Reducing the chronic disease burden in China: tailoring a self-management intervention among Chinese people with chronic lung disease

Song, X.

Chapter 5

Factors influencing REducing Delay through edUcation on eXacerbations implementation: a stakeholder analysis

Submitted

Abstract:

Background

Self-management interventions may fail when implementers neglect contextual factors.

Objectives

This study aimed to identify what factors may influence the implementation of the intervention – REducing Delay through edUcation on eXacerbations (REDUX) – proven-effective in the Netherlands – in China.

Methods

A stakeholder analysis design was used; specifically, a qualitative approach was applied to identify the level of support for the intervention, factors influencing the support, and the preferred mode of program delivery in chronic lung disease patients, healthcare professionals, and policymakers. A quantitative approach was used to identify the necessary conditions to develop and implement a digital-version program in Chinese app developers and cyber-security officers.

Results

Thirty-five participants finished the interviews and 88 app developers and cyber-security officers completed the survey. Most patients, healthcare professionals, and policymakers were highly supportive of the interven-tion. Multiple facilitators (e.g., patient-provide interaction and involvement of doctors) and barriers (e.g., patient's inability to afford the medicine and lack of policy support) were identified to influence the support. The preferred mode of intervention delivery varied due to different reasons. For example, a digital REDUX was preferred when participants had positive previous experiences with digital health or received guidance on how to use/implement digital health applications. The quantitative data showed that the work process of developing the health apps about the app development process, design, and technical issues and protecting the users' security and privacy, such as access control, authentication, data transfer and retention, security, and confi-dentiality, aligned with the related international guideline recommendations.

Conclusions

The identified factors can assist in the successful implementation of the intervention. The method used in this study could serve to develop culturally-tailored self-management interventions.

Introduction

The prevalence of chronic lung diseases (CLD) is high in low-income and middle countries, including China [36,37]. More than 145 million people in China are diagnosed with CLD [7,8]. The CLD in China have resulted in excessive health resource consumption, i.e., the annual medical cost for CLD is more than $156 billion [12,13], and exacerbations account for much of these costs [247,248]. Exacerbations are sustained worsening of a patient's condition beyond normal day-to-day variations, which are acute in onset and often require a change in medication and hospitalization [14]. Evidence shows that Chinese people with CLD are often unaware of the early onset signs of an exacerbation. Furthermore, late responders recognize the exacerbations but choose to wait before taking action [39,221]. To reduce the burden caused by exacerbations, it is necessary to identify effective interventions to help patients recognize and address exacerbations early.

There is evidence that (digital) self-management interventions (SMIs) can help people with CLD manage their exacerbations at home effectively, which expedites recovery days and reduce the disease burden [51,249]. Such interventions aim to increase patients' involvement and control in their treatment, which could be helpful for people with CLD in China [22,27]. It is currently unknown to what extent such interventions can be helpful in China, as previous research has primarily been conducted in high-income countries [51,249]. Such SMIs may be inappropriate for patients in China due to contextual differences.

It is necessary to tailor effective (digital) SMIs to the Chinese context, which can improve the alignment between the (digital) SMI and the local context. It is essential to identify the factors that influence SMI implementation [16,75,250]. Specifically, it is vital to assess the local perceptions about the (digital) SMI in local stakeholders because they are involved in the implementation process and can help optimize the implementation effect [251]. There is a lack of evidence of factors influencing SMI implementation in the Chinese context, especially regarding interventions developed in high-income countries. This study aims to identify the factors that influence the implementation of an SMI in China. A SMI developed in the Netherlands is exampled in this study, i.e., REducing Delay through edUcation on eXacerbations (REDUX).

Background

REDUX aims to help patients self-manage their exacerbations using a paper-version action plan. The intervention was designed and tested in the Netherlands [51]. A pilot study showed that REDUX helped COPD patients reduce the number of days between exacerbation onset and their actions on exacerbations [51]. Given the positive findings of non-digital REDUX, it can be valuable to implement it in China for people with CLD [51]. Evidence has shown that digital interventions for people with COPD, i.e., digital health, can effectively improve quality of life and reduce hospital admissions [73]. A meta-

analysis has also shown that blended SMIs can help reduce the disease burden of CLD [27]. However, it still needs to be determined which modes of delivery are preferred and the necessary conditions to implement a digital SMI in the Chinese context.

