How Can a Canadian-Specific Accessible Mobile Health Tool Improve Doctor-Patient Communication and Patient Symptom Tracking for Higher-Risk (People over 65) Chronic Obstructive Pulmonary Disease Patients

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Abstract

Chronic Obstructive Pulmonary Disease (COPD) is a leading cause of morbidity and hospitalization in Canada among individuals aged 65 and older, who face persistent challenges in daily symptom management (McLean et al., 2012, p. e740; Government of Canada, 2022). Although several mobile health (mHealth) tools have been developed to support chronic disease self-management, existing applications often rely on manual data entry, offer fragmented and overly technical data, and lack accessibility features tailored to aging users. These limitations increase interaction burden, reduce long-term adherence, and hinder effective patient-provider communication (Kaplan et al., 2024, p. 4; Zou et al., 2024, pp. 5-6).

This Major Research Project (MRP) explores how an accessible, low-burden mHealth tool can improve symptom tracking and doctor-patient communication for people 65 and older with COPD. Following an inclusive design methodology grounded in the Knowledge Loop framework, key concepts from literature,and a content analysis of eleven existing chronic disease management apps were conducted to identify core user needs: reducing physical management burden, bridging communication gaps, addressing digital barriers, and supporting long-term adherence. Based on these findings, a mid-fidelity prototype (LungMate) was developed, featuring a daily check-in, a one-page report export with dual summaries (patient and clinician versions), multimodal feedback, and adjustable text size.

The prototype was tested with four participants and one healthcare provider (adults over aged 65) through task-based usability sessions and short interviews. Thematic analysis identified several usability and accessibility barriers, which informed concrete design recommendations. The study demonstrates that simple, low-effort design choices can significantly improve the usability and accessibility of mHealth tools for people 65 and older.

Keywords: Chronic Obstructive Pulmonary Disease; COPD; mobile health; mHealth; inclusive design; older adults; symptom tracking; doctor-patient communication; self-management; multimodal feedback

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1.0 Introduction

1.1 Project Background and Purpose

Chronic diseases represent a major global health challenge, particularly as approaches to management extend beyond clinical settings into patients' everyday lives. Effective care requires long-term monitoring and ongoing self-management, including symptom tracking, adherence to treatment plans, and regular communication with healthcare providers. This reflects a shift toward a more collaborative model of care, where self-management education supports better health outcomes and may reduce healthcare costs (Bodenheimer et al., 2002, p. 2469). In response, digital health technologies, particularly mobile health (mHealth) tools, have increasingly been adopted to support remote care and patient self-management.

Existing research shows that telehealth and mobile health systems can improve chronic disease management by enabling continuous monitoring and early intervention (Bodenheimer et al., 2002, p. 2469). This has been linked to measurable outcomes, including reduced hospital admissions and exacerbations (Ringbæk et al., 2015, p. 1806). In addition, self-management programs have been shown to improve patient's motivation and quality of life by supporting better understanding and monitoring of symptoms (Alwashmi et al., 2019, pp. 5-6).

During the early stages of this research, several common chronic conditions were explored to identify where digital health tools might provide meaningful support. These included cancer, heart disease, diabetes, and chronic respiratory diseases. However, respiratory conditions have received substantially less support compared to other disease areas. In 2022, only 4% of Canadian non-communicable disease research grants were allocated to chronic respiratory diseases, compared to 37% for neuropsychiatric conditions, 21% for cancer, 12% for cardiovascular disease, and 5% for diabetes – a distribution that contradicts the actual burden of respiratory illness, which surpasses diabetes across mortality, morbidity, and prevalence (PHA Canada, 2025). Respiratory diseases, including COPD, asthma, and pulmonary fibrosis, are among the leading causes of death globally. The annual healthcare expenditure for COPD alone is equivalent to 0.1% of global GDP, yet research output in respiratory medicine has been declining for decades relative to other fields (PHA Canada, 2025).

