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# Application of standardized management and effect evaluation of chronic obstructive pulmonary disease patients using the big data center of the Internet of Things

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## Abstract

**Objective:** Early detection, diagnosis, treatment and management of chronic obstructive pulmonary disease can lower morbidity and perhaps mortality. This study aimed to evaluate the effect of the application of standardized management against the background of the rapid development of the big data center of modern internet of things technology.

**Methods:** Participants ≥40 years of age with chronic obstructive pulmonary disease presenting at Xiamen Medical College Affiliated Haicang Hospital from October 2019 to October 2020 were selected as the observation patients based on the Internet of Things big data center for chronic obstructive pulmonary disease standardized management, and control patients from the community were selected for without down to the chronic obstructive pulmonary disease standardized management. Follow-up after 2 years of patient health records and acute episodes using the World Health Organization Quality of Life Questionnaire-Brief version to evaluate the quality of life of the two groups revealed differences.

**Results:** The results of comparative analysis of the number of acute attacks before and after follow-up in the observation and control groups after propensity score matching showed that the decrease in acute episodes before and after in the observation group was significant compared with that in the control group ($t = -3.664$, $P < 0.001$). The quality of life of chronic obstructive pulmonary disease patients indicated that the effect in the observation group was greater than that in the control group according to the World Health Organization Quality of Life Questionnaire-Brief version.

**Conclusion:** In this study, we analyzed the application of modern internet of things technology in the management of chronic obstructive pulmonary disease patients, discussed the effect of standardized management, and promoted the self-management of chronic obstructive pulmonary disease patients. The effectiveness and continuity of the standardized management model for chronic obstructive pulmonary disease implemented in Xiamen city based on the internet of things big data center were considered true and effective.

## Keywords

Chronic obstructive pulmonary disease, internet of things, standardized management, quality of life

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## Introduction

Chronic obstructive pulmonary disease (COPD) is a common disease characterized by airflow limitation that is not fully reversible and progresses progressively, resulting in a progressive decline in lung function.[1] According to the Global Burden of Diseases study in 2019, COPD is a leading cause of morbidity and mortality and was the sixth leading cause of premature death.[2] Worldwide estimates suggest that more than 300 million people suffer from by COPD, creating a high socioeconomic burden.[3] Analysis by the World Health Organization (WHO) predicted that by 2030, COPD will be the third leading cause of death worldwide, trailing behind only ischemic heart disease and stroke.[4] COPD has become one of the most important public health concerns.

In China, COPD was the fifth leading cause of death in 2016.[5] A nationwide cross-sectional study was conducted to assess the prevalence and risk factors of COPD in China using the China Lung Health (CPH) Study database. The results of the CPH study estimated that the prevalence of spirometry-defined COPD among people aged 40 years or older in China was 13.7% in 2012–2015, which reflected an approximately 67% increase compared with the same period in 2002–2004, and the prevalence was higher in men than in women in all age groups.[6] In addition, the data indicated that 99.9 million Chinese adults aged 20 years or older had spirometry-defined COPD, which was significantly higher than estimates from the Global Burden of Diseases study.[7]

Previous studies showed that early diagnosis and treatment may delay the progression of lung function decline, reduce the number of acute exacerbations, and improve the quality of life (QOL) of patients with early-stage COPD.[8] However, many patients with COPD remain undiagnosed and untreated.[9] Patients with COPD often underrecognize the significance of their respiratory symptoms, and physicians also frequently miss opportunities to diagnose COPD.[10] By the time it was discovered, it was irreversible. Therefore, it is essential to improve patients' lung function, functional status, and QOL and to reduce exacerbations to early diagnosis and treatment are essential.[11] At present, COPD self-management, clinical pathway management and community chronic disease health management are based on the management of COPD in China. Some studies have also proposed a COPD ring management model comprising tertiary hospitals and community health service institutions, patients, and family health workers for the stable management of COPD.[12] These management modes play a positive role in the prevention and treatment of COPD, but there are different limitations in effective feedback and continuity. Patients are only managed for a certain length of time, without formulating a comprehensive management system for early diagnosis, acute exacerbation reduction, stabilization or rehabilitation management.

The internet connects people to people, people to machines, and machines to machines through the cloud. Internet of things (IoT) networks objects or people and integrates them with software to collect and exchange data.[13] In recent years, with the rapid development of IoT technology in the medical field, the Internet of medical Things (IOMT) technology that collects, processes and analyzes medical data generated by various IoT devices has developed rapidly.[14] The IOMT is easy to use, which can effectively improve the efficiency of disease treatment, reduce errors, improve the patient experience and lower costs.[15] The hierarchical medical management system for chronic respiratory diseases based on the IoT (referred to as the hierarchical medical system), as an independent Internet data management system for primary medical institutions, completes multi-center data upload, fusion, and summary analysis. It is linked to the health record system, the family doctor management platform, and the data center of the Health Commission. It has the functions of pulmonary function quality control management, pulmonary function detector utilization assessment management and so on.