To address the gap, stakeholder analysis will be applied in this study. A stakeholder analysis is a process of systematically gathering and analyzing qualitative information to determine which factors and conditions should be taken into account when developing and/or implementing a policy or program [252]. A qualitative approach is undertaken in patients, healthcare professionals (HCPs) (e.g., doctors and nurses), and policymakers. These stakeholders are included because of their essential role in the REDUX implementation (**Figure 1**). Involvement of these stakeholders can help to identify their level of support for REDUX, the factors influencing their support, and their preference for the mode of delivery [86-88,253-255]. To gain insight into the requirements to develop and implement a digital-version REDUX, a questionnaire will be administered in the Chinese app developers and cyber-security officers (their roles in the REDUX implementation are specified in **Figure 1**) [81,163,256,257].

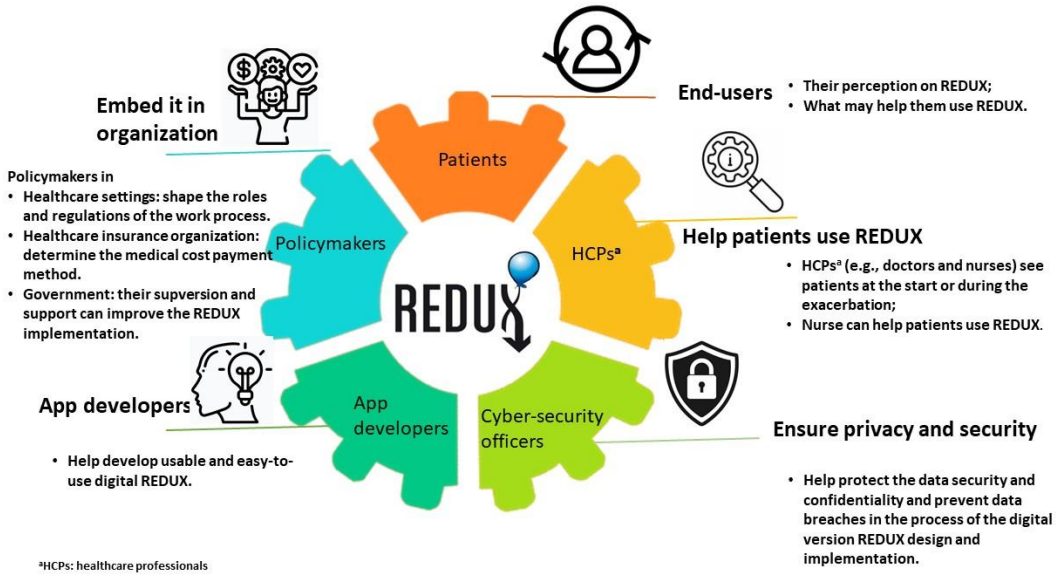

Figure 1. The roles of different stakeholders in REducing Delay through edUcation on eXacerbations (REDUX) implementation.

In sum, this study aims to identify the factors influencing the implementation of REDUX in China by identifying: (a) the level of support, factors influencing the support, and the preferred mode of REDUX delivery from patients, HCPs, and policymakers, and (b) the necessary conditions to develop and implement a digital-version REDUX from app developers and cyber-security officers.

Method

Study design

The study was designed and executed using the stakeholder analysis guidelines (see Box 1) [252]. The data was collected from September 2021 to January 2022.

Study population

Patients were included if diagnosed with a CLD (COPD or asthma, or COPD overlapping with asthma) and aged ≥ 20 years old (without a maximum age) [36,37]. Patients were excluded if they could not read or were diagnosed with mental disabilities by a doctor. HCPs who worked for the respiratory department in secondary care (SC) or with CLD patients in primary care (PC) were included. Policymakers, including the managers at the executive management level in Chinese PC and SC, government, and healthcare insurance institutions, were eligible for inclusion. Software engineers, project managers, and other positions involved in developing health app(s) were included in the group of app developers. Cyber-security officers were individuals who worked as privacy or safety officers, dealing with internet information security or digital health users' privacy [258].