Preliminary research indicates that patients living with COPD – a progressive respiratory condition characterised by persistent airflow limitation, face distinct and ongoing challenges. Although many high-income countries have implemented coordinated national lung health strategies, Canada has not, creating an urgent gap (Lung Health Foundation, 2025). COPD is currently the second leading cause of hospitalisation in Canada, accounting for 2.5% of all admissions. Adults aged 65 and over are the most affected group, though increasing numbers of younger Canadians are also being diagnosed (Lung Health Foundation, 2025). Despite this burden, COPD management continues to receive less attention than other chronic conditions. It remains frequently underdiagnosed or poorly managed in primary care, a consequence of time pressure, fragmented care systems, and persistent gaps between clinical guidelines and real-world practice (Kaplan et al., 2024, p. 4).

These limitations highlight a gap between the significant burden of COPD and the limited support available for patients to manage their condition outside clinical settings. In response, this research focuses on designing an accessible and low-burden mobile health tool to support self-management and health monitoring for adults aged 65 and over with COPD.

1.2 Context: COPD Management in Everyday Life

Chronic obstructive pulmonary disease (COPD) is a progressive respiratory condition characterized by persistent airflow limitation and symptoms such as breathlessness, chronic cough, and fatigue (Vogelmeier et al., 2017, p. 11). It is a major cause of morbidity among adults aged 65 and over and represents a significant burden on healthcare systems, particularly in aging populations (Government of Canada, 2022; Gershon et al., 2012, p. e740). These symptoms often fluctuate over time and may lead to acute exacerbations, which can result in hospitalization or emergency care (Sumner et al., 2023, pp. e739-e740). As a result, effective COPD management requires continuous monitoring and timely response to symptom changes (Kaplan et al., 2024, p. 5).

In everyday life, COPD management is largely carried out outside clinical settings (Bodenheimer et al., 2002, pp. 2469–2470). Patients often rely on subjective awareness of symptoms, such as perceived breathlessness or reduced physical capacity, rather than structured or continuous health data (Kaplan et al., 2024, p. 8). In many cases, this form of self-monitoring is informal

and inconsistent, making it difficult to detect gradual deterioration or early signs of exacerbation (Kaplan et al., 2024, pp.8-9).

Informal support systems also play a significant role in disease management (Medical Economics, 2016). Family members or caregivers may assist with medication reminders, daily routines, or accompany patients to medical appointments (Medical Economics, 2016). While such support can be helpful, it is not always consistent or scalable, particularly for individuals who live independently or have limited social support.

At the system level, the Canadian healthcare context provides publicly funded medical services and community-based support programs, including transportation services and assistance for attending medical visits (Lung Health Foundation, 2025). However, these services are typically episodic and require advance coordination. They are not designed to support continuous, day-to-day monitoring or ongoing decision-making in patients' daily lives.

As a result, COPD management in practice remains fragmented. Patients rely on a combination of subjective symptom awareness, intermittent clinical consultations, and informal support, without access to integrated systems that support continuous monitoring, data interpretation, or coordinated communication with healthcare providers.

1.3 Research Question and Objectives

While COPD patients are often required to monitor symptoms and manage their condition on a daily basis, existing digital tools frequently provide limited support for continuous monitoring and accessible self-management. This investigation began with the following research question: How can a Canadian-specific accessible mobile health tool improve doctor-patient communication and patient symptom tracking for higher-risk (adults over 65) Chronic Obstructive Pulmonary Disease patients.

To address this research question, the project pursues the following objectives:

- to understand the challenges COPD patients face in monitoring and managing their health outside clinical settings;

- to analyze existing digital health applications for chronic disease management and identify current limitations;
- to identify key user needs and design requirements for supporting COPD self-management;
- to explore design opportunities for an accessible mobile health tool
- to explore design opportunities for an accessible mobile health tool

1.4 Limitations

Several limitations should be acknowledged when interpreting the findings of this research. The user testing involved a small sample of five participants, which limits the generalisability of the results. While the sample provided rich qualitative insights, a larger and more diverse group would be needed to identify less common usability issues and to strengthen the robustness of the findings. Therefore, the design recommendations presented in this paper are based on a single round of user feedback and have not been empirically validated through subsequent testing.

Additionally, the content analysis of existing mHealth applications focused exclusively on apps available in the Apple App Store, which may not fully represent the Android ecosystem. Although iOS holds a strong market share in Canada, the findings may not generalise to populations or regions where Android devices dominate. Despite these limitations, the findings offer a foundation for future work.

