Evaluation of the effects of a new integrated health management service model on people with risk factors for dyslipidemia

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Abstract

**Background:** Dyslipidemia is a factor that affects the occurrence and development of many chronic diseases. With its prevalence increasing each year, dyslipidemia has caused substantial disease and economic burdens in China and around the world. Appropriate health management is imperative for people with risk factors for dyslipidemia. We established a new model of health management services (integration of general practice and personalized disease prevention in health management, IGPDP) to more appropriately manage people with risk factors for dyslipidemia.

**Methods:** The experiment was conducted in Shenyang, Liaoning Province, China. We selected 5 administrative districts with populations of more than 100,000. Twenty-three community health service centers with a daily average of more than 50 outpatients were selected. A total of 5,032 subjects with risk factors for dyslipidemia who met the inclusion criteria were included in this study. Using prospective cohort study methods, the subjects were followed up for 24 months. The subjects were randomly divided into the control and test groups, and they received traditional health management services or IGPDP. We analyzed and compared changes in disease prevention, health protection, and health promotion between the two groups.

**Results:** In terms of disease prevention, we found that after the intervention, subjects’ behavioral risk factors (smoking habits, diets, sedentary lifestyles) and health literacy improved. In terms of health protection, we observed a decrease in Body mass index (BMI), a gradual improvement in blood lipid levels, and an overall increase in quality of life scores. In terms of health promotion, after the intervention, the proportion of the subjects who were willing to accept the contracted services of general practitioners increased.

**Conclusion:** IGPDP can effectively cultivate healthy lifestyles, improve health literacy, reduce biological risk factors, decrease risk of dyslipidemia, and improve quality of life of subjects. IGPDP is conducive to improving the quality of the service of general practitioners, increasing the trust of the general public, and facilitating the establishment of a hierarchical medical system.

**Background**

Dyslipidemia usually refers to abnormal blood lipid metabolism in the human body. According to the diagnostic criteria of the revised guidelines for the prevention and treatment of dyslipidemia in Chinese adults, which were newly formulated in 2016, abnormalities in serum triglyceride (TG), total cholesterol (TC), serum low-density lipoprotein cholesterol (LDL-C) and serum high-density lipoprotein cholesterol (HDL-C) can be diagnosed as dyslipidemia [1]. In the past 30 years, the prevalence of dyslipidemia has been increasing each year, and dyslipidemia has become a public health concern [2]. To fundamentally solve this problem, it is necessary to implement sensible health management for people with risk factors for dyslipidemia.

The health management service model is a relatively new health management model that has been proposed in recent years. Different from the general specialized medical service model, this new model mainly targets chronic diseases (including hypertension, diabetes, etc.) whose prevalence rates are increasing annually [3-5]. In the past 30 years, to solve the burden of chronic diseases, health management has rapidly been established in developed countries. However, health management has only started in China, mainly in the form of physical examinations, and health management is gradually attracting the attention of all parties [6-10]. Although some achievements have been made in the application of the traditional health management model in China, there are still many problems to be solved; for example, the complete medical service model has not been formed, and the personalization is not good. In the past, the traditional health management service model only included a physical examination by an examiner to obtain a simple result, nothing more. Participants did not completely understand their health status after the physical examination, and there was no doctor to explain and guide the physical examination. In addition, research on the traditional health management service model mainly focuses on populations with chronic diseases, such as hypertension and diabetes, and pays little attention to populations with risk factors for chronic disease. To solve the drawbacks described above, this study applied a model (integration of general practice and personalized disease prevention in health management, IGPDP) that combines general practice with personalized disease prevention. IGPDP is an evidence-based health management service model that was established based on the Chinese traditional health management service model and includes the experience of general practitioners around the world. IGPDP incorporates general practice and personalized disease prevention in the health management service framework and provides early screening, early warning, risk factor intervention, and long-term follow-up services for people with major chronic diseases and relatively healthy people who are at risk of these diseases (i.e., people with risk factors for dyslipidemia in this study). IGPDP emphasizes that general practitioners and their teams provide subjects with people-oriented, personalized, continuous, comprehensive, and active health management services. The aim is to provide a systematic service program for health managers to help subjects improve self-efficacy, promote behavioral change, and improve health outcomes.

To explore the difference in the application values and effects of IGPDP and traditional health management models in people with risk factors for dyslipidemia, we studied the differences in disease prevention, health protection, and health promotion at different times.

**Methods**

**General Information**

We established the IGPDP prospective study cohort and conducted the study for 24 months. Random sampling was used for sampling. Patients who visited each community health service center within one month and met the inclusion criteria were included in this study, until the number reached the required number.