Sample size calculation

Qualitative interviews were conducted until data saturation was reached [259]. The sample size estimation for app developers was based on the response rate of app developers from a previous study (i.e., 57%) [78]. To be conservative, we expected a response rate of 33%; that is, the average response rate for online questionnaires [260]. Therefore, the required sample size of app developers was 32 (5% alpha and 80% power) [261]. The sample size estimation for cyber-security officers was based on the response rate of a previous study (i.e., 33.3%) [262]. To be conservative, we set the response rate at 10%. Using this, the required sample size of cyber-security officers was 24 (5% alpha and 80% power) [261].

Stakeholder analysis process

The stakeholder analysis process was designed using the Schmeer model, which consisted of six general phases (Box 1) [252]. The stakeholder characteristics and level of support for REDUX were measured with the elements of awareness, power, position, and interest in using REDUX [252]; the definition and relevance of these elements can be found in Appendix A. The location of the stakeholders was categorized into national- and regional-level [84]. The national locations are those organizations responsible for policy-making, and the regional locations are mostly delegated to implement a new policy [84].

Instruments

Qualitative interview

The semi-structured qualitative interviews with patients, HCPs, and policymakers were guided by a topic list, focusing on perceptions and factors influencing the implementation of REDUX in China (Appendix B). The interview started with a brief introduction about REDUX and the objective of the interview. The introduction was followed by a question to identify their general understanding of self-management (SM). Next, the REDUX action plan was shown and explained to the stakeholder. Furthermore, there were questions to identify stakeholders' perceptions of REDUX and the factors influencing the implementation. The specific questions asked varied for stakeholders based on their role in the intervention.

Quantitative data

Two separate questionnaires were developed, including one for app developers and one for cyber-security officers. The questionnaires were based on previous studies [78-80]. To ensure the validity of the questionnaires, two app developers and one cyber-security officer checked the questionnaire for their field.

Both questionnaires started with a brief introduction about REDUX, the questionnaire's objective, and several socio-demographic questions. The app developers completed 18 questions about the app development process, which involved the ditigal health development guideline recommendations related to the app development process and cyber-security and privacy readiness, market, design, and technical issues during the app development. Cyber-security officers answered 24 questions about protecting the user's security and privacy in China and the conditions they needed to consider during the health app development and implementation. The questions involved the perspective on access control, authentication, data transfer, data retention, security and confidentiality, integrity, informing patients, body area network communication, and breach notification. The questionnaires are attached in Appendix B.

Box 1 Process of the stakeholder analysis for the REducing Delay through edUcation on eXacerbations (REDUX) implementation