None of the participants had a confirmed medical diagnosis of COPD. All participants were aged 65 or over, but they did not necessarily experience the specific respiratory symptoms, fatigue levels, or exacerbation patterns characteristic of COPD.

1.5 MRP Outline

This MRP is organized into two main parts. Part I presents the research foundation, theoretical framing, design rationale, and methodology that inform the development of the proposed system. Part II focuses on the evaluation of the design through user testing, followed by iterative design improvements and reflections on future development.

Part I begins with Chapter 2, examining key concepts from the literature related to chronic disease management, COPD monitoring, and digital health technologies. It identifies limitations in existing mHealth tools, particularly in relation to accessibility, interaction clarity, and patient engagement. Building on these insights, the study integrates relevant design approaches, including harm reduction strategies and inclusive design principles, to establish a framework for addressing these challenges. These findings are then translated into design implications that guide the development of the proposed system. This part also introduces the design of the LungMate prototype, outlining its overall design rationale and key features, such as symptom tracking, health data report, and multimodal interaction support. In addition, this part describes the methodology adopted in the study, including the design approach, user testing sessions, and the analytical methods used to interpret user data.

Part II focuses on the evaluation and refinement of the proposed system. It presents findings from user testing, highlighting usability challenges, accessibility issues, and mismatches between user expectations and system design. These findings inform iterative design improvements, particularly in improving interaction clarity between text and icons. The study concludes by reflecting on the implications for accessible mHealth design, outlining its limitations, and suggesting directions for future work.

2.0 Key Concepts from the literature

2.1 Understanding the User Needs of People Over 65 With COPD

Chronic Obstructive Pulmonary Disease (COPD) is a progressive respiratory condition that poses a significant and growing health burden, particularly among people 65 and older. In Canada, individuals aged 65 and above account for the highest proportion of COPD-related hospitalizations (Government of Canada, 2022), and hospital admissions have continued to increase over the past decade despite declining smoking rates and population adjustments (Kaplan et al., 2024, pp. 1-2). In contrast, hospitalization rates for other chronic diseases have declined during the same period. Despite this, COPD remains underprioritized in healthcare systems, highlighting the substantial burden it places on the healthcare system and the urgent need to improve patient outcomes (Kaplan et al., 2024, pp. 1-2).

Effective COPD management requires continuous monitoring, symptom management, and timely medical intervention (Vogelmeier et al., 2017, pp. 14-15). However, a significant disconnect exists between clinical care and patients' daily lives. Once patients leave healthcare settings, they lack systems for continuous monitoring, making it difficult to detect early signs of deterioration. This gap is exacerbated by fragmented healthcare systems in Canada, limited patient monitoring, and inconsistencies between clinical guidelines and real-world practice, often leading to underdiagnosis and suboptimal management in primary care (Kaplan et al., 2024, pp. 8-9). Consequently, many patients experience worsening symptoms or acute exacerbations before receiving medical attention.

The lived experiences of people aged 65 and over living with COPD reveal several interconnected challenges that hinder effective self-management and communication with healthcare providers. A qualitative study synthesizing patient perspectives identified four central themes: i) the pervasive nature of breathlessness; ii) benefits and barriers to lifestyle changes; iii) social isolation and stigma; and iv) financial burden (Sumner et al., 2023, p. e741). These themes highlight that COPD affects not only physical health but also psychological and social well-being.

2.1.1 Key Challenges Faced by People Over 65 With COPD:

1. Physical Management Burden

The physical symptoms of COPD, such as breathlessness, cough, fatigue, poor sleep quality, and depression, pervade every aspect of patients' daily lives. These symptoms do not remain stable; their severity shifts unpredictably depending on the time of day, the type of activity being performed, and even the weather conditions (Sumner et al., 2023, p. e739). As a result, even routine activities such as dressing, cooking, and housework become significant challenges. This unpredictability makes self-management particularly complex, as patients cannot easily anticipate when their symptoms will flare up or what triggers them. The constant need to adapt to fluctuating physical states places a continuous burden on older adults, leaving them with less energy and cognitive capacity to actively monitor and manage their condition (Sumner et al., 2023, p. e740).

