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Development and real-world implementation of a multicenter digital registry and management platform for chronic obstructive pulmonary disease: an observational implementation study

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Development and real-world implementation of a multicenter digital registry and management platform for chronic obstructive pulmonary disease: an observational implementation study

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Abstract

Background

Patients with chronic obstructive pulmonary disease (COPD) require long-term, multidisciplinary management. Still, multicenter programs often face fragmented data capture, delayed quality control, incomplete follow-up, and limited visibility of remote monitoring data. We developed a multicenter digital registry and management platform to support data acquisition, quality control, role-specific reporting, and wearable-device monitoring.

Methods

We conducted an observational implementation study of a digital COPD registry and management platform deployed in a multicenter project in China. The platform integrated electronic data capture (EDC) data, questionnaire and examination records, cohort and physician–patient management, daily COPD exacerbation recognition tool (CERT) symptom reporting, wearable-device monitoring, role-specific WeChat reports, and hierarchical dashboards. We synchronized data from cloud sources to a local adjunct management database and transformed them into management indicators. We evaluated registry and organizational coverage, CERT activity, current wearable-device binding, recent 30-day wearable-monitoring events and alerts, questionnaire-index coverage, and production WeChat messaging using verified production data available on 10 September 2026.

Results

The platform indexed 2,894 included participants across 18 regional subcenters and 114 participating units, with 347 physicians linked to at least one recruited participant. The CERT index contained 26,092 valid records, and 277 participants had current wearable-device bindings. During the most recent 30-day monitoring period, the platform recorded 44,879 blood-pressure events, 8,685 abnormal blood-pressure or heart-rate alerts, and 2,417 low-oxygen-saturation alerts (SpO_2 <90%). The questionnaire index contained 3,373 question-index entries, and production messaging logs recorded 9,144 successfully sent WeChat reports.

Conclusions

This multicenter COPD digital registry and management platform integrated heterogeneous source data into an operational registry, converted registry data into management indicators, and delivered those indicators through role-specific reporting and hierarchical dashboards. The verified 10 September 2026 snapshot demonstrated registry-scale implementation across participating centers, physicians, symptom monitoring, wearable monitoring, and production messaging. Further work should evaluate workflow impact, user adoption, and patient outcomes.

Trial registration

The parent IMPACT COPD Cohort (China) was prospectively registered at ClinicalTrials.gov (NCT07382986) on 3 February 2026.

Keywords

Chronic obstructive pulmonary disease; digital health; electronic data capture; wearable devices; WeChat; remote monitoring

Background

Chronic obstructive pulmonary disease (COPD) is a major chronic respiratory disease that requires sustained assessment, risk stratification, symptom monitoring, pulmonary rehabilitation, medication management, and follow-up over long time horizons [1-5]. Multicenter COPD programs depend heavily on high-quality data capture and timely operational feedback because different users, systems, and institutions often generate baseline assessments, pulmonary-function reports, imaging files, symptom questionnaires, wearable-device data, and follow-up records.

Digital health technologies have been increasingly explored in COPD care. Systematic reviews suggest that digital interventions may improve selected outcomes, but evidence remains heterogeneous, and clinical effectiveness remains uncertain across intervention types, settings, and outcome definitions [6-8]. Prior studies have evaluated WeChat-based pulmonary rehabilitation and self-management programs [9,10], smartwatch-based intensive monitoring in patients with COPD [11], smartphone and smartwatch self-management applications [12], integrated digital monitoring and pulmonary rehabilitation models [13,14], digital health systems designed for personalized long-term COPD management [15], and clinical knowledge bases for mobile decision support in chronic respiratory diseases [16]. These studies support the feasibility of

mobile health, wearable monitoring, and knowledge-supported care, but many interventions focus on a single patient-facing or device-facing component.

Registry and decision-support studies further show that COPD programs require standardized data elements, reliable guideline translation, and attention to implementation outcomes [17-20]. In real-world multicenter COPD management, the operational challenge is therefore broader than deploying a mobile application or a wearable device: data must be captured through robust electronic data capture architectures [21], transformed into reliable cohort and quality-control indicators, delivered to the right clinical or administrative role, and monitored over time without disrupting existing clinical systems.

