent quality (I) and reverse quality(Q) (Table 1)[7]. Kano questionnaire is one of the main tools of Kano model. By setting forward and reverse questions for each function in the questionnaire, users' different attitudes towards the existence of functions are identified. Functional attributes are classified through Kano model evaluation form (Table 2). And the maximum of the statistic is used as the basis for evaluating the characteristics of product quality. Berger judge the degree of influence of a function on user satisfaction by calculating customer satisfaction index (SI) and customer dissatisfaction index (DSI) on the basis of Kano model[8]. In order to prioritize functions more accurately, this study uses customer SI and customer dissatisfaction (DSI) index as guidance, based on the Kano questionnaire. And the formula is as follows:

$$SI = \frac{1}{A+O}(A+0+M+I)$$

$$DSI = -\frac{1}{M+O}(A+O+M+I)$$

## 3. RESULTS

### 3.1 User research

In the user research stage, we identified users' goals, requirements and pain points through user interviews and user journey map. In order to ensure comprehensive coverage of interview information, the interviewees included 5 patients with CHD and 3 cardiovascular physicians. In the interview, interviewees described their behaviors, experiences, opinions and attitudes related to CHD health management. Based on the user interview analysis, the user journey map was established to gain insight into the user requirements and pain points (Figure 2).

Table 1. Product quality characteristics of kano model.

| **Product quality Type** | **Characteristics of product quality** |
|---|---|
| Must-be quality | When such requirements are satisfactory, satisfaction will not increase significantly; If not, satisfaction will be greatly reduced. |
| One-dimensional quality | Satisfaction is positively correlated with the optimization level of this kind of requirements. |
| Attractive quality | When such requirements are satisfactory, satisfaction will increase sharply. And deficiency will not make satisfaction reduce. |
| Indifferent quality | Whether such requirements are provided or not will not affect the experience and satisfaction. |
| Reverse quality | Providing such requirements will reduce satisfaction. When there is no such requirement, it will improve satisfaction. |

Table 2. The evaluation of kano model.

| | **Dysfunctional** | | | | |
|---|---|---|---|---|---|
| **Functional** | **Like** | **Should be** | **Neutral** | **Live with** | **Dislike** |
| Like | Q | $A_1$ | $A_2$ | $A_3$ | O |
| Should be | $R_1$ | $I_1$ | $I_2$ | $I_3$ | $M_1$ |
| Neutral | $R_2$ | $I_4$ | $I_5$ | $I_6$ | $M_2$ |
| Live with | $R_3$ | $I_7$ | $I_8$ | $I_9$ | $M_3$ |
| Dislike | $R_4$ | $R_5$ | $R_6$ | $R_7$ | Q |

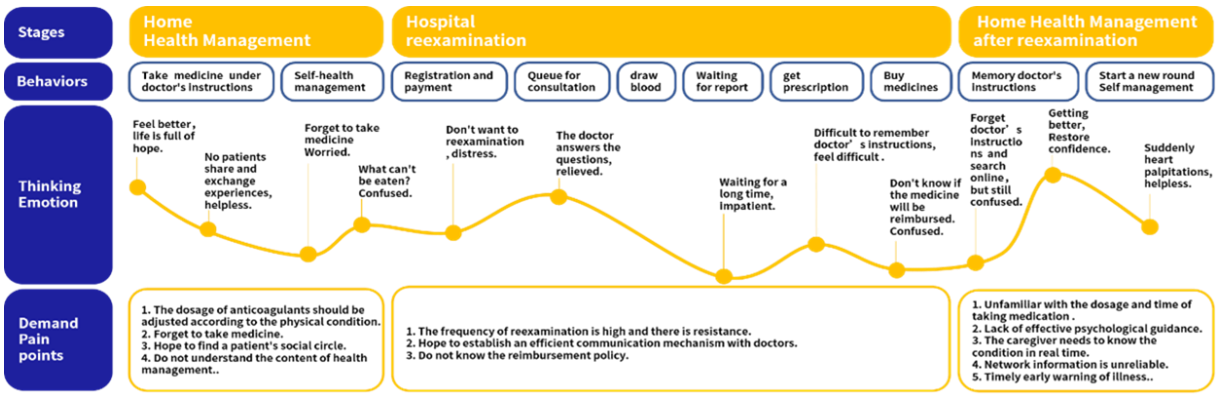


Figure 2. User journey map.