1. **The process to select and define a policy was planned.**
   - The aim of the stakeholder analysis, the timeline to collect and analyze the data, and the targeted stakeholder categories were determined.
   - The policy, i.e., REDUX, was determined [51].
2. **Identifying key stakeholders**
   - Random and purposive techniques were used to include patients, HCPs, and policymakers[a].
   - A questionnaire was administered in app developers and cyber-security officers. They were identified by posting the questionnaire on research websites, i.e., Wenjuanxing and Dingxiangyuan.
3. **Adapting the tools**
   - The topics in the questionnaire and the interview list (see 3.5 Instruments) were defined. The stakeholder characteristic was defined, and the location category was added (see Appendix A).
4. **Collecting and recording the information and filling in the stakeholder table**
   - Written informed consent was obtained before the online semi-structured interviews. Interviews were conducted through Wechact or VooV (i.e., Chinese social media applications). After finishing the interviews, XYS and BBL copied the responses from the interview to the stakeholder characteristic table.
   - Participants gave their informed consent before participating in the quantitative questionnaire. Next, XYS and QZ copied the data from the completed questionnaires to SPSS 'IBM SPSS Statistics for Windows, version 25.0 for analysis.
5. **Analyzing the stakeholder information**
   - Resource scores for each stakeholder were averaged with integer numbers, resulting in a power score between 1 (low power) to 3 (high power). The number of perceived benefits or disadvantages of REDUX was counted to assess the interest in REDUX. Interest was scored between 1-3; 1 = low interest (i.e., perceived more disadvantages), 2 = medium interest (i.e., an equal number of perceived benefits and disadvantages), and 3 = high interest (i.e., perceived more benefits). The position was determined by participants' self-reported level of support and interest, ranging from 1 (low support) to 3 (high support). The score was averaged across stakeholders with integer numbers, resulting in a position score between 1 (low position [low support]) and 3 (high position [high support]). The awareness of REDUX was assessed with the knowledge of REDUX. The level of awareness was rated from 1 (no knowledge) to 3 (a lot of knowledge). Discrepancies between XYS and BBL were discussed to achieve agreement.
   - XYS divided the data on socio-demographical characteristics into three groups, i.e., patients, HCPs, and policymakers. Next, XYS categorized the stakeholders in a matrix where power was in the row (n = 3) and position was in the column (n = 3).
   - To identify the factors influencing support, deductive content analysis of transcripts was used by XYS and BBL using the CFIR [16], which comprises 39 specific constructs within five major domains, i.e., domains of the intervention characteristics, inner and outer setting, the individuals involved, and the process. Discrepancies in the codes were discussed to reach an agreement. Atlas.ti Web (Version 9.0) was used to store and manage the qualitative data.
   - Descriptive analyses (e.g., N, percentages) were used to summarize the quantitative data.
6. **Using the information**
   - Identifying the support for the REDUX implementation and the factors influencing it can help improve the implementation success of REDUX. The knowledge of the development of health apps in China can help determine what conditions are necessary when developing a digital version of REDUX.

HCP: healthcare professional; CFIR: Consolidated Framework for Implementation Research. [a] XYS sent invitation emails and messages to HCPs and policymakers who published publications on chronic lung disease self-management or showed nterest in this topic. When the HCPs or policymakers showed interest in our research, they were invited to participate in the research and/or were asked to refer other people who would be interested in it. in response to the invitation from a recruited policymaker, an online public presentation – presenting chronic lung disease management in the Netherlands – was given to employees of one hospital in Zhengzhou, China. The online presentation helped recruit HCPs and policymakers.

Ethical considerations

The study's objective and requirements were explained to the participants, and all participants provided written informed consent. This study received ethical approval from Zhengzhou University in September 2021 (ZZUIRB202187).

Result

Descriptive statistics

Interviews

Thirty-five stakeholders participated in the interviews (response rate = 83.3%); eight patients, 19 HCPs, and eight policymakers. Four people did not participate due to a busy schedule, and four did not respond to the invitation.

All patients showed low power; the majority scored low on position (5/8) and high on interest in the intervention (5/8). Moreover, the majority scored middle to high on awareness of the intervention (6/8). Nearly half of the HCPs showed high power (8/19) and a medium level of position (10/19). In addition, most reported high interest in (13/19) and awareness of (12/19) the intervention. Furthermore, all policymakers showed high power, and most had a high interest in (6/8) and awareness of (7/8) the intervention. The position of policymakers varied from low to high. Most patients (5/8), HCPs (14/19), and policymakers (5/8) were from regional locations. The power and position in specific locations are detailed in **Table 3**. All patients - in regional and national locations - showed low power and varied position. Most HCPs in national locations (4/5) had high position and power, whereas the position-power relationship varied for HCPs in regional locations. Most policymakers (4/5) from regional locations showed high power with middle position, whereas most policymakers in national locations had high power with a high position (2/3). Detailed stakeholder characteristic data are specified in Appendix C.

Online questionnaire

Sixty-one app developers participated in the questionnaire, with sixty completing the questionnaire. Respondents included software engineers (n = 44), project managers (n = 9), and others (n = 7). The other category included three backend developers, one quality assurance engineer, and three user experience designers. The majority worked on the health apps for 1-5 years (n = 41), and the minority for over five years (n = 19). The number of apps they had developed was 1-5 (n = 57), and over five (n = 3). Twenty-seven cyber-security officers completed the questionnaire. They worked on IT security-related tasks (n = 4) and privacy/data protection related tasks (n = 23).