The sampling steps were as follows: First, the experiment was conducted in Shenyang, Liaoning Province, China. The sampling frame of this study were the lists of districts and community health service centers in Shenyang. We selected 5 administrative districts with populations of more than 100,000, and we selected community health service centers in these administrative areas with an average daily outpatient volume of more than 50 people. Then, according to
the population distribution of Shenyang, a certain number of community health service centers were randomly selected in each administrative region to be included in this study (Table 1) [11, 12]. Finally, the subjects were randomly divided into a control or test group. In Dadong District, Heping district, and Shenhe District, half of the community health centers were randomly selected as the control group, and the other half were selected as the test group. At the community health centers in Huanggu District and Tiexi district, half of the study subjects were randomly selected as the control group, and the other subjects were selected as the test group (Table 1). The Medical Ethical Commission of the China Medical University approved this study. We obtained written consent from the study participants.

Table 1 Source and grouping of research samples

| Inclusion and exclusion criteria |
|---------------------------------|

A prospective cohort study was carried out, and the inclusion and exclusion criteria are shown in the table below (Table 2). The population with risk factors for dyslipidemia was selected as the research population. Overweight or obesity, current smoking habits, unhealthy diets, and sedentary lifestyles were inclusion criteria. People who were older than or equal to 80 years old or younger than 18 years old, who had been clearly diagnosed with cardio-cerebrovascular diseases (myocardial infarction, stroke), lung cancer, and chronic obstructive pulmonary disease, who are unable to adhere to treatment or use other treatment methods that affected the data collection and efficacy assessment, who were pregnant or lactating, or who had with a genetic dyslipidemia disorder were excluded.

Table 2 Inclusion and exclusion criteria

| Intervention methods |
|----------------------|

IGPDP was used in the test group, and the traditional health management service model was used in the control group. In the control group, an annual physical examination was carried out according to the medical examination package for the subjects, group health consultation was provided for the subjects, and coordinate specialist referral was required. In the test group, the one-year intervention cycle was divided into a two-month strengthening phase, a one-month consolidation phase, and a nine-month stable phase (Fig. 1). According to the individual condition of the subjects, we designed a health plan for them and provided personalized diet and exercise guidelines according to the plan. After a period of intervention, the health plan was modified or reformulated according to changes in the subjects' health status. The effect of implementation was evaluated by analyzing the subjects' questionnaire results and clinical indicator results at baseline, 12 months, and 24 months (Fig. 2).

Fig. 1 Health management cycle

Fig. 2 Technology roadmap

| Evaluation index system |
|-------------------------|

We evaluated the effect of IGPDP from three perspectives: "disease prevention", "health protection", and "health promotion". The results at baseline, 12 months after intervention, and 24 months after intervention were collected by measuring clinical indicators and questionnaires. The data were collected by trained investigators (Table 3).

Table 3 Evaluation index system

| Specific information of questionnaires |
|--------------------------------------|

When formulating an index system for evaluating the effectiveness of health management services, we used evidence-based methods to study a large amount of literature, learn from advanced health management experiences around the world, and hire multidisciplinary senior experts. From multiple angles and multiple dimensions, the main measurable and quantifiable indicators that could reflect the difference between the two health management models were selected within the research time limit.

| Health risk assessment questionnaire |
|-------------------------------------|

This questionnaire was used to collect the subjects' basic information, behavioral risk factors, biological risk factors, and other related indicators. The questionnaire included the subjects' basic information, disease history, family history, tobacco use, alcohol consumption, daily diet and exercise, sleep quality, psychological status, living environment, and basic physical indicators (waist circumference, BMI, blood pressure, blood lipid, fasting blood glucose, etc.).

| National Residents' Health Literacy Monitoring Questionnaire |
|-------------------------------------------------------------|

This questionnaire was used to measure participants' health literacy. The questionnaire covers three dimensions: basic knowledge and concept, healthy lifestyle and behavior, and basic skills. This questionnaire is specifically divided into six categories: health science concept, prevention and treatment of infectious diseases, prevention and treatment of chronic diseases, basic medical treatment, safety and first aid, and access to health information. The scoring standard of the questionnaire is 1 point for each question of judgment and single-choice questions, and two points are given for each multiple-choice question. Patients scoring greater than 80% accuracy are considered to have health literacy [13].

| Health status SF-36 Questionnaire |
|-----------------------------------|


This questionnaire was used to measure the quality of life of the subjects. This questionnaire comprehensively measured the quality of life of the subjects from 8 perspectives: physical enginery, physiological function, physical pain, general health, energy, social function, emotional function, and mental health. In addition, this questionnaire also included health change indicators to evaluate the overall changes in the subjects' health status over the past year. According to the choice weight or score of the SF-36 questionnaire, the total score of SF-36 was 145.

**Basic Health Service Demand Questionnaire**

This questionnaire was used to investigate the needs of community residents for basic medical and health services. The questionnaire included three aspects: basic medical and health service, general practitioner, and community health service center. This questionnaire provided a reference for improving the services of general practitioners and allowing them to better meet the needs of the public.