### 3.2 Function research

3.2.1 Function Transformation. On the basis of the user journey map of patients with CHD, the collected requirements and pain points were sorted out and transformed into functions. Eleven main functions were finally extracted as the analysis object of Kano model, and recorded as F1, F2, F3… (Table 3).

Table 3. Function transformation of requirements and pain points.

| Category | Requirements/pain points | Function transformation | Serial number |
|---|---|---|---|
| Particularity of disease management | The dosage of anticoagulants needs to be adjusted according to physical conditions | Test of coagulation value | F1 |
| | The frequency of reexamination is high, there is resistance, and I hope to establish an efficient communication mechanism with doctors | Peripheral index collection | F2 |
| | Do not understand the reimbursement policy | Electronic patient record | F3 |
| Administration of medication | Forget to take medicine | Online doctor-patient communication mechanism | F4 |
| | Unfamiliar with the dosage and time of taking medicine | Associated social security function | F5 |
| Daily life management | Do not understand the content of health management | Medication reminding function | |
| | Lack of effective psychological guidance | | F6 |
| Social needs | Hope to find a social circle of patients | Lifestyle guidance function | |
| Health knowledge | Network information is unreliable | Psychological guidance function | F7 |
| Prevention and care | Timely early warning of illness | Patient-to-patient communication mechanism | F8 |
| | The caregivers need to know the condition in real time | Targeted health knowledge push | F9 |

3.2.2 Function Refining and Sorting. Kano questionnaires were formulated according to the functions obtained from the transformation of requirements and pain points. And 60 questionnaires were distributed to patients with CHD, 59 valid questionnaires were recovered. Based on the evaluation of Kano model, according to the results of questionnaire, the attributes of functions were classified. In order to understand the influence degree of different functions on user satisfaction, the SI and the DSI were calculated by using the formula (Table 4). Due to the results of questionnaires show that the "peripheral index collection function" is an indifference quality, and the existence of this function will not affect users, so there is no need to calculate the user satisfaction of it.

According to the calculation results of SI and DSI, a four-quadrant graph with the SI and the absolute values of DSI as abscissa and vertical coordinates respectively is constructed, and its average value is taken as critical line[9]. The four quadrants represent one-dimensional quality, must-be quality, indifferent quality and attractive quality in turn (Figure 3). After classifying the functional attributes in four quadrants, the functional priorities are sorted according to the order of must-be quality, one-dimensional quality and attractive quality (Table 5).

Table 4. Attributes and SI and DSI of functions.

| Serial number | Functional attributes | Attribute proportion | SI | DSI |
|---|---|---|---|---|
| F1 | M | 45.76% | 0.41 | -0.78 |
| F2 | I | 35.59% | - | - |
| F3 | M | 37.29% | 0.56 | -0.69 |
| F4 | O | 40.68% | 0.49 | -0.54 |
| F5 | A | 59.32% | 0.59 | -0.27 |
| F6 | M | 37.30% | 0.29 | -0.53 |
| F7 | O | 40.68% | 0.8 | -0.58 |
| F8 | O | 35.59% | 0.68 | -0.63 |
| F9 | A | 55.93% | 0.59 | -0.17 |
| F10 | A | 54.24% | 0.59 | -0.24 |
| F11 | A | 50.85% | 0.66 | -0.19 |