In the present project, we developed an adjunct digital management platform for a multicenter COPD management program. The platform was designed to preserve existing cloud EDC and patient-facing workflows while adding cohort governance, structured questionnaire and examination management, quality-control rules, daily symptom monitoring, smartwatch monitoring, role-specific WeChat service account reports and hierarchical dashboards. Additional modules for intelligent voice follow-up, device distribution management, and personalized recommendation and knowledge retrieval were under iterative development. Intelligent voice follow-up had not been deployed for routine use by the analytical cutoff date of 10 September 2026. This study aimed to describe the platform architecture and implementation workflow and to quantify the operational performance of functions for which complete evaluation data were available.

Methods

Study design and setting

This was an observational implementation study of a multicenter digital registry and management platform for COPD. The study evaluated system design, deployment, and operational data generated during routine use. The platform served as an adjunct management layer connected to existing EDC and monitoring data sources. It did not replace the source EDC system or modify the underlying cloud-source data structures.

The implementation supported a multicenter COPD project in China. Its organizational structure comprised four administrative levels: the overall project, regional subcenters, participating units, and individual physicians. Project administrators oversaw the overall cohort; regional principal investigators (regional PIs)

coordinated their respective subcenters; participating-unit investigators supervised local implementation; and frontline physicians managed assigned participants.

Stakeholder involvement, pilot testing, and iterative development

The team defined platform requirements at a project-initiation needs-assessment meeting. The co-design group included respiratory clinicians at different levels of seniority (chief physicians and resident physicians), the project principal investigator, project administrators, data-management personnel, and members of the research and development team. Clinicians described the clinical workflow, follow-up tasks, data-interpretation requirements, and patient-level problems that required attention. The project principal investigator and administrators defined the information required for management across the project, regional subcenter, participating unit, and physician levels. The data-management and development teams translated these requirements into data mappings, synchronization procedures, registry indexes, role-based permissions, quality-control rules, reports, and dashboard functions.

A test version of the platform was piloted before formal launch. We retained pilot-phase records as real-world operational data when they met the study eligibility and data-validity criteria. During the development period, the multidisciplinary project team held an initial needs-discussion meeting and subsequently met weekly to review development progress. These meetings covered demonstrations, workflow reviews, user feedback, and problems identified during pilot use. The team implemented and reviewed corresponding modifications before formally launching the platform.

After launch, the team continued weekly platform-use meetings. These meetings reviewed baseline data entry, user-reported problems, progress in resolving previously reported issues, and requirements for iterative optimization. Feedback was obtained from frontline clinical use, center-level management, project administration, and technical monitoring. The team recorded issues, assigned them to the relevant clinical, data-management, or development personnel, and reviewed them at subsequent meetings to determine whether they had been resolved.

Problems identified during pilot testing and early operational use included patient-information display, role-based permissions, aggregation of mobile-device data, presentation of wearable-derived indicators, and other operational issues. The clinical and development teams jointly reviewed these issues, leading to iterative

refinements to data-processing rules, interface presentation, user access controls, and related platform functions.

Feedback-led modifications included refining the baseline submission definition and cohort-inclusion rules; revising report contents; adding hierarchical drill-down pages; improving device reminders; clarifying user permissions; refining data-quality-control rules; updating COPD follow-up personnel and physician–patient relationships; and recording user operations for traceability. The system also introduced additional processing of wearable-device data before aggregation and display. Platform versions and operational rules were updated iteratively rather than being treated as fixed at the initial deployment.

Platform architecture and data flow

The platform was organized into five functional layers that progressively transformed heterogeneous source data into structured registry information, actionable management indicators, and role-specific reporting and visualization.

1. Source-system layer: existing cloud systems remained the authoritative sources of clinical and operational data, including EDC records, questionnaire and examination responses, participant and physician information, organizational records, WeChat-related data, weather data, device bindings, and wearable-device events. The adjunct platform did not modify the underlying source systems or their data structures.
2. Data-integration layer: selected source data were synchronized to the local adjunct management database through a scheduled workflow each day at 06:00. This layer was responsible for transferring, mapping, validating, and normalizing incoming data and for maintaining consistent identifiers across the connected systems. It therefore provided a standardized local data foundation for subsequent processing.
3. Registry layer: the synchronized data were reorganized into a structured operational registry that linked participants, physicians, organizational units, time points, and devices. The registry converted heterogeneous source records into a consistent, query-ready representation of the cohort and its longitudinal clinical and monitoring information. This layer served as the common data basis for all downstream management functions.