We verified the reliability and validity of the questionnaire items. We also carefully designed each indicator item, the total evaluation item, and subindicator item for the research question to confirm each other. We analyzed the reliability of this questionnaire based on a small sample of survey data and tested the comprehensibility of each survey index. We sent the questionnaire to the relevant industry experts, and we asked the industry experts to check and correct it to ensure the scientific and structural rationality of the index system. We standardized the research process and avoided random filling-in. We chose the subjects carefully and emphasized the importance of the research data. We prevented the subjects filling in the data at will, trying to maintain the rigor and objectivity of the survey data.

**Statistical analysis**

Each monitoring and investigation in this study underwent the process of data cleaning, data verification, and standard database establishment. Epidata 3.1 software was used to establish a database. Logical error checking was conducted after data entry, and the outliers, such as missing values, singular values and extreme values, were returned to the original research institution for verification against the original questionnaire. Then, we randomly selected data at a rate of 20% and verified these data with the original data. Each research subject had finished the observation and follow-up, and the data had been retrieved, entered, and verified. After ensuring that that the database was correct, we locked the database for statistical analysis. Under normal circumstances, the data cannot be modified again. SPSS 22.0 software was used for statistical analysis of the data. The measurement data are described as the mean ± standard deviation, and the rate was used to describe the counting data. We used the rate to calculate the proportion of a certain type of patient in the total population. The numerator is the number of patients of a certain type, and the denominator is the total number in the population. The chi-squared test was used to compare the rates. The changes in behavioral risk factors of current smoking habits, unhealthy diets, sedentary lifestyles, changes in health literacy levels, and proportion of people who were willing to accept general practitioners in different study groups were compared by the chi-squared test. The t-test of two independent samples was used to compare the measurement data between the two groups. The comparison of the BMI levels in obese people, comparison of the blood lipid levels in people with dyslipidemia, and changes in the total score of the quality of life assessment in the different study groups were compared by T test. Test level $\alpha = 0.05$.

**Results**

**General Characteristics of subjects**

The general characteristics of the subjects in the test and control groups at baseline are shown in Table 4. There was no statistically significant difference between the two groups in terms of general conditions and health indicators, indicating that the two groups were balanced and comparable at baseline.

The average age of the control group was 50.2 ± 14.0 years old, and in this group, 56.8% were female, 71.3% were married, 36.1% had a junior college degree, 42.7% were retired, 83.4% were nonsmokers, and 85.2% had never consumed alcohol. The average age of the test group was 53.8 ± 14.9 years old, and in this group 56.8% were female, 67.9% were married, 33.9% had received a junior college education, 33.9% were retired, 76.1% had never smoked, and 78.8% had never consumed alcohol.

**Changes in behavioral risk factors before and after intervention in different groups**

In both the control and test groups, the proportion of subjects who smoked, ate unhealthy diets, and sat for long periods after the intervention decreased compared with that before the intervention, and the differences were statistically significant. The changes in behavioral risk factors before and after intervention in the different groups are shown in Table 5.

**Changes in health literacy levels after intervention**

In the test group, the baseline health literacy level of the subjects of different genders and ages was higher than that in the control group, except for the group aged 60-79 years, and the differences were statistically significant. After 12 months of intervention, except for the test group aged 60-79 years, the health literacy level of the subjects of different genders and age groups all showed a downward trend, the reasons for which need further analysis. After 24 months of intervention, the level of health literacy was generally improved compared with that before the intervention, and the difference was statistically significant. The health literacy level of the test group was still higher than that of the control group, and the difference between the two groups of subjects of different genders and ages was statistically significant. The changes in the health literacy levels in the different groups after intervention are shown in Table 6.
Table 6 Changes in health literacy levels after intervention in different study groups

BMI changes in obese people before and after intervention in different groups

After the intervention, the BMI of obese people in both the control and test groups showed a decreasing trend, and the difference was statistically significant. BMI changes in the obese people before and after intervention in the different study groups are shown in Table 7.

Table 7 Comparison of BMI levels in obese people in different study groups

Changes in blood lipid levels in subjects with dyslipidemia before and after intervention in different groups

After the intervention, the TC, TG, and LDL-C levels of the subjects showed a decreasing trend in both the control and test groups. Except for the difference in the LDL-C levels, the other differences were statistically significant. After intervention, the HDL-C levels increased slightly, with no statistically significant difference. Compared with the control group, the test group showed no obvious improvement in this decrease. The changes in the lipid levels in the dyslipidemia subjects in the different groups before and after intervention are shown in Table 8.

Table 8 Comparison of blood lipid levels in people with dyslipidemia in different study groups

Changes in total score of quality of life assessment after intervention

There was no statistically significant difference in the total quality of life score at baseline between the test and control groups when subjects aged 18-44 years and 60-79 years were assessed. The total score of the quality of life in the test group was higher than that in the control group, and the difference was statistically significant. After 12 months of intervention, the total quality of life scores in the different groups, genders, and age groups showed a general decreasing trend compared with that before the intervention, and the difference was statistically significant. The reasons need to be further analyzed. After 24 months of intervention, the total quality of life scores in the different groups, genders, and age groups showed an overall increasing trend compared with those before the intervention, and the differences were statistically significant. Compared with that of the control group, the total extent of the increased quality of life was lower in the test group. The changes in the total score of the quality of life assessment in the different intervention groups are shown in Table 9.