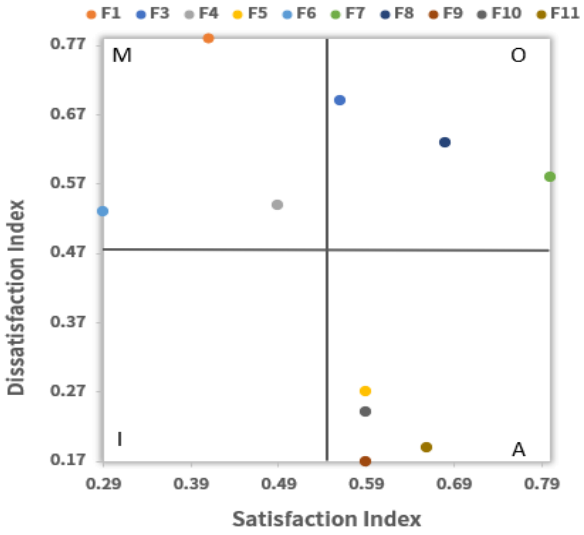


Figure 3. Four-quadrant diagram of Kano model.

### 3.3 Design of household coagulation testing PSS

3.3.1 Framework of Household Coagulation Testing PSS. The household coagulation testing PSS has four parts including tester and APP, patient, hospital and external businesses (Figure 4). The tester and APP part includes household coagulation tester and APP used by patients. The patient part is CHD patients who need health management, the hospital part refers to professional medical teams, and the external business part includes pharmacies and outsourcing service teams.

Table 5. Functional prioritization.

| Serial number | Functions | Four-quadrant attribute | Ranking |
|---|---|---|---|
| F1 | Test of coagulation value | Must-be quality | 1 |
| F4 | Online doctor-patient communication mechanism | | |
| F6 | Medication reminding function | | |
| F3 | Electronic patient record | One-dimensional quality | 2 |
| F7 | Lifestyle guidance function | | |
| F8 | Psychological guidance function | | |
| F5 | Associated social security function | Attractive quality | 3 |
| F9 | Patient-to-patient communication mechanism | | |
| F10 | Targeted health knowledge push | | |
| F11 | Function of associating relatives | | |

3.3.2 Service Blueprint. Based on the framework of household Coagulation testing PSS, taking optimizing the service process as the key point, the visual results of the product service system are presented by using the service blueprint (Figure 5). The service blueprint includes the stages, locations, service nodes, front stages and back stages, providing basis for the design of PSS and APP's framework.

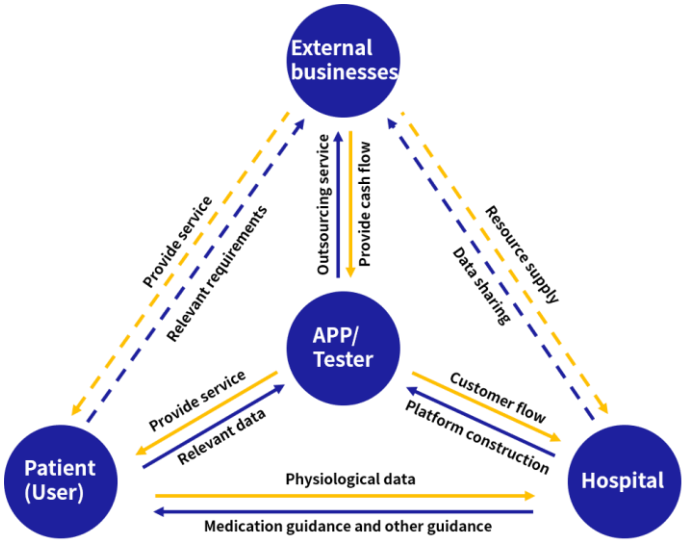


Figure 4. Framework of household coagulation testing PSS.