2. Communication Gaps with Healthcare Providers

COPD patients commonly report interpersonal communication concerns, including fears that healthcare providers do not take their complaints seriously, delays in seeking care, and difficulty explaining the severity of their symptoms (Madawala et al., 2023, p. 9). Research indicates that when patients seek care for worsening COPD, there is often no efficient system to ensure all providers (e.g., walk-in clinics, emergency departments, primary care) are informed of the exacerbation history (Kaplan et al., 2024, p. 4). This fragmented communication leads to missed opportunities for timely intervention and places a heavy reliance on patients to verbally convey complex health data (Kaplan et al., 2024, p. 5).

3. Digital Barriers Specific to Older Adults

While mHealth interventions have shown promise in reducing infection risks and supporting chronic disease management for older adults, this population faces unique digital barriers. Common concerns include poor eyesight, low technical literacy, lack of personalized features, and fears regarding privacy, advertising, fraud, and financial loss (Zou et al., 2024, p. 2). As one older adult participant noted, "Not knowing how to operate it is my biggest concern; today's high-tech products are very complicated." These barriers contribute to a "digital divide" that results in underutilization of mHealth among older COPD patients, exacerbating health inequities (Zou et al., 2024, pp. 5-6).

4. Poor Long-Term Adherence to Self-Management

The need for continuous monitoring, tracking symptoms, vital signs, and daily health status, requires sustained effort over time, which is particularly difficult for people over 65 with COPD who already experience fatigue, breathlessness, and cognitive load from managing their chronic condition (Sumner et al., 2023, p. e739). Even when they successfully adopt a monitoring routine initially, maintaining long-term adherence remains a significant challenge (Sumner et al., 2023, p. e742).

Research has shown that adherence to self-management interventions can be variable, with some patients facing difficulties due to symptom severity, comorbidities, and psychosocial factors that limit their ability to consistently engage with self-care programs (Hardinge et al., 2015, p. 9). Evidence from a randomized controlled trial found that while patients used core monitoring features consistently for a period, their engagement with certain functions

declined over time (Naranjo-Rojas et al., 2025, pp. 9-10). Thus, the key barrier to long-term monitoring adherence is that sustained effort is required from users who are already burdened by their condition.

2.2 Harm Reduction Strategy

People with COPD often experience feelings of guilt and self-blame, particularly when their condition is associated with lifestyle factors such as smoking (Madawala et al., 2023, p. 2). Research has shown that these emotional responses can lead to resistance toward external interventions and a tendency to withdraw from support systems. Rather than facilitating behavior change, direct pressure to quit smoking or make sudden lifestyle modifications may trigger frustration or disengagement (Madawala et al., 2023, p. 8). This suggests that interventions should move beyond directive approaches that demand immediate behavior change and instead adopt strategies that acknowledge patients' emotional and behavioral realities (Madawala et al., 2023, p. 13).

Harm reduction offers an alternative framework. Originating from addiction research, harm reduction strategies focus on minimizing the negative consequences of a behavior rather than demanding its complete elimination (Bickel et al., 2012, pp. 337-338). This approach recognizes that behavior change is a gradual process, and that meeting patients where they are, without judgment or coercion, is more effective in promoting long-term engagement than requiring abrupt transformation. For people over 65 with COPD, this means accepting that habits developed over a lifetime cannot be changed overnight, and that small, incremental steps toward self-management are valuable outcomes in themselves.

Furthermore, the concept of ego depletion suggests that self-control is a limited resource that becomes depleted after sustained use (Baumeister et al., 1998, p. 1253). For people over 65 with COPD who already expend significant physical and cognitive energy managing their daily symptoms, such as breathlessness, fatigue, medication routines, and medical appointments, their capacity for additional self-regulatory demands, such as quitting smoking or completely overhauling daily habits, is substantially reduced (Sumner et al., 2023, pp. e739-e740). Demanding abrupt behavior change from an already burdened population is therefore not only unrealistic but may also be counterproductive, leading to disengagement and reinforcing feelings of failure (Baumeister et al., 1998, pp. 1259-1260).