This study aimed to establish an intelligent big data center for chronic respiratory diseases in an IOMT-based system to carry out the standardized management of COPD and achieve the early diagnosis, intervention, and active management of COPD. The IoT big data management platform has changed the past follow-up management mode of discharged COPD patients and promoted the close integration of patients, families, primary care settings, tertiary medical institutions and telemedicine institutions, forming a new information standardized management system of COPD patients. In our study, we defined the work process and content, and patients, doctors, primary care settings, and other objects assumed corresponding responsibilities in the management process of COPD patients to evaluate the effectiveness and continuity of self-management of COPD patients and the application effect.

## Materials and methods

### *Study participants*

This was a prospective study based on an IoMT-based intelligent big data center for chronic respiratory diseases. Patients with COPD aged ≥40 years who presented at the Department of Respiratory and Critical Care Medicine at Xiamen Medical College Affiliated Haicang Hospital from October 2019 to October 2020 were included in this study. COPD was defined as a forced expiratory volume in 1 s/forced vital capacity ($FEV_1$/FVC) ratio less than 0.7 after bronchodilator inhalation, according to the Global Initiative for the Diagnosis, Management, and Prevention of Chronic Obstructive Lung Disease (GOLD) 2019 Report.[16] FVC is the maximal volume of air that can be forcibly exhaled after taking in the deepest breath possible, and $FEV_1$ is the maximal volume of air exhaled in the first second during an FVC maneuver. Patients underwent an initial evaluation that included an exposure history, standardized symptom assessment, and lung function measurements. Patients were defined as having COPD if they reported an $FEV_1$/FVC ratio lower than 0.7. Alternatively, normal spirometry was defined by an $FEV_1$, FVC, and $FEV_1$/FVC ratio greater than 0.7 and within the lower limits of normal.

The inclusion criteria were as follows: (a) a history of smoking or occupational exposure (dust, smoke, oil mist, carbon heating, etc.) and biomass exposure; (b) chronic cough lasting over 3 months; (c) progressive dyspnea after exercise; (d) questionnaires completed independently or at local community health centers by well-trained staff; and (e) underwent a 2-year follow-up.

We excluded patients from the study groups who had a previous pneumonectomy, severe cardiac insufficiency, pulmonary tuberculosis, lung cancer, pulmonary fibrosis, interstitial lung disease, bronchial asthma, bronchiectasis or other lung diseases that could affect the results of this study. Additionally, patients with COPD who were unable or unwilling to complete the questionnaire survey or follow-up (including more than 2 missed follow-ups) were excluded. We selected COPD patients based on the IoT big data center of COPD standardized management as the observation patients. Control patients included those without COPD according to community COPD standardized management. Follow-up after 2 years of patient health records and acute episodes using the World Health Organization Quality of Life Questionnaire-Brief version (WHOQOL-BREF) to evaluate the QOL of the two groups revealed differences. The study protocol was approved by the ethics review committee of Xiamen Medical College Affiliated Haicang Hospital and other participating institutes, and written informed consent was obtained from all study participants.

## Standardized management

Through the construction of models, hierarchical processing and intelligent assisted decision-making, Medical IoT technology can transmit screening data in real time and intelligently assist in clinical diagnosis or rehabilitation management to establish an intelligent chronic respiratory disease big data center. The respiratory big data management platform of the IoT has changed the traditional COPD management model of community outpatient screening and promoted the close integration of patients, families, community health service systems, tertiary medical institutions, and telemedicine institutions to form a new information-based standardized management path for COPD patients.

The hierarchical diagnosis and treatment system can realize the routine ventilation test functions of lung function (slow vital capacity, forced vital capacity, maximum ventilation per minute). It can not only output the report in real time, but also carry out the comparison test before and after the medication (bronchodilation). It measured MIP and MEP simultaneously with lung function. It not only has the function of respiratory rehabilitation training (inspiratory training, expiratory training), but also has powerful data storage ability and data management function. It can meet the needs of medical institutions at all levels for disease diagnosis, respiratory rehabilitation, bedside testing, efficacy evaluation, epidemiological investigation, health examination, occupational disease screening, scientific research projects, etc., and realize the construction of a hierarchical diagnosis and treatment system of respiratory chronic disease medical alliance, two-way referral, and interconnection of chronic disease management. The three-stage diagnosis and treatment management model of COPD under the IoT medical technology is as follows:

1. According to the results of an intelligence-assisted diagnosis, the general practitioner makes a comprehensive judgment on whether to refer the patient to a higher-level institution. Patients with acute exacerbations are transferred to the higher-level hospital through the green channel.
2. Specialists can perform real-time online consultations to know the patient's referral condition at intake, perform further clinical diagnosis and treatment and hospitalization of patients, and provide remote assistance in the identification, diagnosis and treatment of pulmonary nodules. When stable, patients can be transferred to primary management, where personalized rehabilitation treatment plans are formulated.
3. Health managers conduct online and offline follow-up tracking through the unified platform of Xiamen primary medical institutions or the COPD management platform of Xiamen Health and carry out education in various forms of media to provide patients with respiratory training, diet and lifestyle, psychological and medication guidance, and so on.