4. Management-service layer: predefined operational rules were applied to the registry to derive management indicators, identify incomplete or abnormal records, and generate exception and follow-up tasks. In this layer, structured registry data were transformed into information that could directly support quality control, monitoring, and task prioritization. Automated rule-based screening was used to support, rather than replace, subsequent human review.

5. Application layer: the resulting management information was delivered to different users through role-specific WeChat reports and hierarchical dashboards. These applications provided project administrators, regional PIs, and frontline physicians with views appropriate to their management responsibilities and supported progressive drill-down from project-level summaries to participant-level follow-up tasks.

Figure 1 illustrates this five-layer architecture and the progression from source data acquisition to operational management and user-facing applications. Additional application functions, including intelligent voice follow-up, device distribution management, and personalized recommendation and knowledge retrieval, were under iterative development during the study period. Intelligent voice follow-up was not deployed for routine use before the analytical cutoff date of 10 September 2026. These additional functions were not included in the present quantitative evaluation.

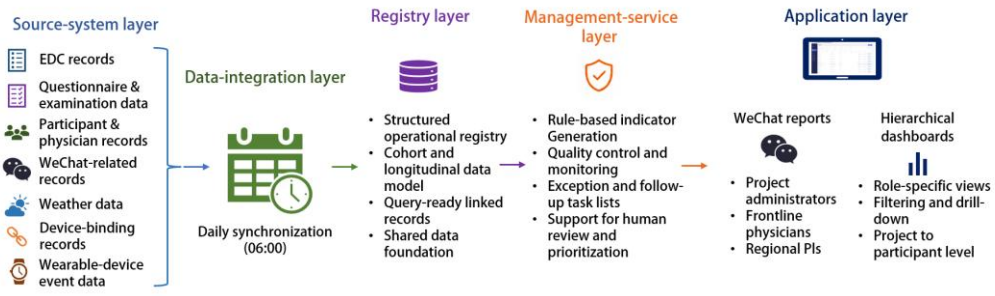


Figure 1. *Five-layer platform architecture showing the progression from source systems through data integration and registry construction to management services and role-specific applications.*

Operational cohort and clinical-data management

The operational cohort comprised participants with a valid enrollment record for the COPD management project and an available participant identifier. We excluded test users, management accounts, and records not linked to the study cohort. The cohort index retained the participant identifier, participant code, inclusion

status, and, where applicable, the reason for exclusion. All participant-level analyses used this operational cohort definition.

Active physician–patient assignments linked each included participant to the responsible physician and organizational unit for role-specific follow-up. We transformed EDC-derived questionnaire and examination records into structured indexes covering questionnaire-derived comorbidities, pulmonary-function testing, chest computed tomography, six-minute walk testing, and other project-required baseline assessments. A baseline assessment was classified as formally submitted only when the corresponding baseline-stage record contained a submission date; draft or incomplete records without a submission date were not classified as formally submitted. The resulting indexes captured baseline submission status and date, completed and missing assessment items, and outstanding information. They supported data-quality monitoring, dashboard aggregation, and role-specific reporting.

The platform incorporated previously published standardized patient-reported assessment instruments, including the COPD Assessment Test (CAT), St George's Respiratory Questionnaire for COPD (SGRQ-C), Gastroesophageal Reflux Disease Questionnaire (GerdQ), modified Medical Research Council (mMRC) Dyspnea Scale, Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7), EuroQol 5-Dimension 5-Level questionnaire (EQ-5D-5L), 36-Item Short Form Health Survey (SF-36), STOP-Bang questionnaire, Pittsburgh Sleep Quality Index (PSQI), and Epworth Sleepiness Scale (ESS) [22–32]. These instruments were administered at different assessment intervals according to the study protocol. Questionnaire responses were incorporated into the electronic data capture system and organized as structured assessment records within the operational registry.