Table 9 Changes in total scores of quality of life assessment in different study group populations

The proportion of subjects who were willing to accept general practitioners contract services after the intervention

After 24 months, the proportion of people in the different study groups, gender group, and age groups who were willing to receive general practitioners contract services was higher than that before the intervention. There were statistically significant differences before and after intervention in the male, female, 18-44 and 45-59 years old test groups, and 60-79 years old control group. The proportion of people willing to accept general practitioners contract services was slightly higher in the experimental group than in the control group. The comparison of the proportion of people who were willing to receive general practitioners contract services after the intervention in the different groups is shown in Table 10.

Table 10 Comparison of the proportion of people who were willing to accept general practitioners

Discussion

This research used the IGPDP model, combined routine practice with personalized disease prevention, and solved the problems of simplification and popularization of traditional health management service models.

The baseline survey results showed that there is no significant difference between the control and test groups in terms of general conditions and health indicators, and they are balanced and comparable. The prevalence of dyslipidemia in the test and control groups were 70.7% and 76.6%, respectively, which were both higher than the national average, suggesting that the study population had a heavy burden of dyslipidemia.

IGPDP was used in the test group and a traditional health management service model was used in the control group. We evaluated the effect of IGPDP from three perspectives: "disease prevention", "health protection", and "health promotion". The results at baseline, 12 months after intervention, and 24 months after intervention were collected by measuring clinical indicators and by questionnaires. After the intervention, the proportion of subjects with behavioral risk factors, such as smoking, unhealthy eating, and sitting for a long time, decreased, the subjects’ health literacy levels increased, and the BMI of obese people showed a decreasing trend. This result shows that IGPDP can effectively cultivate healthy lifestyles, improve health literacy, and reduce biological risk factors of subjects. After the intervention, the TC, TG, and LDL-C levels of the subjects with dyslipidemia decreased, and the total score of quality of life assessment increased. These findings show that IGPDP can reduce the risk of dyslipidemia and improve the quality of life of subjects. In addition, we used the proportion of subjects who were willing to receive contract services from a general practitioner to evaluate the utilization of primary care facilities. The results showed that compared with that before the intervention, the number of people who were willing to accept contracted services by general practitioners in the experimental group after the intervention showed an increasing trend, and the increase was significantly higher than that in the control group. In short, IGPDP is scientific in design and feasible in operation. Based on the current effect of implementation, IGPDP is more effective and better than the traditional health management model.

The traditional health management service model does not implement the new "health management path and implementation process of grassroots high-risk groups of chronic diseases" and does not establish a vertical collaboration platform between comprehensive departments of general hospitals and grassroots medical institutions. The subjects received follow up and nonindividualized health education at the community health service center. However, this service
model is too simple to meet the needs of people with risk factors for dyslipidemia. The IGPDP provides health management services to selected high-risk groups with the aim of achieving effective interactions between general practitioners, clients, patients, families, and the community in health status assessment, self-management support, health management program optimization, and follow-up management. IGPDP adopts the contract service model of general practitioners, establishes a vertical cooperation platform among general hospitals, primary medical institutions, and some pilot institutions to establish a remote "Internet +" cooperation platform to develop a reasonable division of labor and management model between primary medical institutions and 3A hospitals and between general practitioners and experts. IGPDP trains primary-level general practitioners and their teams, provides convenient "two-way referral" channels for patients, and gradually forms a progressive diagnosis and treatment model of "initial diagnosis, two-way referral, rapid division and treatment, and linkage up and down". IGPDP can improve the service quality and utilization of health management, improve service target satisfaction and compliance, and help control the lipid level of high-risk populations.

The IGPDP emphasizes that general practitioners and their teams provide subjects with people-oriented, personalized, continuous, comprehensive, and active health management services. Specifically, personalization is reflected in the fact that researchers carry out personalized health counseling and health education services according to the differences in the subjects' own conditions, formulate corresponding and specific health management plans for these subjects and supervise the implementation of these plans. This model overcomes the shortcomings of the traditional health management model which ignores individual differences.

The continuity of IGPDP is reflected in the fact that its intervention process is a continuous dynamic process. We divided the entire intervention cycle into the strengthening, consolidation, and stable phases. During each phase of the intervention cycle, the subjects were steadily and continuously followed, and their health plans were monitored throughout. In addition, we measured the health status of the subjects in stages, monitored the changes in their health status, adjusted the intervention intensity in a timely manner, and improved the intervention plan according to the changing health status to finally achieve the goal of improving the health status of the subjects.

The comprehensiveness of IGPDP is reflected in its diversified management methods. Different forms of health counseling and health education were given to the subjects, and health knowledge was popularized to the subjects to help them master the prevention and treatment methods of dyslipidemia and other chronic diseases and improve their health literacy.