## Follow-up and questionnaire survey

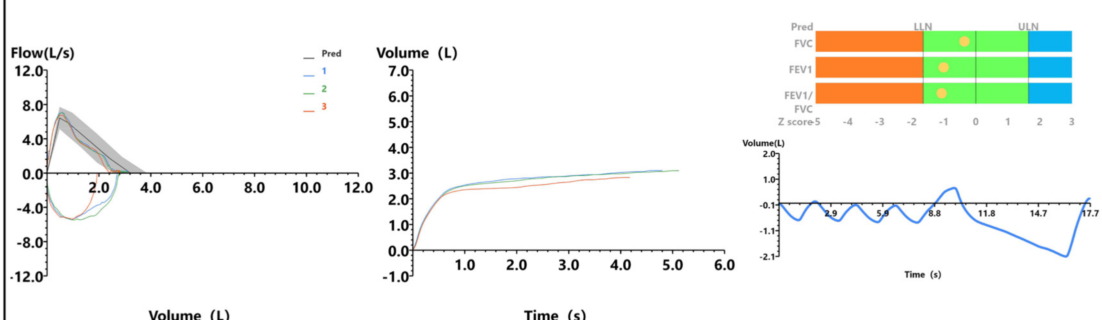
1. Basic information included demographic data, smoking history (length of smoking history, smoking amount, current smoking status), medication history (irregular medication), comorbidities, related genetic history, number of acute exacerbations, etc.
2. Measurement of lung function: Screening was performed by a qualified general practitioner using a portable lung function detector (model X1), and a report was automatically generated (Figure 1). The waveforms of the instrument have been tested against the American Thoracic Society standard, and the measurement error meets the requirements of the JJF1213-2008 pulmonary

# XEEK MEDICAL HOSPITAL

## Pulmonary Function Test Report

| | | |
|---|---|---|
| Name：Heidi | Inpatient number： | Test date：2024–03–05 10:30:04 |
| Gender：Female | Height：155cm | Print date：2024–03–05 10:31:50 |
| Weight：55kg | Age：26.3 years old | Ethnicity：NE Asian |
| Select predicted value：Chinese aged 4–80 | Department：Respiratory | Physician：Heidi |

| | BEST | %Pred | Pred | LLN | z–score | ACT1 | ACT2 | ACT3 |
|---|---|---|---|---|---|---|---|---|
| FVC(L) | 3.102 | 96.5 | 3.216 | 2.690 | –0.4 | 3.102 | 3.093 | 2.830 |
| PEF(L/s) | 7.086 | 110.1 | 6.435 | 4.961 | 0.7 | 7.086 | 7.021 | 6.774 |
| FEV0.5(L) | 2.022 | –– | –– | –– | –– | 2.022 | 2.010 | 2.015 |
| FEV1(L) | 2.533 | 89.8 | 2.823 | 2.350 | –1.0 | 2.533 | 2.508 | 2.354 |
| FEV1/FVC | 0.817 | 92.6 | 0.882 | 0.781 | –1.1 | 0.817 | 0.811 | 0.832 |
| FEV1/VCmax | 0.817 | –– | –– | –– | –– | 0.817 | 0.811 | 0.832 |
| FEV2(L) | 2.781 | –– | –– | –– | –– | 2.781 | 2.707 | 2.444 |
| FEV2/FVC | 0.896 | –– | –– | –– | –– | 0.896 | 0.875 | 0.864 |
| FEV3(L) | 2.896 | –– | –– | –– | –– | 2.896 | 2.879 | 2.656 |
| FEV3/FVC | 0.933 | –– | –– | –– | –– | 0.933 | 0.931 | 0.939 |
| FEV6(L) | 3.102 | –– | –– | –– | –– | 3.102 | 3.093 | 2.830 |
| MEP(cmH2O) | 130 | 131.5 | 99 | 69 | 1.7 | 127 | 130 | 128 |
| FEF10[V10](L/s) | 5.968 | –– | –– | –– | –– | 5.968 | 5.775 | 5.465 |
| FEF25[V25](L/s) | 6.356 | 108.0 | 5.885 | 3.825 | 0.4 | 6.356 | 6.004 | 6.351 |
| FEF25/H | 4.10 | –– | –– | –– | –– | 4.10 | 3.87 | 4.10 |
| FEF50[V50](L/s) | 3.281 | 86.0 | 3.813 | 2.572 | –0.7 | 3.281 | 3.061 | 3.300 |
| FEF50/H | 2.12 | –– | –– | –– | –– | 2.12 | 1.97 | 2.13 |
| FEF75[V75](L/s) | 1.27 | 73.6 | 1.72 | 1.01 | –1.0 | 1.27 | 1.01 | 1.39 |
| FEF75/H | 0.82 | –– | –– | –– | –– | 0.82 | 0.65 | 0.89 |
| FEF50/FEF25 | 0.52 | 79.7 | 0.65 | –– | –– | 0.52 | 0.51 | 0.52 |
| MMEF(L/s) | 2.771 | 84.6 | 3.275 | 2.201 | –0.8 | 2.771 | 2.598 | 3.034 |
| Vexp(L) | 0.094 | –– | –– | –– | –– | 0.094 | 0.095 | 0.091 |
| Vexp%FVC(%) | 3.0 | –– | –– | –– | –– | 3.0 | 3.1 | 3.2 |
| FET(s) | 4.8 | –– | –– | –– | –– | 4.8 | 5.1 | 4.2 |
| BSA(m2) | 1.54 | –– | –– | –– | –– | | | |
| FIVC(L) | 2.785 | 86.6 | 3.216 | 2.690 | –1.3 | 2.702 | 2.785 | 1.928 |
| PIF(L/s) | 5.474 | –– | –– | –– | –– | 5.459 | 5.474 | 5.352 |
| MIP(cmH2O) | 87 | 109.4 | 80 | 56 | 0.5 | 87 | 87 | 85 |
| FEV1*35 | 89↓ | 76.9 | 115 | 92 | –1.9 | 89 | 88 | 82 |
| MVV(L/min) | 32↓ | 28.0 | 115 | 92 | –5.0 | | | |
| MVV/BSA | 21.02 | –– | –– | –– | –– | | | |
| MVV1(L/min) | 29↓ | 25.0 | 115 | 92 | –5.0 | | | |
| MVV1/BSA | 18.72 | –– | –– | –– | –– | | | |
| MVV6(L/min) | 32↓ | 27.4 | 115 | 92 | –5.0 | | | |
| T–MVV(s) | 12.96 | –– | –– | –– | –– | | | |
| MV(L/min) | 17.516 | 222.9 | 7.857 | 6.286 | 3.0 | | | |
| VC(L) | 2.742 | 85.3 | 3.216 | 2.690 | –1.5 | | | |
| BF[RR] | 25 | 124.2 | 20 | –– | –– | | | |
| VT(L) | 0.705 | 179.5 | 0.393 | 0.314 | 3.0 | | | |
| ERV(L) | 1.358 | 106.4 | 1.276 | 1.021 | 0.5 | | | |
| IRV(L) | 0.678 | –– | –– | –– | –– | | | |
| IC(L) | 1.384↓ | 67.7 | 2.043 | 1.634 | –2.7 | | | |