Table 2 Characteristics of patients, healthcare professionals (HCPs), and policymakers in REducing Delay through edUcation on eXacerbations (REDUX) implementation (n = 35)

	Position*	Power*	Interest*	Awareness*	Location (NL/RL)
Patient (n = 8)	1/2/5	0/0/8	5/2/1	3/3/2	3/5
HCPs (n = 19)	10/7/2	8/11/0	13/4/2	12/6/1	5/14
Policy-makers (n = 8)	3/4/1	8/0/0	6/1/1	7/1/0	3/5

*:category of the variable: high/middle/low; NL: national location; RL: regional location.

Table 3 Estimation of position and power of patients, healthcare professionals (HCPs), and policymakers in REducing Delay through edUcation on eXacerbations (REDUX) implementation

	Power		
	Low	Medium	High
Position			
High	Patient in RL (n = 1)	HCP in RL (n = 2)	HCP in RL (n = 3) HCP in NL (n = 5) Policymaker in NL (n = 2) Policymaker in RL (n = 1)
Medium	Patient in RL (n = 1) Patient in NL (n = 1)	HCP in RL (n = 7)	Policymaker in RL (n = 4)
Low	Patient in NL (n = 2) Patient in RL (n = 3)	HCP in RL (n = 2)	Policymaker in NL (n = 1)

NL: national location; RL: regional location.

Factors influencing stakeholders' support for the REDUX implementation

Factors, including 14 facilitators and eight barriers, across the CFIR domain of intervention, the individual characteristics, inner and outer settings and process were identified. Specifically, three facilitators (i.e., high adaptability, low complexity, and patient-HCP interaction) and two barriers (i.e., unclear content, external entity) were identified in the intervention characteristics domain. Three facilitators (i.e., perceived intervention benefits, positive experience with SM and high level of self-efficiency) and one barrier (i.e., lack of knowledge) were identified in the domain relating to individuals involved. Regarding the inner setting domain, five facilitators (i.e., regular interaction with colleagues, involvement of physicians, active commitment from leaders of HCPs, sufficient time and human resources, and access to databases or resources) and three barriers (lack of commitment from

leaders of HCPs, increased workload, and lack of staff) were identified. In the outer setting, policy support for intervention was a facilitator. In contrast, the inability to afford the medicine and lack of support for the intervention by national guidelines or policy were the barriers. Empathy and the appropriate time to deliver the intervention were the facilitators in the process domain. These factors depended on each other; details on how they influenced the support for REDUX are specified in Appendix C.

Preferred mode of livery: qualitative data from patients, HCPs and policymakers

Patients, HCPs, and policymakers showed different preferences regarding the mode of REDUX delivery (Appendix C). A digital REDUX was considered feasible by some patients (4/8) and HCPs (6/19) and most policymakers (5/8) if these participants had positive previous experiences with digital Health or they had received guidance on how to use/implement digital health application. Yet, a paper-version REDUX was preferred by a part of the patients (1/8) and HCPs (4/19). Various reasons were given, i.e., the older patient preferred to receive the information/education in a face-to-face interaction with HCPs, and HCPs preferred to use the paper-version REDUX to collect additional relevant health data from patients during the face-to-face consultation. Furthermore, blended care was regarded as a solution to integrate digital- and paper-version advantages by some patients (3/8), HCPs (8/19), and policymakers (2/8). One HCP and one policymaker showed indifference to the delivery model because they showed low interest in REDUX.