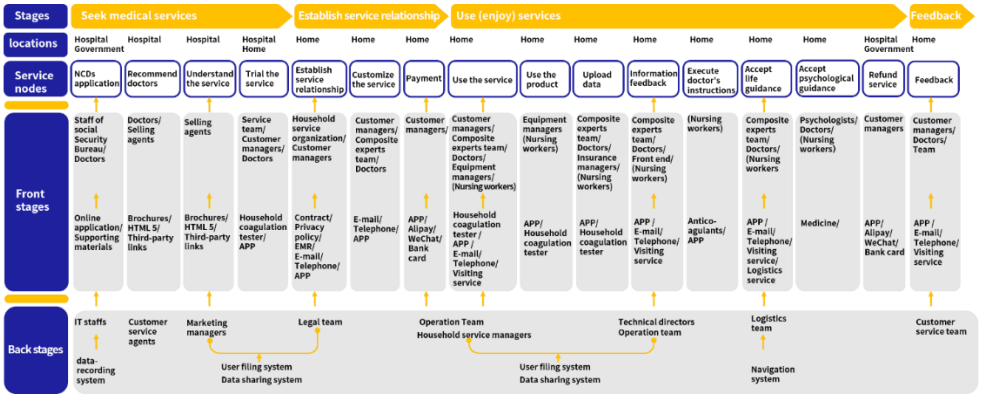


Figure 5. Service blueprint.

3.3.3 Design of Household Coagulation Tester. At present, the coagulation detection equipment on the market is limited by technology, with large volume, complex structure and high price, so it is only suitable for large hospitals. Bioengineering College of Chongqing University, aiming at the research results of magnetoelastic sensor of coagulation testing equipment, has realized the portability and low cost of coagulation testing equipment, and also has realized that coagulation index can be tested by using a small amount of untreated blood, providing important technical support for this research (Table 6). In the modeling design of the household coagulation tester, considering the large base of elderly patients with CHD, the appearance design of the tester, the key setting and content display is as simple as possible to ensure the ease of use of the tester. Due to the high frequency of use of the tester, the charging device is designed as a base to ensure the dual-purpose of charging and storage (Figure 6).

Table 6. Patent for invention.

| Patent name | Patent no. |
|---|---|
| Multi-channel magnetoelastic sensor detection chip | 201410312542.2 |
| A kind of Magnetoelastic sensor detection device | 201710153873.X |
| A kind of multi-channel magnetoelastic sensing device | 201710153466.9 |


Figure 6. Design of household coagulation tester.

3.3.4 Design of the Software. Based on the research of the PSS, design of interactive interface part is divided into the mobile APP terminal used by patients and their families and the PC terminal used by cardiovascular physicians (Figure 7).

The APP mainly has three core functions: the first core function is to assist coagulation test. Patients connect the household coagulation tester through mobile phone Bluetooth to obtain coagulation index and upload it to cardiovascular physicians. The second core function is the doctor's medicine list. Cardiovascular physicians make medicine lists and instructions for patients based on coagulation testing index, and patients can place orders with one click. The third function is medication reminder, which will push medication reminder when patients need to take medication. In the interface design of APP, considering that most users are the elderly, the interface information is concise and clear. Improve the contrast in color to make the interface clearer and easier to identify (Figure 8). The PC used by cardiovascular physicians mainly covers three parts: patient coagulation testing index record page, instructions filling page and online diagnosis page. The page is designed to be simple and easy to use (Figure 9).

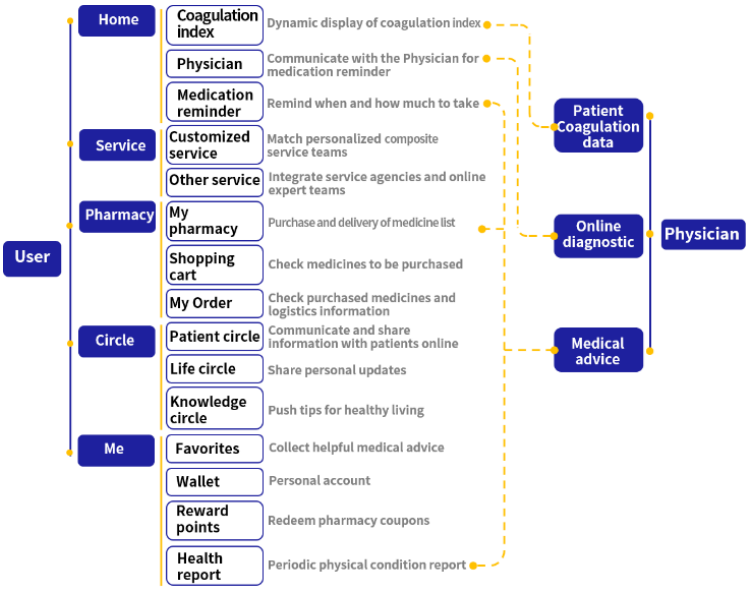


Figure 7. Functional framework of APP.