FEV1: A FVC: B

Comprehensive quality grading: C

Patient coordination： Good coordination

Normal Pulmonary Ventilation

Normal small airway function

Operator Signature：__________

Doctor Signature：__________

**Figure 1.** Report.

function instrument calibration specification, which indicates that the instrument has high measurement accuracy and can meet the clinical application of COPD diagnosis, hierarchical diagnosis and treatment and basic pulmonary function screening.[17] The diagnosis of COPD was further classified into stages of severity according to the FEV1 percentage predicted.

I Mild $FEV_1/FVC < 0.70$, $FEV_1 \geq 80\%$predicted

II Moderate $FEV_1/FVC < 0.70$, $80\% > FEV1 \geq 50\%$ predicted

III Severe $FEV_1/FVC < 0.70$, $50\% > FEV1 \geq 30\%$ predicted

IV Very severe $FEV_1/FVC < 0.70$, $FEV_1 < 30\%$ predicted or $FEV_1 < 50\%$ predicted plus chronic respiratory failure

3. COPD assessment test

The COPD Assessment Test (CAT), which is used to identify and assess baseline symptomatology, can be used to monitor changes in severity over time. CAT comprises eight items that are each scored using a 6-point scale (0–5) and is useful in assessing the symptomatic impact of COPD. A higher CAT score indicates poorer health. The CAT is more sensitive in detecting improvements with treatment or a decline in disease progression or exacerbations.[18]

4. Modified Medical Research Council

The modified Medical Research Council (mMRC) dyspnea scale comprises five statements that describe a range of dyspnea effects in increasing order of severity, corresponding to 0–4 points, and the score is the mMRC score. The use of this questionnaire is recommended in the Global Initiative for the Diagnosis, Management, and Prevention of Chronic Obstructive Lung Disease (GOLD) 2020 report.[19] This questionnaire can be helpful for the initial identification of breathlessness and support evaluation for COPD.[20]

### *World Health Organization Quality of Life Questionnaire-Brief Version*

The WHOQOL-BREF is a standard instrument used for measuring health domains. It includes 24 items of satisfaction divided into four domains (physical health, psychological health, social relationships, and environmental domains) and two items on overall QOL and general health awareness.[21] The total score for each domain ranges from 4 to 20 points and each item is scored on a 5-point Likert scale in a positive direction from 1 to 5.Although there is no official cutoff value, higher scores indicate a higher QOL, with 1 being the worst possible health condition and 5 being the best.[22] The questionnaires were completed through a combination of face-to-face interviews, self-reporting, or telephone interviews and aimed to evaluate whether there were differences in various indicators of QOL between the two groups before and after follow-up. The questionnaire showed the effectiveness and continuity of the implementation of COPD standardized management based on the big data center of the IoT in Xiamen city. The reliability values of the test scores (including Cronbach's α and split-half reliability Cronbach's α) for the four domains of the WHOQOL-BREF were above 0.8, and their standard deviations ranged from 0.001 to 0.008. Table 1 shows the reliability analysis.