Three-month follow-up information was documented using structured case report forms (CRFs). These forms were completed by research personnel based on available clinical records rather than administered to patients as standardized questionnaires. The collected information was organized into predefined clinical data fields, reviewed by the physicians responsible for patient management, and subsequently entered into the EDC system.

231 Daily symptom and wearable monitoring

232 Daily respiratory symptoms were monitored using a project-adapted questionnaire based on the previously
233 published COPD Exacerbation Recognition Tool (CERT) [33]. The questionnaire comprised five CERT-
234 related symptom items assessing worsening cough, increased sputum volume, insufficient air intake, labored
235 breathing, and activity limitation, together with an additional 0–10 numerical rating item assessing dyspnea
236 severity.

237 Patients completed the questionnaire daily through the patient-facing digital platform. For the five symptom
238 items, patients were asked to compare their current symptoms with their usual condition and select one of
239 five response categories: same as usual, mild, moderate, severe but tolerable, or severe and intolerable. The
240 additional dyspnea item used an 11-point numerical rating scale ranging from 0 (no breathlessness) to 10
241 (maximum breathlessness).

242 The English-language translation of the complete six-item questionnaire used in this study is provided in
243 supplemental materials.

244 We indexed valid responses to the project-adapted CERT-based questionnaire with the participant identifier,
245 responsible physician, score, data source, response time, validity status, and structured question–answer
246 content. For operational summaries, the platform counted only valid submitted records in the CERT index.

247 Wearable-device monitoring used current patient–device binding records and device-generated physiological
248 data. For the present quantitative evaluation, wearable-device coverage was defined as the number of
249 included participants with a current device binding. Recent monitoring activity was summarized over the
250 most recent 30-day period using the number of blood-pressure events and rule-based abnormal alerts. These
251 alerts included abnormal blood-pressure or heart-rate alerts and low-oxygen-saturation alerts, with low
252 oxygen saturation defined as SpO_2 <90%.

253 Quality control, hierarchical review, and role-specific reporting

254 The platform applied predefined deterministic rules to synchronized EDC, questionnaire, follow-up, and
255 device data to generate preliminary quality-control indicators and exception lists. These rule-based outputs
256 identified potentially incomplete or inconsistent operational records for subsequent human review. Frontline
257 physicians reviewed participant-level information, including baseline submission status, missing CERT

reports, smartwatch binding and upload status, and other follow-up exceptions. In the reporting interface, a baseline overdue flag identified participants whose baseline assessment had remained unsubmitted for more than 30 days. Questions concerning rule interpretation, data inconsistencies, or clinically implausible information were referred to the clinical, data-management, and development teams for review and iterative correction.

The team reviewed quality-control information through a hierarchical process. Frontline physicians assessed participant-level information in its clinical and operational context; regional PIs reviewed aggregated information from participating units within their respective regional subcenters; and project administrators monitored implementation across the project. This process separated automated screening from human review and supported data-quality monitoring and task prioritization.

Role-specific reporting was delivered through a production WeChat service account workflow with predefined recipient bindings and dispatch logs. Project administrators received project-level reports; frontline physicians received reports on participants under their management; and regional PIs received summaries for participating units within their regional subcenters. Reports included structured management indicators and links to detailed records. Production-log evaluation in the current snapshot used successfully sent report records as the reporting measure. Figure 2 illustrates the data flow from synchronized source data through the operational registry to role-specific management reports.