Limitations

Although IGPDP is scientific and effective, this model still has some limitation. First, general practitioners play an irreplaceable role in IGPDP. However, the number of general practitioners in China is not enough to meet the requirements of implementing IGPDP on a large scale. Second, the development of a healthy lifestyle requires a long-term process. Although the IGPDP intervention improved the participants' lifestyle in the short term, there may be relapses after the intervention. Finally, this study only selected some of the indicators that should be included in the evaluation system described this study, and thus, this system could not be analyzed more comprehensively. More evaluation indicators can be included in future research to achieve a more comprehensive evaluation effect.

Conclusion

The purpose of constructing, implementing, and evaluating the new health management model is to innovate the health management model, improve the ability, quality, and effect of general practitioners in managing the population with risk factors for dyslipidemia, improve the health status of service subjects, and delay the occurrence of dyslipidemia. This is a beneficial exploration of health management for dyslipidemia, which provides a basis for reducing the occurrence and development of chronic diseases such as dyslipidemia and decreasing the cost of human resources. By transforming the model of grassroots medical and health services, realizing the contract service of general practitioners, and strengthening the network function of grassroots medical and health service, these measures can not only deepen the reform of the medical and health system but also better safeguard people's health in the new situation. The promotion of contract services for general practitioners will gradually form a hierarchical diagnosis and treatment model of "primary-level diagnosis, two-way referral, rapid diagnosis and treatment, and linkage between upper and lower levels". With the aid of modern information technology, we can establish and improve the long-term working mechanism of general hospitals and general practitioners, provide support for the development of general practitioners in grassroots medical institutions and construction of their teams, improve the medical and health service capabilities and primary health management capabilities of grassroots general practitioners, and sign the service contract of grassroots general practitioners. The above measures are of great significance for the establishment of the hierarchical diagnostic system.

List Of Abbreviations

BMI: Body mass index; HDL-C: High-density lipoprotein cholesterol; IGPDP: Integration of general practice and personalized disease prevention in health management; LDL-C: Low-density lipoprotein cholesterol; TC: Total cholesterol; TG: Triglyceride

Declarations

Ethics approval and consent to participate

The Medical Ethical Commission of the China Medical University approved this study. The consent we obtained from study participants was written.

Consent for publish

Written informed consent for publication was obtained from all participants.
Availability of data and materials

The datasets used or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

All authors declare that they have no competing interests.

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Authors’ Contributions

The research was designed by XSY and RZ. It was executed by RZ, SW, YNH, BW, YW, KY, and DJQ. The first draft was prepared by RZ. XSY reviewed and helped to revise the manuscript. All authors read and approved the final manuscript.

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### Table 1 Source and grouping of research samples

| District | Group       | Community Health Center | Baseline Population |
|----------|-------------|-------------------------|---------------------|
| Dadong   | Control     | Dabei                   | 115                 |
|          |             | Guancheng               | 104                 |
|          |             | Dongzhan                | 118                 |
|          |             | Wanquan                 | 92                  |
|          | Test        | Xiaobei                 | 144                 |
|          |             | Ertaizi                 | 136                 |
|          |             | Xiaodong                | 147                 |
|          |             | Liaoshen                | 120                 |
| Heping   | Control     | Taiyuan                 | 101                 |
|          |             | Maluwan                 | 277                 |
|          |             | Hunhewan                | 244                 |
|          | Test        | Beishi                  | 107                 |
|          |             | Xita                    | 184                 |
|          |             | Nanzhan                 | 275                 |
| Huanggu  | Control/Test| Santongqiao             | 44/41               |
|          |             | Huaihe                  | 100/98              |
|          |             | Beita                   | 89/94               |
|          |             | Shouquan                | 45/51               |
| Shenhe   | Control     | Daxi                    | 284                 |
|          |             | Nanta                   | 284                 |
|          | Test        | Danan                   | 286                 |
|          |             | Binhe                   | 281                 |
| Tiexi    | Control/Test| Qigong beiyixin Village | 583/588             |
| Subtotal | Control     |                         | 2480                |
|          | Test        |                         | 2552                |
| Total    |             |                         | 5032                |

### Table 2 Inclusion and exclusion criteria

| Criteria         | Evaluation index                                                                 |
|------------------|-----------------------------------------------------------------------------------|
| Inclusion criteria | Biological risk factors | Overweight or obesity: According to the Chinese standard, a BMI greater than 24 is considered overweight, while a BMI greater than 30 is considered obese. |
|                  | Behavioral risk factors            | Current smokers (Those who have smoked continuously or cumulatively for 6 months or more in their lifetime, or those who have smoked within 30 days before the visit). |
|                  | Unhealthy diet                     | The daily intake of cooking oil for each person is greater than 30 grams as the judgment standard of unhealthy diet. |
|                  | Sedentary                          | Sit with sitting time accumulates 8 hours everyday as the judgment standard of sedentary. |
| Exclusion criteria| Age ≥80 years or ≤18 years          |                                                                                     |
|                  | People who have been clearly diagnosed with cardio-cerebrovascular diseases (myocardial infarction, stroke), lung cancer, and chronic obstructive pulmonary disease |                                                                                     |
|                  | People who are unable to adhere to treatment or use other treatment methods, affecting data collection and efficacy assessment |                                                                                     |
|                  | Pregnant or lactating women         |                                                                                     |
|                  | People with a genetic dyslipidemia disorder |                                                                                     |
### Table 3 Evaluation index system