This measurement also showed good construct validity. The validity analysis used factor analysis. The value of the Kaiser–Meyer–Olkin measure of sampling adequacy was 0.909, and Bartlett's test of sphericity value was 923.059 (degrees of freedom (df) = 276; $P < 0.001$), indicating that the partial correlation was weak and suitable for factor analysis. After principal component factor extraction, the values were greater than 0.9. The results showed that there were 5 factors with eigenvalues greater than 0.9, and the cumulative contribution rate was 74.424%. Overall, the WHOQOL-BREF was found to be a reliable instrument with high mean reliabilities and small standard deviations across studies.

## Sample size

The sample size was calculated based on the following parameters. COPD patients discharged from Xiamen Medical College Affiliated Haicang Hospital before 2019 were selected. According to the registered address, patients were divided into a family group and a nonfamily group (the family group was managed by family doctors, while the nonfamily group was not). The number of acute attacks in the two groups of patients in one year was counted: the mean and standard deviation of the number of acute exacerbations in the family group were $0.61 \pm 0.65$, and the mean and standard deviation of the number of acute exacerbations in the nonfamily group were $0.95 \pm 0.76$. Two-sample $t$ tests allowing unequal variance were used to estimate the sample size. The margin of error was 5%, and the confidence level was 90%. Therefore, according to the formula, we calculated that at least 120 people were needed for the observation group and 60 people for the control group using PASS Sample Size Calculator version 15.0.

## Statistical analysis

### *Propensity score matching*

Propensity score matching is a statistical method, which is increasingly used in observational comparative efficacy studies. It can reduce the bias arising from non-experimental data processing effects.[23] This study used

**Table 1.** World Health Organization Quality of Life Questionnaire-Brief version (WHOQOL-BREF) reliability analysis.

| | | Reliability values | | Split-half reliability values | |
|---|---|---|---|---|---|
| Dimension | Number of entries | Cronbach's α | Cronbach's α after calibration | Spearman-Brown formula values between entries | Cronbach's α |
| Physical health domains | 7 | 0.866 | 0.874 | 0.726 | 0.841 |
| Psychological domains | 6 | 0.879 | 0.88 | 0.762 | 0.865 |
| Environmental domains | 8 | 0.935 | 0.935 | 0.813 | 0.897 |
| Social relationship domains | 3 | 0.898 | 0.897 | 0.719 | 0.836 |
| Total | 26 | 0.961 | 0.961 | 0.819 | 0.901 |

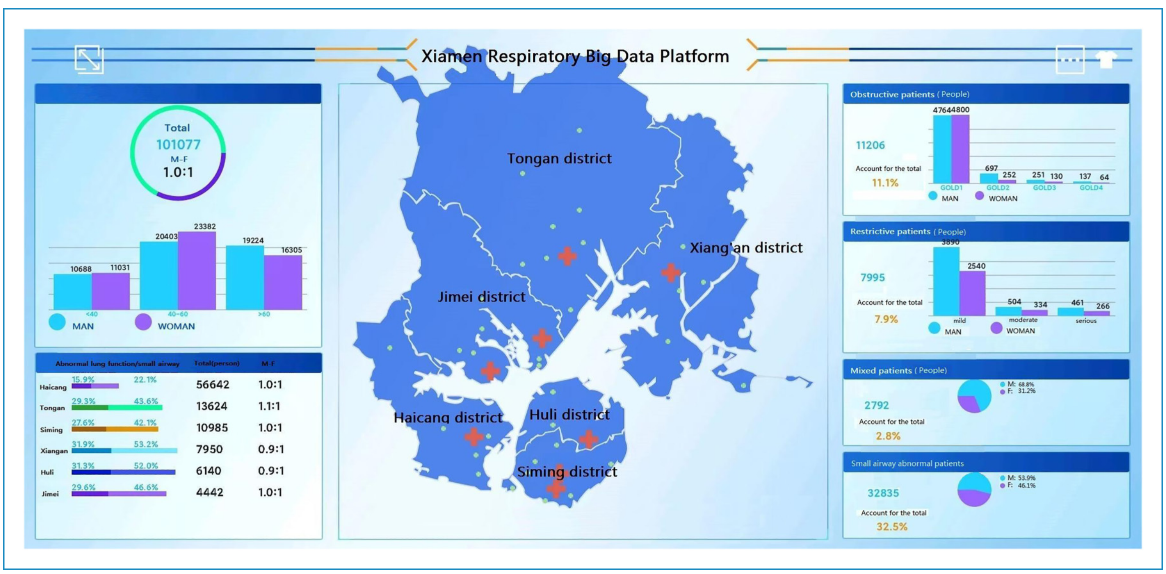



**Figure 2.** Intelligent big data center platform for chronic respiratory diseases.

R4.1.3 software with the number of acute attacks as the dependent variable and sex and age as independent variables. The nearest neighbor matching method was used to pair the same or similar individuals between the observation group and the control group (the caliper value was set to 0.2) to create a 1:2 pair to remove the interference of the imbalance of confounding factors between the groups in the study results.