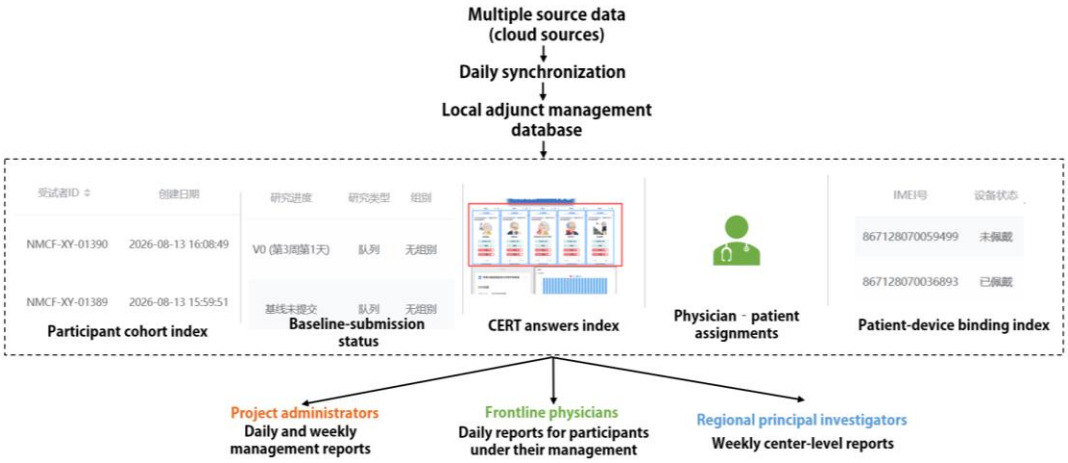


Figure 2. Data flow from multiple cloud sources through synchronization and the operational registry to role-specific management reports.

The management dashboard complemented the WeChat reports by presenting recruitment, baseline submission, questionnaire and examination status, daily CERT participation, smartwatch binding and upload indicators at the project, regional-subcenter, participating-unit, and physician levels. Hierarchical filtering and drill-down allowed project administrators to review project-wide and regional patterns, regional PIs to compare participating units within their respective subcenters, and frontline physicians to identify participant-level data-completion and follow-up tasks.

Implementation outcomes and statistical analysis

The implementation evaluation focused on the operational scale, organizational reach, and use of the major platform functions for which verified data were available at the latest analytical snapshot. The primary implementation outcomes were:

1. Registry and organizational coverage: number of included participants, regional subcenters, participating units, and physicians linked to at least one recruited participant.
2. Daily symptom-monitoring activity: total number of valid COPD Exacerbation Recognition Tool (CERT) records.
3. Wearable-device coverage and recent monitoring activity: number of participants with a current wearable-device binding and, during the most recent 30-day monitoring period, the numbers of blood-pressure events, abnormal blood-pressure or heart-rate alerts, and low-oxygen-saturation alerts (SpO_2 <90%).
4. Production messaging activity: number of successfully sent WeChat reports recorded in the production messaging logs.
5. Questionnaire-index coverage: number of entries in the questionnaire question index.

The quantitative evaluation was restricted to indicators verified from the production dashboard, local adjunct management database, and production reporting records. Platform functions or operational indicators for which an updated verified value was unavailable were not included in the present quantitative analysis.

The primary analysis used the latest verified production data available on 10 September 2026. Aggregate indicators were derived from the operational registry, questionnaire and CERT indexes, wearable-device binding and monitoring records, and production messaging logs. Descriptive statistics were used to

summarize implementation scale and activity. Counts were reported for all implementation indicators; no inferential statistical analyses were performed.

Results

Platform deployment and analytical snapshot

The platform operated as an adjunct management system connected to cloud data sources and local operational services. The analytical snapshot comprised the latest verified production dashboard and database data available on 10 September 2026.

The operational registry organized synchronized source data into domain-specific indexes covering the participant cohort, physician–patient relationships, questionnaire items, CERT responses, device bindings, device events, and messaging records.

The platform covered 18 regional subcenters and 114 participating units. Unless otherwise specified, quantitative results reported in the text and Tables 1 and 2 were derived from this analytical snapshot.

Registry coverage and organizational reach

The platform indexed 2,894 included participants across 18 regional subcenters and 114 participating units. A total of 347 physicians were linked to at least one recruited participant. In addition, 18 physicians were registered as regional PIs in the system roster. Because the physician-management and regional-PI indicators were derived from different operational definitions, they are reported separately. Registry coverage and organizational indicators are summarized in Table 1.