Necessary conditions for the implementation of a digital REDUX: quantitative data from app developers and cyber-security officers

The app developers reported that the most frequently mentioned functionalities in the developed Chinese health apps were disease education (n = 32), health monitoring using sensors (n = 35) or self-report (n = 26), making (nationwide) doctor's appointments (n = 24), or medical consultation (n = 26). In the app development process, the following stakeholders were frequently involved: researchers (n = 42), doctors (n = 38), and patients (n = 22). The potential target population of health apps were researchers (n = 42), patients (n = 31), policymakers (n = 25), doctors (n = 27), and nurses (n = 27). Regarding the guidelines for developing health apps, control objectives for information and related technologies (n = 27) were regularly used. Structured threat information expressions were usually used to measure cyber-security and privacy readiness (n = 23). While, 11 health app developers did not use guidelines to measure their cyber-security and privacy readiness. The Android system (n = 49) and IOS (n = 37) were the most frequently used mobile platform to publish health apps. Furthermore, Windows was the most frequently used operating system to publish health software. Most app developers (strongly) agreed with the guideline recommendations about the app development process, design, and technical issues. Moreover, most cyber-security officers

(strongly) agreed with protecting the users' privacy and security in the international guideline recommendations such as access control, authentication, data transfer, data retention, security and confidentiality, integrity, informing patients, body area network communication, and breach notification. Yet, some cyber-security officers disagreed with such guideline recommendations. The specification about how to develop and implement Chinese health apps and ensure data security and privacy in China are included in Appendix C.

Discussion

This stakeholder analysis study identified the level of support for REDUX, factors influencing the level of support and the preferred model of intervention delivery according to the patients, HCPs, and policymakers. Additionally, Chinese app developers and cyber-security officers provided data on the necessary conditions to develop and implement the digital-version of REDUX. The patients, HCPs, and policymakers had various levels of power, awareness, and interest in REDUX. Most patients, HCPs, and policymakers were highly supportive of REDUX for its potential positive effect on improving patients' SM. Yet some patients, HCPs and policymakers showed a lower level of support potentially because it would be difficult for them to implement a new SMIs with insufficient resources and/or inadequate awareness of the intervention. Such a finding is in line with earlier stakeholder analysis studies in implementation science [82,84]. Multiple factors, covering facilitators and barriers within the CFIR domains, were identified that influenced their support (see Box 2).

Box 2. Factors – positioned within the consolidated framework for implementation research (CFIR) - influencing the implementation of REducing Delay through edUcation on eXacerbations (REDUX).

Domain I: Intervention characteristics	
Constructs	Explanation
1. Adaptability	HCPs considered it easy to incorporate REDUX into their work processes and felt confident using it. However, the open questions in the action plan were different from what they usually ask. The questions required HCPs to provide an extra explanation to patients, which hindered them from using the intervention to the Chinese context. This finding was attributed to the different contexts. To illustrate, the HCPs - in the Netherlands – use interaction strategies with open questions to empower patients to manage their disease [51]. But Chinese HCPs chose to use paternalistic strategies in practice, in which HCPs used closed questions to get information about patients and provide education benefiting them [81,269].

2. Complexity	All patients and some HCPs believed the action plan was simple and low in complexity. However, some HCPs believed that the questions in the action plan cost them extra time and effort. To circumvent complexity issues, making some minor adjustments when using REDUX in the Chinese context is required. At the same time, adequate training of HCPs using the patient-centered intervention is required as Chinese HCPs may not be used to this way of working (e.g., they use paternalistic strategies that can limit the educational effect of the intervention).
3. Design quality and packaging	The action plan is easily accessible to patients and HCPs, which promotes its use in the Chinese context.
4. Intervention source	A concern was expressed by the HCPs that a SMI developed in the Netherlands could not help people with CLD in China as the intervention is not tailored for Chinese patients. The input from this study can provide data to tailor REDUX in the Chinese context.
5. Relative advantage	Patients, HCPs, and policymakers reported that compared with other interventions (e.g., medication intervention), REDUX could actively empower patients to SM their disease.
Domain II: Individual characteristics	
1. Knowledge and beliefs about the intervention	The perceived benefits of intervention helped to increase HCPs' desire to be involved in the REDUX implementation. This facilitator was in line with a previous study, in which stakeholders showed higher interest when they perceive the benefits of an intervention [16]. Lack of knowledge was a barrier. Of great concern is that limited knowledge of the intervention may lead to other barriers, such as low self-efficacy to implement REDUX, which may hinder the implementation of REDUX.
2. Self-efficacy	Most HCPs believed in their capabilities to execute courses of action to achieve REDUX goals, which leads to a high possibility of up-taking and implementing REDUX successfully.
3. Positive experience with SM	With the experience of benefitting from SMIs, HCPs and patients would be more willing to implement or use other SMIs. For example, the positive experience with SM can promote patient collaboration during the REDUX implementation.
Domain III: Inner setting	
1. Networks and communications	Regular interaction with colleagues (including the formal and informal nurse-nurse, doctor-nurse, and doctor-doctor communication) was a facilitator. That is because such interactions can engage more HCPs with the intervention. The involvement of physicians was also a facilitator because they have more authority – compared with Chinese nurses– over patients, which can optimize patient involvement in the SMI implementation.
2. Readiness for implementation 2a. Leadership engagement	Active engagement from leaders of HCPs was a facilitator. Their engagement in the implementation process can assign dedicated staff to perform the necessary change, which may ease the workload and the concern for increased work. The inadequate leadership sub-optimized the effect of interventions due to the lack of management.