Thus, a harm reduction strategy is particularly well-suited to this population. Instead of requiring users to make drastic behavioral changes, an approach that supports small, manageable actions. This approach reduces resistance, supports gradual engagement with self-management, and respects the realistic limitations imposed by both the disease and the natural cognitive aging process.

2.3 Integrating Inclusive Design Principles into the Design

Building on the user needs identified in the previous section, this part examines the inclusive design principles that inform the development of the proposed COPD self-management app. Inclusive design, as a philosophy, "redefines what it means to be human-centered" by requiring designers to "respect and represent many different perspectives". For people over 65 with COPD, this means moving beyond age-based stereotypes and designing for the spectrum of physical, sensory, and cognitive abilities that exist within this population (Kane, 2019).

As Apple's inclusive design framework articulates, "when there's a difference between what a person can actually do and what society expects, that is where disability is really born" (Apple, 2025). This perspective is particularly relevant for people over 65 with COPD, who may experience age-related declines in vision, hearing, motor control, and cognition alongside the specific symptoms of their respiratory condition (Zou et al., 2024, p. 10). Rather than viewing these users as "deficient," inclusive design reframes the challenge as a design problem: how can technology close the gap?

Research on mHealth for people 65 and older with COPD has shown that age-related disabilities, including cognitive, motor, and sensory declines, significantly affect how this population interacts with technology (Zou et al., 2024, pp. 5-6). Studies consistently find that people over 65 require simple methods to interact with complex technologies, and successful interventions have demonstrated that when design accounts for deficits in vision, hearing, attention, and memory, older users achieve high task completion rates and satisfaction levels (Apple, 2025).

2.3.1 WCAG 2.1 Principles as a Design Foundation

The Web Content Accessibility Guidelines (WCAG) 2.1 provide a widely adopted framework for accessible design, structured around four core principles: content must be Perceivable, Operable, Understandable, and Robust (Naylor, 2025).

Perceivable means that users must be able to perceive the information presented. For people 65 and older with COPD who may have declining vision, this translates into requirements for sufficient color contrast (minimum 4.5:1 for text), scalable text that can be adjusted without breaking the layout, and alternative formats for information (Naylor, 2025).

Operable means that interface components and navigation must be usable by everyone. For people 65 and older with reduced fine motor control or hand strength, this requires touch targets of adequate size (minimum 44×44 points on iOS, 48×48 dp on Android) with sufficient spacing to prevent accidental taps (Naylor, 2025).

Understandable means that both the information and interface operation must be clear and predictable. People over 65 with cognitive declines or low digital literacy benefit from simplified content presentation, breaking information into smaller, manageable chunks, using clear headings, and providing consistent navigation structures (Naylor, 2025).

Robust means that the content can be interpreted reliably by a wide variety of user agents, including assistive technologies. This requires following standard coding practices and ensuring compatibility with screen readers (Naylor, 2025).

2.3.2 Multimodal Feedback

A key inclusive design principle is supporting multiple senses to ensure that information can be accessed in ways that match users' abilities (Apple, 2025). Multimodal feedback refers to the integration of multiple sensory channels, typically visual, auditory, and tactile (haptic) to convey information to users.

Rather than relying on a single mode of presentation, multimodal interfaces combine two or more modalities to create redundant or complementary information streams (El Kamali et al.,

2023, p. 3). Redundant presentation means the same information is delivered through multiple channels simultaneously, for example, a visual alert accompanied by an audible tone (El Kamali et al., 2023, p. 4). This ensures that if one channel is unavailable or difficult to perceive, the information remains accessible through another channel. Complementary presentation means different channels carry different but related information that together forms a complete message (El Kamali et al., 2023, p. 4). To avoid higher cognitive and visual overload, auditory and haptic cues can be designed to complement, replace, or reinforce visual cues (Nukarinen et al., 2014, p. 61).

This approach is particularly relevant for people 65 and older, who often experience age-related declines in vision, hearing, and motor function that can impair their ability to interact with conventional single-modality interfaces (Bhattacharya et al., 2025, p. 5). Research indicates that approximately 61% of people 65 and older experience age-related decreases in vision, hearing, or dexterity (Bhattacharya et al., 2025, p. 1). Hearing impairment affects 71% of adults over 70, and more than 96% of those aged over 50 wear spectacles at least some of the time (Badham, 2024). For individuals with concurrent sensory losses, information presented through a single sensory channel, such as a purely visual interface may be partially or completely inaccessible. As one researcher notes, "health data from physiological sensors is often conveyed to users through a graphical interface but this is not always accessible to people with disabilities or people 65 and older due to low vision, cognitive impairments or literacy issues" (Peterson Jean, n.d.).