| Aspect               | Evaluation index                                                                 |
|----------------------|----------------------------------------------------------------------------------|
| Disease prevention   | **Behavioral risk factors** Smoking; Diet; Sedentary.                             |
|                      | **Health literacy** A survey was conducted using the National Residents' Health Literacy Monitoring Questionnaire. |
| Health protection    | **Biological risk factors** BMI                                                   |
|                      | **Risk** Dyslipidemia                                                            |
|                      | **Quality of life** A survey was conducted using the Health status SF-36 Questionnaire. |
| Health promotion     | **Utilization of primary medical institutions**                                  |
|                      | A survey was conducted using the Basic Health Service Needs Questionnaire.        |
| Clinical index       | **measurement methods** Height, weight, waist circumference (weight and waist circumference should be measured on an empty stomach in the morning), blood pressure (measured with an electronic sphygmomanometer), fasting blood glucose (blood glucose measured by fasting venous blood), etc. |
|                      | **Serum lipid levels** TG, TC, LDL-C and HDL-C levels were detected in fasting venous blood. TG ≥ 1.7mmol/L, HDL-C < 0.9mmol/L (male) or < 1.0mmol/L (female), TC ≥ 5.2mmol/L, LDL-C > 3.4mmol/L, meeting one of the above conditions was diagnosed as dyslipidemia. |
| Specific information | **of questionnaires** Health risk assessment questionnaire                          |
|                      | National Residents' Health Literacy Monitoring Questionnaire                      |
|                      | Health status SF-36 Questionnaire                                                 |
|                      | Basic Health Service Demand Questionnaire                                         |

### Table 4 General Characteristics of the management and control groups at baseline
| Variables                    | Control group (n=2480) | Test group (n=2552) |
|------------------------------|------------------------|---------------------|
| **Age**                      |                        |                     |
| Mean±SD                      | 50.2±14.0              | 53.8±14.9           |
| Range                        | 18-79                  | 18-79               |
| **Gender**                   |                        |                     |
| Male                         | 1072(43.2)             | 1103(43.2)          |
| Female                       | 1408(56.8)             | 1449(56.8)          |
| **Resident Status**          |                        |                     |
| Unmarried                    | 179(7.2)               | 1566(6.1)           |
| Married                      | 1768(71.3)             | 1734(67.9)          |
| Divorced or widowed          | 196(7.9)               | 179(7.0)            |
| Others                       | 337(13.6)              | 483(18.9)           |
| **Educational Level**        |                        |                     |
| Elementary school and below  | 29(1.2)                | 35(1.4)             |
| Junior high school           | 229(9.2)               | 425(16.7)           |
| Senior high school           | 403(16.3)              | 545(21.4)           |
| Secondary school             | 625(25.2)              | 562(22.0)           |
| Junior college               | 895(36.1)              | 865(33.9)           |
| University and above         | 299(12.1)              | 120(4.7)            |
| **Nationality**              |                        |                     |
| Han nationality              | 2383(96.1)             | 2387(93.5)          |
| Other                        | 97(3.9)                | 165(6.5)            |
| **Occupation**               |                        |                     |
| Institutional enterprise management | 184(7.4) | 219(8.6)           |
| Professional skill worker    | 392(15.8)              | 607(23.8)           |
| General staff                | 258(10.4)              | 260(10.2)           |
| Business/service staff       | 103(4.2)               | 158(6.2)            |
| Individual industrial and commercial households | 91(3.7) | 103(4.0)           |
| Non-agricultural industrial workers | 162(6.5) | 207(8.1)           |
| Non-labor farmers            | 23(0.9)                | 19(0.7)             |
| Agricultural laborer         | 33(1.3)                | 15(0.6)             |
| Retired staff                | 1059(42.7)             | 864(33.9)           |
| Student at school            | 4(0.2)                 | 10(0.4)             |
| Unemployment or unemployment | 171(6.9)               | 90(3.5)             |
| **Smoking**                  |                        |                     |
| Never smoked                 | 2068(83.4)             | 1942(76.1)          |
| Quit smoking                 | 61(2.4)                | 123(4.8)            |
| Smoking now                  | 351(14.2)              | 487(19.1)           |
| **Drinking**                 |                        |                     |
| No alcohol                   | 2112(85.2)             | 2010(78.8)          |
| Drinking                     | 368(14.8)              | 542(21.2)           |
| **Unhealthy diet**           |                        |                     |
| Unhealthy diet               | 1002(40.4)             | 467(18.3)           |
| **Sedentary method**         |                        |                     |
| 84(3.4)                      | 78(3.1)                |                     |
| **Dyslipidemia**             |                        |                     |
| 1900(76.6)                   | 1804(70.7)             |                     |
Table 5. Changes in behavioral risk factors after intervention in different study groups