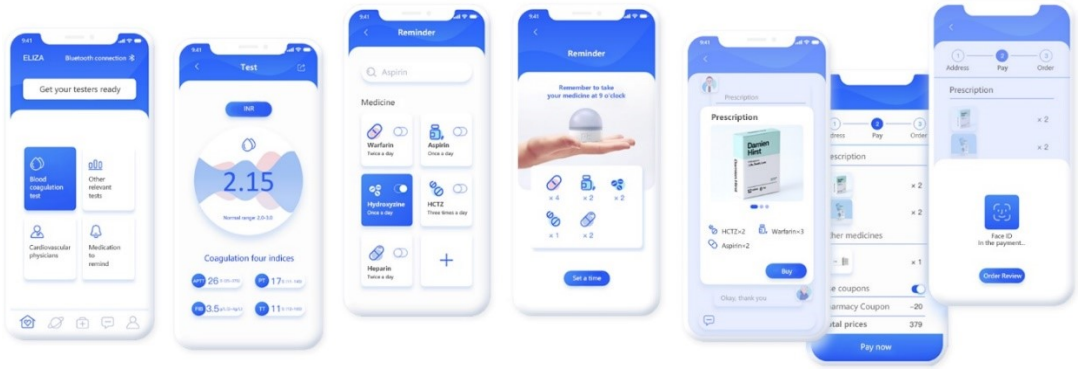

Figure 8. Design of APP interactive interface for patients.

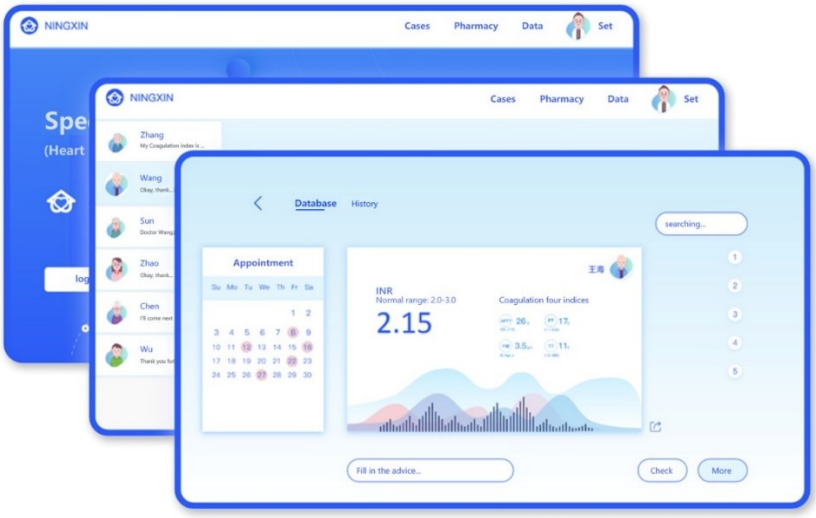


Figure 9. Design of PC interactive interface for physicians.

## 4. DISCUSSION AND CONCLUSION

In this study, a postoperative health management system for household coagulation test of patients with CHD under the mode of PSS is proposed. Based on user research, Kano model is applied to refine and sort the functions of the PSS, which ensures the rigor of the design, and at the same time, excavates the functions that can improve the user experience from the user's perspective, and to avoid the waste of design resources. The findings of this research can provide some reference for subsequent related research.

Since the household coagulation testing PSS needs to be evaluated after the users actually use the system, the household coagulation testing PSS needs to be iterated and improved continuously according to the feedback of users' usage in the follow-up research.

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