Table 1. Registry coverage and organizational reach

Indicator	Value
Included participants	2,894
Physicians managing at least one recruited participant	347
Regional PIs	18
Regional subcenters	18
Participating units	114

Digital monitoring and production activity

The questionnaire index contained 3,373 question-index entries. The CERT index contained 26,092 valid records. A total of 277 participants had current wearable-device bindings. During the most recent 30-day monitoring period, the platform recorded 44,879 blood-pressure events. Rule-based monitoring generated 8,685 abnormal blood-pressure or heart-rate alerts and 2,417 low-oxygen-saturation alerts, defined as SpO_2 <90%. These event and alert counts represent activity during the most recent 30-day period rather than cumulative platform totals.

Production messaging logs contained 9,144 successfully sent WeChat reports as of the 10 September 2026 analytical snapshot. These reports supported role-specific operational management for project administrators, frontline physicians, and regional PIs. Digital monitoring and production-activity indicators are summarized in Table 2.

Table 2. Digital monitoring and production activity

Indicator	Indicator	Value	Observation period
Questionnaire index	Question-index entries	3,373	Current snapshot
CERT monitoring	Valid CERT records	26,092	Current snapshot
Wearable monitoring	Participants with current wearable-device bindings	277	Current snapshot
Wearable monitoring	Blood-pressure events	44,879	Most recent 30 days
Wearable monitoring	Abnormal blood-pressure or heart-rate alerts	8,685	Most recent 30 days
Wearable monitoring	Low SpO_2 alerts (<90%)	2,417	Most recent 30 days
Production messaging	Successful WeChat report sends	9,144	Current snapshot

Figure 3 illustrates the role-specific quality-control reporting workflow for project administrators, frontline physicians, and regional PIs.

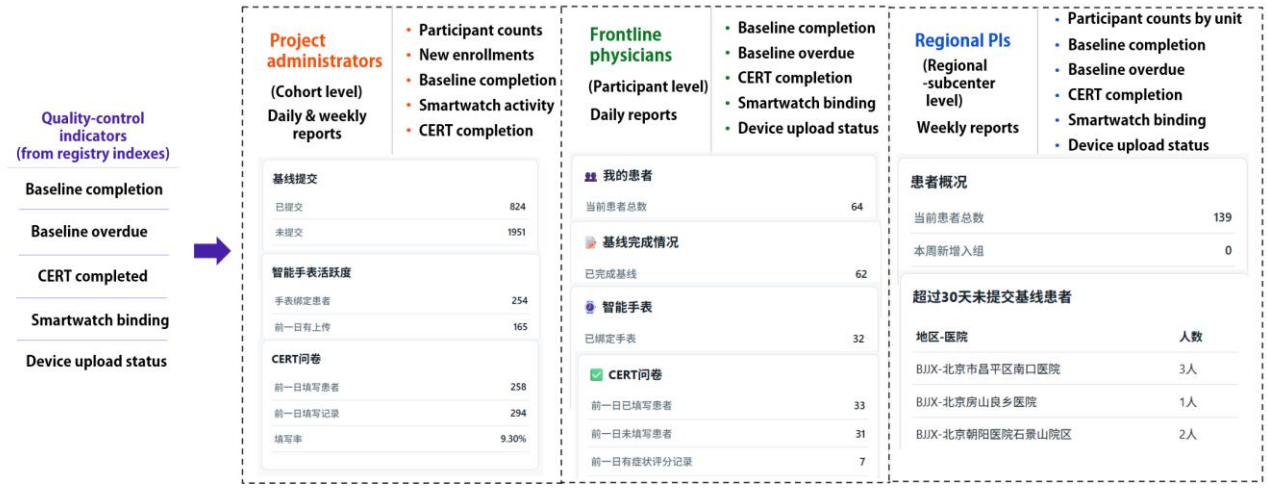


Figure 3. Role-specific quality-control reporting for project administrators, frontline physicians, and regional PIs.

Management dashboard

The management dashboard displayed recruitment progress, baseline submission, questionnaire and examination completion, daily CERT participation, smartwatch binding and upload status, and quality-control indicators at the project, regional-subcenter, participating-unit, and physician levels.

The dashboard supported hierarchical filtering and drill-down from the overall project to a regional subcenter, a participating unit, and an individual physician. Project administrators could review project-wide indicators, regional PIs could review participating units within their respective subcenters, and frontline physicians could identify participant-level follow-up and data-completion tasks. Figure 4 shows the integrated dashboard and hierarchical drill-down workflow.