## Data analysis

The data were analyzed using SPSS software version 22.0. Descriptive analysis was used to evaluate the demographic characteristics, spirometry parameters and questionnaire scores. Continuous parametric variables are reported as the means ± standard deviations. Differences between the observation group and the control group were assessed using the independent Student's $t$ test for quantitative variables and the $x^2$ test or nonparametric test for qualitative variables.

# Results

## Big data center of the IoT

Through model construction, hierarchical processing, and intelligent auxiliary decision-making, real-time transmission of screening data, and intelligent auxiliary clinical diagnosis and rehabilitation management,[1] the big data center of the IoT was established, and on this basis, standardized and intelligent COPD prevention and treatment and management were conducted (Figure 2).

The big data center of respiratory chronic diseases in the IoT has the function of intelligence-assisted clinical diagnosis. Firstly, the quality of testing was intelligent rated, and then according to the results of strict quality control, the disease category, acute exacerbation, medication reference, and comparative analysis before and after medication were automatically analyzed, and the reference conclusions were generated. Second, the test report displayed by the software can automatically diagnose obstructive, restrictive, and mixed ventilatory dysfunction. Patients with obstructive ventilatory dysfunction can be graded according to the Global Initiative for COPD criteria for severity. When connected to the wireless network or Bluetooth device, the detection data can be automatically uploaded to the database or Bluetooth device in real time, and preliminary statistical analysis can be performed, making the data collation and analysis more convenient. Finally, combined with the definition and setting of the predicted values of pulmonary function parameters, the predicted values of pulmonary function parameters were quantified into a coordinate graphic form to realize the automatic acquisition of the diagnosis and treatment data of the equipment, and the visual display through the form of charts. It greatly reduces the probability of missed diagnosis and human misjudgment in primary care. At the same time, it also makes up for the lack of primary medical level.

As seen from the big data center platform, as of October 31, 2022, a total of 10,1077 people had participated in free lung function screening, and a total of 11,206 COPD patients were screened, accounting for 11.1% of the total number; there were 7995 restricted patients, accounting for 7.9% of the total number; 2792 mixed patients, accounting for 2.8% of the total number; and 32,835 patients with small airway abnormalities, accounting for 32.5% of the total number. The details of free lung function screening in each region are shown in Figure 3.

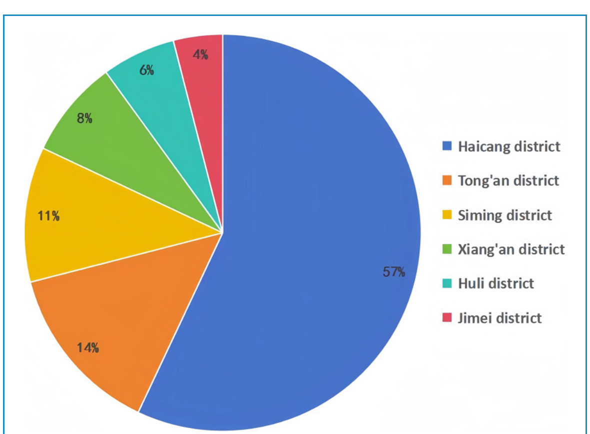



**Figure 3.** Pulmonary function screening situation in each district of Xiamen city.

A total of 11,206 patients with COPD were screened. After automatic quality control, 11,095 patients were removed, accounting for 10.9% of the total number of patients screened, among which 5849 were males, accounting for 52.72%, and 5246 were females, accounting for 47.28%. The details of each grade according to the severity classification are shown below (Table 2):

**Table 2.** Classification of chronic obstructive pulmonary disease (COPD) severity.

| | Sex | | |
|---|---|---|---|
| Severity classification | Male | Female | Percentage (%) |
| GOLD 1 | 4764 | 4800 | 86.20 |
| GOLD 2 | 697 | 252 | 8.55 |
| GOLD 3 | 251 | 130 | 3.43 |
| GOLD 4 | 137 | 64 | 1.81 |
| Total | 5849 | 5246 | 100 |

## Propensity score matching

To evaluate the effect of standardized management, we followed up 332 COPD patients (272 in the observation group and 60 in the control group). Since the number of acute episodes among COPD patients was greatly influenced by sex and age (control group $70.77 \pm 8.98$, observation group $75.14 \pm 9.89$), especially the age difference between the two groups before follow-up ($t = -3.152$, $P = 0.002$), the bias score matching method was adopted to randomize the confounding factors that affected the study results to reduce the influence of sex and age.