| Behavioral risk factors | Smoking now | Unhealthy diet | Sedentary |
|------------------------|-------------|----------------|-----------|
|                        |             |                |           |
| Research group         |             |                |           |
| Total people           | 2480        | 2552           | 2480      |
| Baseline               | Number of people (%) | 351 | 487 | 1002 |
|                        |             |                |           |
| Comparison between groups | $\chi^2$ | 22.023 | 297.294 | 0.441 |
|                        | p           | 0.000          | 0.000     | 0.524 |
| Intervention 12 months | Number of people (%) | 265 | 367 | 469 |
|                        |             |                |           |
| Comparison between groups | $\chi^2$ | 15.640 | 3.100 | 10.449 |
|                        | p           | 0.000          | 0.084     | 0.001 |
| Intervention 24 months | Number of people (%) | 210 | 338 | 478 |
|                        |             |                |           |
| Comparison between groups | $\chi^2$ | 29.573 | 32.723 | 0.002 |
|                        | p           | 0.000          | 0.000     | 0.010 |
| Comparison before and after intervention | $\chi^2$ | 41.267 | 37.203 | 38.787 |
|                        | p           | 0.000          | 0.000     | 0.000 |

Table 6. Changes in health literacy levels after intervention in different study groups

| Demographic characteristic | Gender | Age |
|----------------------------|--------|-----|
|                            | Male | Female | 18-44 years old | 45-59 years old | 60-79 years old |
| Research group             |      |        |                |                  |                  |
| Total people               | 1072 | 1103    | 1408           | 1449             | 787              |
| Baseline                   | Health literate (%) | 203 | 344 | 297 |
|                            |             | 18.9% | 31.2% | 21.1% |
| Comparison between groups  | $\chi^2$   | 43.345 | 32.072 | 60.407 |
|                            | p           | 0.000   | 0.000      | 0.000 |
| Intervention 12 months     | Health literate (%) | 161 | 307 | 227 |
|                            |             | 15.0% | 27.8% | 16.1% |
| Comparison between groups  | $\chi^2$   | 52.863 | 57.992 | 54.154 |
|                            | p           | 0.000   | 0.000      | 0.000 |
| Intervention 24 months     | Health literate (%) | 346 | 455 | 475 |
|                            |             | 32.3% | 41.3% | 33.7% |
| Comparison between groups  | $\chi^2$   | 18.823 | 28.183 | 15.366 |
|                            | p           | 0.000   | 0.000      | 0.000 |
| Comparison before and after intervention | $\chi^2$ | 102.011 | 48.340 | 128.601 |
|                            | p           | 0.000   | 0.000      | 0.000 |
Table 7. Comparison of BMI levels in obese people in different study groups

| Obesity           | BMI                        |
|-------------------|----------------------------|
| Research group    | Control group | Test group  |
| Total people      | 204           | 234         |
| Baseline          | Blood lipid   | 29.98±2.90  | 29.95±2.45 |
| Comparison between groups | t  | -0.100 |
|                   | p            | 0.921       |
| Intervention 12 month | Blood lipid   | 27.18±3.34  | 27.96±3.17 |
| Comparison between groups | t  | 2.507   |
|                   | p            | 0.013       |
| Intervention 24 month | Blood lipid   | 27.03±3.39  | 27.77±2.83 |
| Comparison between groups | t  | 2.480   |
|                   | p            | 0.013       |
| Intervention 12 month group comparison | F value | 87.966 | 60.447 |
|                   | P value      | 0.000       | 0.000     |
| Intervention 24 month group comparison | F value | 99.216 | 77.485 |
|                   | P value      | 0.000       | 0.000     |