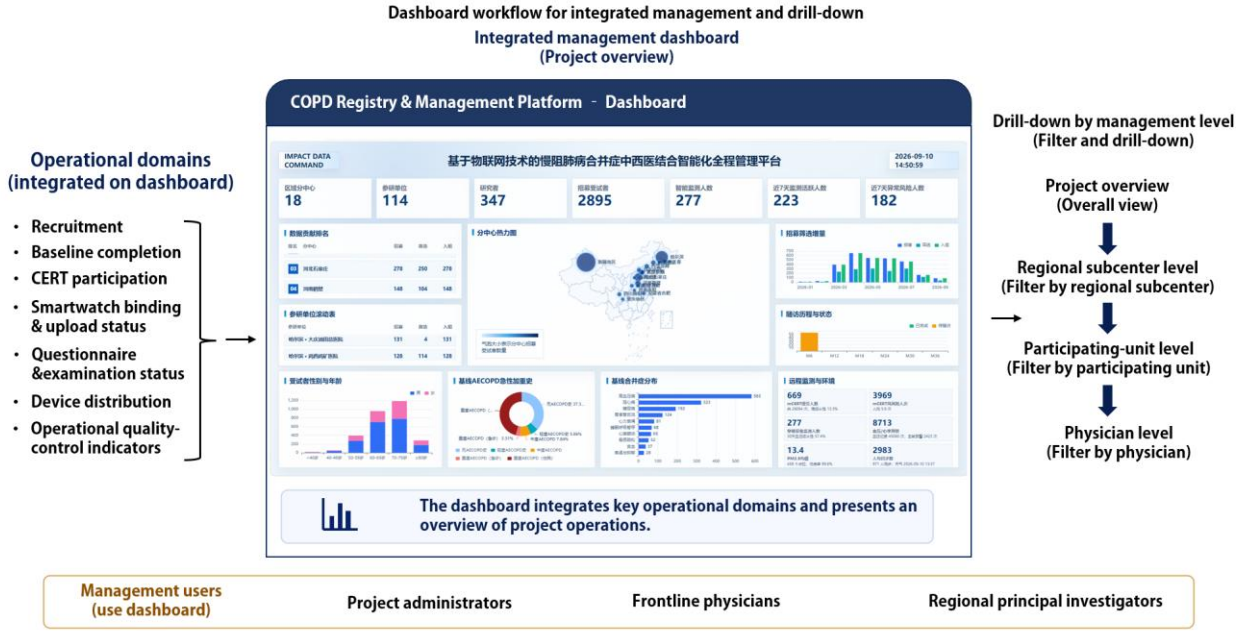


Figure 4. Integrated management dashboard and hierarchical drill-down workflow from the project level to the regional-subcenter, participating-unit, and physician levels.

Discussion

Principal findings

The principal contribution of this study is the real-world implementation of an operational architecture that integrates heterogeneous multicenter data into a structured registry and delivers role-specific management information across organizational levels. By the latest verified analytical snapshot, the platform supported 2,894 included participants across 18 regional subcenters and 114 participating units, with 347 physicians linked to recruited participants. In addition to registry-scale coverage, the platform supported substantial ongoing digital activity, including CERT reporting, wearable-device monitoring, automated physiological alerts, and production messaging.

The recent 30-day wearable data illustrate the operational burden generated by continuous monitoring. 44,879 blood-pressure events were processed during this period, together with several thousand rule-based blood-pressure or heart-rate and low-SpO_2 alerts. These findings demonstrate that implementation of wearable monitoring involves not only device deployment but also sustained processing, screening, and prioritization of high-volume physiological data.

Comparison with previous work

Previous COPD digital health studies have largely focused on patient-facing rehabilitation, self-management, physiological monitoring, and mobile or wearable interventions [9-15], whereas registry and decision-support research has emphasized standardized data and computable clinical knowledge [16-18]. In contrast, this platform was designed for multicenter operational coordination, linking heterogeneous data to an operational registry, generating actionable management indicators, and delivering role-specific information across organizational levels. Its main contribution is the integration of registry governance and operational management within a shared multicenter workflow.