A total of 332 patients were recruited, including 60 subjects in the control group and 272 subjects in the observation group. There were no significant differences in clinical or pathological characteristics between the groups after propensity score matching (60 matched pairs). The caliper value was set to 0.2, and the 1:2 nearest neighbor matching method was performed. The final matching results are shown in Table 3. The sex and age differences between the two groups were not statistically significant. After propensity score matching, the number of acute episodes changed before and after follow-up. The decrease in acute episodes before and after in the observation group was significant compared with that in the control group ($t = -3.664$, $P < 0.001$).

## WHOQOL-BREF

In this study, the QOL of 60 patients in the control group and 120 patients in the observation group was analyzed,

**Table 3.** Comparative analysis of the number of acute attacks before and after follow-up in the observation and control groups after propensity score matching (PSM).

| Group | Before follow-up | After follow-up | D-statistic | Within the group | |
|---|---|---|---|---|---|
| | | | | *t* | *P* |
| Control group | 2.433 ± 2.037 | 2.311 ± 1.931 | 0.123 ± 0.519 | 1.829 | 0.072 |
| Observation group | 2.650 ± 2.343 | 1.975 ± 1.549 | 0.675 ± 1.526 | 4.847 | <0.001* |
| *t* | −0.610 | 1.172 | −3.576 | | |
| *P* | 0.543 | 0.244 | <0.001* | | |

*Note.* *$p<0.001$.

and a total of 180 study subjects completed a follow-up questionnaire. The comparison of the general data of both groups showed no statistically significant difference between the two groups, indicating the comparability between them (Table 4).

As shown in the table below, there was no significant difference between the two groups before the follow-up, indicating that the groups were comparable. The difference between the observation group based on the standardized management of the big data center of the IoT and the control group without standardized management was statistically significant, indicating that the QOL of COPD patients was improved after both interventions. The difference before and after the intervention in both groups was statistically significant, indicating that both groups improved after the intervention; the observation group had a greater effect than the control group, indicating that the effect of the observation group was greater than that of the control group (Table 5).

## Discussion

COPD is not fully reversible. As no current pharmacological treatment is known to halt or reverse the progression of established COPD, it is essential for the disease to be diagnosed early and prior to the establishment of irreversible pathology to allow timely interventions.[24] Furthermore, patients with COPD require long-term routine medical care by specialists to maintain a stable status. The successful control of COPD mainly depends on how well patients manage their disease conditions with the aid of healthcare providers. In this study, IoT medical technology was used to establish a smart big data center for chronic respiratory diseases through population screening and to carry out standardized management of COPD patients based on this IoT big data management platform. The system promotes the close integration of patients, families, community health service systems, tertiary medical institutions, and telemedicine institutions to form a new information-based standardized management model for COPD patients. After propensity score matching, we found that the decrease in acute episodes before and after the intervention in the observation group was significant compared with that in the control group ($t = -3.664$, $P < 0.001$).

Long-term home-based self-management can promote better health and reduce the frequency of acute exacerbation of COPD for COPD patients.[25] A increasing number of information and communication technologies are used for patients, healthcare providers, health system managers, and data services, such as mobile phones, laptops, tablets and wearable biological capacitors/sensors. As an alternative to conventional clinical practice, they can improve the quality of patient care, promote links between healthcare providers and patients to increase patient engagement and, more importantly, achieve better health outcomes throughout the course of their disease.[26] Based on the IoT big data center for the standardized management of patients with COPD, patients, families, community health service systems, tertiary medical institutions, and remote medical institutions should be integrated to maximize the efficiency of medical staff, compensate for the lack of grassroots medical treatment regarding missed diagnoses and the probability of artificial misjudgment, and realize self-management among patients with COPD. Furthermore, clinicians can develop personalized treatment options based on different patient conditions, considering all available biological and psycho-social factors at the individual patient level to improve assessment, treatment, outcomes, and cost-effectiveness.[27] The effectiveness and continuity of the standardized management model of COPD implemented in Xiamen city based on the IoT big data center were evaluated through the WHOQOL. From the results, based on the IoT big data center standardized management of the observation group compared with no standardized management of the control group, the difference was