Table 8. Comparison of blood lipid levels in people with dyslipidemia in different study groups
| Blood lipid          | TC     | TG     | HDL-C  | LDL-C  |
|----------------------|--------|--------|--------|--------|
| **Research group**   | Control | Test | Control | Test | Control | Test | Control | Test |
| **Total people**     | 1900   | 1804  | 1900   | 1804  | 1900    | 1804 | 1900    | 1804 |
| **Baseline**         | Blood  |       |        |        |         |      |         |      |
| lipid                | lipid  |       |        |        |         |      |         |      |
| ±1.20               | ±1.13  | ±0.84 | ±0.80  | ±0.66  | ±0.53   | ±1.01| ±1.07   |      |
| **Comparison between** | **groups** |        |        |        |         |      |         |      |
|                     | t      |        |        |        |         |      |         |      |
|                     | p      |        |        |        |         |      |         |      |
| **Intervention 12** | Blood  |       |        |        |         |      |         |      |
| month                | lipid  |       |        |        |         |      |         |      |
| ±1.28               | ±1.08  | ±0.76 | ±0.74  | ±0.59  | ±0.57   | ±0.92| ±1.00   |      |
| **Comparison between** | **groups** |        |        |        |         |      |         |      |
|                     | t      |        |        |        |         |      |         |      |
|                     | p      |        |        |        |         |      |         |      |
| **Intervention 24** | Blood  |       |        |        |         |      |         |      |
| month                | lipid  |       |        |        |         |      |         |      |
| ±1.19               | ±1.10  | ±0.64 | ±0.76  | ±0.67  | ±0.64   | ±0.91| ±1.02   |      |
| **Comparison between** | **groups** |        |        |        |         |      |         |      |
|                     | t      |        |        |        |         |      |         |      |
|                     | p      |        |        |        |         |      |         |      |
| **Intervention 12** | F value |       |        |        |         |      |         |      |
| month group comparison | P value |        |        |        |         |      |         |      |
|                     | 128.165 | 51.478 | 49.397 | 3.623  | 0.121   | 2.041| 0.443   | 0.998 |
|                     | 0.000   | 0.000  | 0.000  | 0.057  | 0.728   | 0.153| 0.506   | 0.318 |
| **Intervention 24** | F value |       |        |        |         |      |         |      |
| month group comparison | P value |        |        |        |         |      |         |      |
|                     | 209.596 | 54.338 | 101.045 | 11.314 | 23.034  | 3.734| 5.122   | 2.489 |
|                     | 0.000   | 0.000  | 0.001  | 0.001  | 0.000   | 0.053| 0.024   | 0.115 |

Table 9. Changes in total scores of quality of life assessment in different study group populations.
Table 10. Comparison of the proportion of people who were willing to accept general practitioners
| Demographic characteristic | Gender | Age | 18-44 years old | 45-59 years old | 60-79 years old |
|----------------------------|--------|-----|-----------------|-----------------|-----------------|
|                            | Male   | Female | Control group | Test group | Control group | Test group | Control group | Test group | Control group | Test group |
| Research group             |        |        |                |            |                |            |                |            |                |            |
| Total people               | 1072   | 1103  | 1408           | 1449       | 787           | 959       | 695           | 891       | 998           | 702       |
| Baseline                   |        |        |                |            |                |            |                |            |                |            |
| Willing to accept signing service% | 954 | 991  | 1304           | 1299       | 703           | 855       | 637           | 792       | 918           | 643       |
|                             | 89.0%  | 89.8% | 92.6%          | 89.6%      | 89.3%         | 89.2%     | 91.7%         | 88.9%     | 92.0%         | 91.6%     |
| Comparison between groups  |        |        |                |            |                |            |                |            |                |            |
| X^2                        | 0.419  | 7.754 | 0.013          | 3.349       | 0.083         |
| p                          | 0.531  | 0.006 | 0.938          | 0.075       | 0.788         |
| Intervention 12 months     |        |        |                |            |                |            |                |            |                |            |
| Willing to accept signing service% | 991 | 985  | 1278           | 1276       | 723           | 847       | 623           | 776       | 923           | 638       |
|                             | 92.4%  | 90.0% | 88.1%          | 91.9%      | 88.3%         | 89.6%     | 87.1%         | 92.5%     | 90.9%         |
| Comparison between groups  |        |        |                |            |                |            |                |            |                |            |
| X^2                        | 6.457  | 5.517 | 5.999          | 2.436       | 1.408         |
| p                          | 0.011  | 0.021 | 0.016          | 0.136       | 0.243         |
| Intervention 24 months     |        |        |                |            |                |            |                |            |                |            |
| Willing to accept signing service% | 999 | 1037 | 1320           | 1357       | 714           | 911       | 646           | 822       | 959           | 661       |
|                             | 93.2%  | 94.0% | 93.8%          | 93.7%      | 90.7%         | 95.0%     | 92.9%         | 92.3%     | 96.1%         | 94.2%     |
| Comparison between groups  |        |        |                |            |                |            |                |            |                |            |
| X^2                        | 0.620  | 0.012 | 12.222         | 0.273       | 3.433         |
| p                          | 0.483  | 0.939 | 0.001          | 0.631       | 0.080         |
| Comparison before and after intervention |        |        |                |            |                |            |                |            |                |            |
| X^2                        | 13.888 | 18.017| 9.064          | 27.849      | 3.005         | 30.429    | 4.926         | 12.931     | 16.546        | 5.806     |
| p                          | 0.001  | 0.000 | 0.011          | 0.000       | 0.233         | 0.000     | 0.085         | 0.002      | 0.000         | 0.055     |

**Figures**
Figure 1

Health management cycle.

Health management cycle:

- **Strengthening phase (2 months)**: Baseline data collection, health risk assessment, establishment of health intervention plan, weekly follow-up

- **Consolidation phase (1 months)**: Adjust intervention intensity, change fixed behavior, form active habits, conduct weekly follow-up

- **Stable phase (9 months)**: Supervise and remind follow up and monitor, follow up monthly, evaluate intervention effect
Figure 2

Technology road map.