Implementation implications

The iterative, stakeholder-informed development approach used in this project is consistent with user-centered approaches reported in the development of mobile health platforms for chronic disease management [34]. Three implementation lessons emerged. First, effective multicenter registry management depended on transforming raw source data into clinically and operationally interpretable management indicators. Second, the value of the same management indicators depended on organizational role: administrators required cohort-level oversight, regional PIs required center-level comparison, and frontline physicians required participant-level follow-up information. Third, wearable deployment required operational management beyond data ingestion, including device allocation, binding, upload continuity, missing-data detection, and activity monitoring.

The verified snapshot demonstrates that an integrated registry can bring recruitment, physician–patient management, symptom monitoring, wearable-device binding, questionnaire indexing, and production messaging into a shared operational framework. The current data also show that these functions were being used at multicenter scale, providing a basis for subsequent analyses of data quality, workflow performance, and longitudinal clinical value.

Strengths

The main strength of this study is its evaluation of a production platform under real-world multicenter conditions rather than in an isolated prototype environment. The analysis used routinely generated operational data, including registry records, device data, and production reporting logs, allowing the study to

characterize both system reach and implementation gaps. A further strength is the explicit separation of data integration, registry construction, management services, and user-facing applications, which provides a reusable architecture for multicenter operational management.

Limitations

This study has several limitations. First, the evaluation focused on implementation outcomes and did not assess clinical effectiveness or patient outcomes. Second, the reported indicators represent a time-specific production snapshot and may change as source data and registry records are updated. Third, the quantitative analysis was limited to a defined set of operational indicators and did not capture all platform activities. Finally, formal usability, user adoption, and behavioral responses to the reporting workflow were not evaluated.

Future work

Future studies should evaluate user adoption and workflow impact, assess the clinical value of longitudinal symptom and wearable data, and conduct module-specific validation of additional platform functions [19,20,35].

Conclusions

We implemented a multicenter COPD digital registry and management platform that linked heterogeneous source data to an operational registry, transformed registry data into actionable management indicators, and delivered those indicators through role-specific reporting and hierarchical dashboards. The verified 10 September 2026 snapshot demonstrated multicenter operational reach across participant recruitment, physician management, CERT monitoring, wearable-device binding, questionnaire indexing, and production WeChat reporting. These findings support the feasibility of an integrated operational architecture for multicenter COPD management and provide a foundation for subsequent evaluation of workflow impact, user adoption, data quality, and clinical outcomes.

List of abbreviations

CERT: COPD Exacerbation Recognition Tool

COPD: Chronic obstructive pulmonary disease

CT: Computed tomography

EDC: Electronic data capture

PI: Principal investigator

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Beijing Chao-Yang Hospital, Capital Medical University (approval no. 2025-ke-848-1). The revised study protocol and related study documents were approved by expedited review on 25 August 2026. All participants provided informed consent for participation in the parent COPD management project and for use of de-identified operational data for research. The present analysis used de-identified registry and system-log data. All research procedures were conducted in accordance with the Declaration of Helsinki and relevant ethical guidelines and regulations.

Consent for publication

Not applicable. The manuscript does not contain identifiable individual-person data.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available because they contain clinical registry data and operational records from a multicenter COPD management project, but de-identified aggregate data and analysis code may be available from the corresponding author on reasonable request and subject to institutional approval.

Competing interests

The authors declare that they have no competing interests.

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role in the design of the study; the collection, analysis, or interpretation of the data; the preparation of the manuscript; or the decision to submit the manuscript for publication.

Authors' contributions

All authors conceived the study. RHZ, XQS, and MQZ designed the digital platform workflow. RHZ, SR, TW, and XBT implemented data synchronization, indexing, dashboard, and messaging functions. SR, ZJL, HCL, WLS, DZ, LA and XQS contributed to clinical definitions, quality-control rules, and interpretation of COPD registry data. RHZ and XQS performed data extraction and descriptive analysis. RHZ drafted the manuscript. All authors critically revised the manuscript and approved the final version.

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