**Table 4.** Comparison of the results between the two groups.

| | Observation group (*n* = 120) | Control group (*n* = 60) | $\chi^2$ | *P* |
|---|---|---|---|---|
| Sex (%) | | | - | 1.000 |
| Male | 112(93.3) | 56(93.3) | | |
| Female | 8(6.7) | 4(6.7) | | |
| Age (%) | | | 0.160 | 0.983 |
| 51–60 years | 18(15) | 8(13.3) | | |
| 61–70 years | 41(34.2) | 22(36.7) | | |
| 71–80 years | 40(33.3) | 20(33.3) | | |
| Over 80 years | 21(17.5) | 10(16.4) | | |
| Occupation (%) | | | 2.121 | 0.346 |
| Employed | 28(23.3) | 13(21.7) | | |
| Retired | 47(39.2) | 18(30) | | |
| Unemployed | 45(37.5) | 29(48.3) | | |
| Marital status (%) | | | - | 1.000 |
| Married | 104(86.7) | 52(86.7) | | |
| Unmarried | 4(3.3) | 2(3.3) | | |
| Divorced or widowed | 12(10) | 6(10) | | |
| Effect of family friction on patient's life (%) | | | - | 0.250 |
| Does not affect at all | 2(1.7) | 0(0) | | |
| Very small impact | 12(10.0) | 5(8.3) | | |
| Impact (general) | 43(35.8) | 32(53.3) | | |
| Large impact | 40(33.3) | 14(23.3) | | |
| Great impact | 23(19.2) | 9(15) | | |
| Appetite (%) | | | - | 0.248 |
| Very poor | 2(1.7) | 0(0) | | |
| Poor | 5(4.2) | 2(3.3) | | |
| Not poor | 57(47.5) | 39(65) | | |
| Good | 30(25.0) | 9(15.0) | | |
| Very good | 26(21.7) | 10(16.7) | | |

*Note.* "-" indicates the use of Fisher's exact test.

**Table 5.** Comparative analysis of the scores of each factor before and after the intervention in the two intervention groups.

| Index | Group | Number | Before the intervention | After the intervention | *t* | *P* |
|---|---|---|---|---|---|---|
| Physical health domains | Observation group | 120 | 14.36 ± 2.03 | 15.92 ± 1.78 | −9.263 | <0.001 |
| | Control group | 60 | 14.66 ± 2.35 | 15.10 ± 2.32 | −5.759 | <0.001 |
| | *t* | | −0.887 | 2.655 | | |
| | *P* | | 0.376 | 0.009 | | |
| Psychological domains | Observation group | 120 | 14.29 ± 2.64 | 16.03 ± 2.32 | −7.951 | <0.001 |
| | Control group | 60 | 14.41 ± 2.45 | 14.89 ± 2.29 | −3.89 | <0.001 |
| | *t* | | −0.286 | 3.119 | | |
| | *P* | | 0.775 | 0.002 | | |
| Environmental domains | Observation group | 120 | 14.57 ± 2.20 | 15.88 ± 1.99 | −7.866 | <0.001 |
| | Control group | 60 | 14.66 ± 2.51 | 15.10 ± 2.29 | −3.246 | 0.002 |
| | *t* | | −0.251 | 2.351 | | |
| | *P* | | 0.802 | 0.02 | | |
| Social relationship domains | Observation group | 120 | 15.29 ± 2.98 | 17.42 ± 1.80 | −8.411 | <0.001 |
| | Control group | 60 | 15.42 ± 2.92 | 16.49 ± 2.92 | −4.247 | <0.001 |
| | *t* | | −0.285 | 2.638 | | |
| | *P* | | 0.776 | 0.009 | | |

significant, and the QOL was better in the observation group; the IoT big data center for COPD standardized management was better than traditional management of COPD patients.All the above results prove that the standardized management of COPD patients can bring great benefits to the patients.

## Conclusion

In the future, the management of COPD will undoubtedly become more personalized and bring good news for patients. However, many challenges remain. Grassroots medical personnel should not only master the operation technology of lung function examination and pulmonary rehabilitation training, but also gradually establish grassroots health records of chronic respiratory diseases, including screening, intervention, health management, disease monitoring, and pulmonary rehabilitation programs. Xiamen took the lead in establishing an IoT big data management platform to achieve early screening in the community, linkage between institutions of all levels, home monitoring, and rehabilitation training, comprehensive closed-loop management, and hospital treatment data and regional patient information sharing to gradually change data islands and medical resource optimization, which is worth reference and promotion.

The number of COPD patients is large and the growth rate is fast. The intervention and management of COPD patients is a persistent task, which is easy to cause loss to follow-up. The pulmonary function test needs standardized training and assessment certification, and the primary physicians who pass the assessment will carry out the certificate. The medical level of primary care is generally insufficient, and it is necessary to improve the professional skills of primary care doctors, and to overcome difficulties such as the imbalance of human and material resources. In the early stage of research, high investment in equipment, heavy task of personnel training, and high human investment cost affect the promotion and implementation of the hierarchical management model of COPD under the IoT medical technology. The study was based on the national COPD

Early screening and Intervention in primary Care project, and was strongly supported by local health authorities. After two years of exploration and practice, it has achieved remarkable results, and has been recognized and supported by relevant authorities. In the future, we will continue to achieve quantitative, specific, and continuous management of chronic respiratory diseases. Using the established hierarchical diagnosis and treatment management system of chronic respiratory diseases based on the IoT, the goal of connecting medical resources up and down, early diagnosis and treatment, early intervention, and early rehabilitation can be achieved.

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