2b. Available resources	Sufficient time and human resource is a facilitator. Sufficient time and human resources can ensure that the HCPs commit to the REDUX implementation, significantly optimizing healthcare outcomes and reducing the disease burden. The lack of staff and increased workload can be considered as barriers; these barriers were also reported in many other studies on SMIs [16,270,271]. It is essential to stimulate other facilitators, e.g., leadership engagement and regular interaction with colleagues, to address these barriers. These solutions could reduce HCPs' workload and time of adding new interventions, increasing the likelihood of successful evidence implementation in busy settings.
2c. Access to knowledge and information	Access to databases or resources was a facilitator. To illustrate, ease of access to information and knowledge about the intervention helped to incorporate it into the work process.
Domain IV: Outer setting	
1. Patient needs & resources	The inability to afford medicine was a barrier. Insufficient funds for the medicine will limit the patient's ability to follow the action plan; the action plan expects patients to increase their medicine promptly when symptoms are worsening. Inadequate use of medicine could lead to worse exacerbation, which should be targeted to improve patient outcomes. Increasing patients disease knowledge e.g., adequate use of medication, can help to prevent worsening of health outcomes.
2. External policies and incentives	With policy support, such as promoting the SMI implementation, HCPs would prioritize SMIs such as REDUX in their work practice. Policies or standards could also be essential in reaching an agreement on goals and feedback during the REDUX implementation. Without policy support, some HCPs and policymakers expressed their concerns about the return of investments of implementing REDUX. The financial benefits of the REDUX implementation – such as reduced emergency room visits and hospital stay - is difficult to measure within a short time, and the healthcare insurance cannot reimburse the implementation of REDUX without such knowledge. HCPs will put more time and effort to implement REDUX when such interventions are prioritized in the policy recommendations.
Domain V: Process	
1. Planning	The appropriate time to deliver the intervention was a facilitator. This facilitator can help patients obtain the optimal benefit from the intervention when actively attempting to change their behaviors.
2. Engaging	Empathy was regarded as a facilitator. For example, patients would be more engaged in REDUX when their voices were listened to, and their needs were considered in the intervention.

HCP: healthcare professional; CLD: chronic lung disease; SMI: self-management intervention.

The preferred model to deliver REDUX varied because of different perceived benefits or feasibility of the delivery modes Such findings aligned with the previous studies, which compared the delivery and effect of different modes of SMI delivery [27,263]. Previous studies indicate that all SMI delivery modes can have advantages; tailoring the mode of delivery to the local context could help optimize the implementation effect [27,263].

When it came to the work process to develop and implement the health apps, quantitative data showed that it was possible for the Chinese patients to make nationwide doctor appointment; this could be because there is a lack of strict referral and counter-referral system between different healthcare settings, such as SC and PC [264]. These identified findings did not align with previous studies focusing on health app development outside of China [265,26]. Considering such an appointment system allows patients to access different HCPs, which can bring difficulties to collect patient data during the REDUX implementation. Accordingly, implementing REDUX to patients who have fixed HCPs can optimize the implementation.

Additionally, Chinese app developers presented that the work process – about the health app development, cyber-security, and privacy readiness, market, design, and technical issues – is in line with other studies on health app development and implementation [78-80]. Furthermore, most app developers (strongly) agreed that their work in access control, authentication, data transfer, data retention, security and confidentiality, integrity, informing patients, body area network communication, and breach notification aligned with the requirement in the guideline recommendations. This finding is new because – to our knowledge – this is the first study to identify the necessary conditions for developing and implementing health apps from the perspective of health app developers and cyber-security officers. Yet, some app developers disagreed on a few recommendations, such as access control, authentication, data transfer, data retention, security and confidentiality, integrity, informing patients, body area network communication, and breach notification. The discrepancy could be explained by the fact that the standard of digital health use is feasible for most app developers and cyber-security officers worldwide [81,267], but some guideline recommendations were beyond the standard in their practice [268]. The data explanation in the health app development - most agreement and some disagreement response on guideline recommendations - can also explain the similar data in the field of cyber-security from cyber-security officers.

Several limitations should be addressed in the interpretation of the results of this study. First, although this study applied the stakeholder analysis, there might have been some missing information on the power. That was because the power of patients, HCPs, and policymakers might shift over time or is only be applicable in specific contexts. For example, China is in a new round of healthcare innovation [72 88], which addresses the role of HCPs, especially nurses, in helping patients improve their

healthcare outcomes. That indicated that HCPs could have a higher power in the SMI implementation. Second, selection bias could exist because the questionnaire was offered on the research websites, resulting in some missing data from app developers or cyber-security officers who are inexperienced with research.

Relevance for clinical practice

We identified that the open questions in the action plan required extra explanation to patients. To improve the adaption of REDUX in the Chinese context, it is necessary to make minor adjustments to the questions (e.g., using local norms and adding answer options). To illustrate, the second question, 'what do you do', can be adjusted to a question like ' what kinds of actions did you have'. Instead of having an open answer format, answer options could be provided. Then, patients can select the answer(s) suitable for them. Patients can also add more responses when necessary. Besides, a lack of patient-centered interaction during the REDUX implementation can jeopardize SM for patients. Therefore, it is necessary to provide training to HCPs on how to provide patient-centered interventions and help patients SM their diseases.

The REDUX implementation experience in the Netherlands has shown that the return on investment could be very quick when it saves patients' hospital admissions [51]. The different perception on the same topic was identified in this study. The divergence can be due to the lack of practice using REDUX in China. It is recommended for that Chinese HCPs to implement REDUX, which can help to measure the return of REDUX. In addition, external policies and incentives were also identified as the essential factors influencing the REDUX implementation. To improve the REDUX implementation, policymakers must develop policies or guideline recommendations prioritizing patient-centered interventions, e.g., SMIs. Besides, not all Chinese CLD patients can afford medicine, which sub-optimizes not only treatment of the CLD, but also the REDUX implementation. An adequate healthcare insurance system is an essential external force that can facilitate the REDUX implementation and ensure everyone can benefit from the intervention. For example, the healthcare insurance system should improve reimbursement to help cover the medication cost due to CLD. Additionally, HCPs and policymakers worried that their investment in REDUX would not benefit patients within a short-time. In the new round of healthcare innovation [72,88], it is necessary to address the long-term benefit of implementing SMIs, e.g., prioritize the human and resource investment in SMI implementation.

Conclusion

Most patients, HCPs, and policymakers (highly) supported the REDUX implementation in China, yet some had a lower level of support for it. Multiple factors influenced their support for REDUX; critical

facilitators are patient-provide interaction in the intervention, patients' positive experience with SMIs, and involvement of physicians in the implementation process. Yet the barriers, such as patients' inability to afford the medicine, and lack of HCPs, should be addressed. The work process to develop and implement the digital-version REDUX in China should align with the international guideline recommendations. The identified factors in this study can help leverage the local resource to ensure the REDUX implementation successfully, consequently optimizing patient health outcomes. Furthermore, the method used in this stakeholder analysis study could serve to develop culturally-tailored SMIs.