Evidence from controlled studies demonstrates that multimodal sensory feedback enhances both objective and subjective measures of the performance of users aged 65 and over on interactive devices (Murphy, 2016, p. 360). Participants receiving multimodal feedback complete tasks more efficiently and report lower subjective cognitive workload compared to those receiving single-modality feedback (Murphy, 2016, p. 360). Thus, multimodal feedback is particularly well-suited for people 65 and older with chronic conditions, who may face compounding barriers from both sensory decline and disease-related cognitive load.

2.4 Rationale for Physiological Data Collection

The physiological parameters relevant to COPD monitoring include heart rate (HR), heart rate variability (HRV), respiratory rate (RR), oxygen saturation (SpO_2), and the composite

assessment derived from integrating these metrics — heart-lung stress condition. Clinical evidence links these metrics to disease progression, exacerbation risk, and autonomic function (Raju et al., 2023, p. 329; Zhang et al., 2025, pp. 1-4). Modern smartwatches use photoplethysmography (PPG) to estimate these parameters continuously, offering a passive and low-effort alternative to manual logging, a significant advantage for people with COPD (Hermans et al., 2024, pp. 2-3). Validation studies indicate that consumer wearables produce measurements of HR, RR, and HRV that are generally consistent with clinical devices, and SpO_2 readings correlate well with standard pulse oximetry (Hermans et al., 2024 pp. 1-3; Spaccarotella et al., 2022, pp. 3-5). Furthermore, recent research suggests combining such multi-modal sensor data from smartwatches and smartphones can generate higher-level health indices for continuous, unobtrusive COPD monitoring (Tognetti et al., 2025). These capabilities support self-awareness of health status and early recognition of warning signs, while reducing the burden of self-management for people 65 and older.

Heart Rate and Heart Rate Variability

Patients with COPD typically exhibit elevated resting heart rate and reduced heart rate variability compared to healthy individuals, reflecting underlying autonomic nervous system dysfunction (Raju et al., 2023, p. 329). Research has demonstrated that HR, HRV, and RR measured via smartwatches are significantly correlated with COPD severity as classified by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) grade (Zhang et al., 2025, p. 4). The Global Initiative for Chronic Obstructive Lung Disease (GOLD) is an international guideline that classifies COPD severity into four stages based on spirometry results: mild (GOLD 1: FEV_1 ≥80% predicted), moderate (GOLD 2: 50% ≤ FEV_1 <80% predicted), severe (GOLD 3: 30% ≤ FEV_1 <50% predicted), and very severe (GOLD 4: FEV_1 <30% predicted) (Lin et al., 2022). The GOLD system also incorporates symptom burden and exacerbation history using the ABE assessment tool (BMJ Best Practice, 2025).

Furthermore, reduced HRV is consistently associated with greater COPD severity and has been identified as a prognostic marker of mortality and exacerbation risk in this population (Raju et al., 2023, pp. 328-330). The autonomic nervous system adjusts heart rate in response to internal and external stimuli, and COPD-induced alterations in autonomic function make HRV a valuable non-invasive indicator of disease progression (Raju et al., 2023, pp. 329-330).

Respiratory Rate

Respiratory rate is a fundamental clinical parameter that changes noticeably when a COPD exacerbation develops(Zhang et al., 2025, p. 2). Patients with COPD typically breathe faster than healthy individuals, and tracking this trend can help detect worsening of the condition (Zhang et al., 2025, p. 9). Research has shown that combining respiratory rate with other simple measurements can reliably indicate whether a patient's COPD severity is mild, moderate, or severe (Zhang et al., 2025, p. 4). This means that by wearing a smartwatch, a patient may receive early clues about a decline in their lung health without needing to visit a clinic.

Oxygen Saturation

Oxygen saturation (SpO_2) is a key indicator of how well the lungs are delivering oxygen to the blood. In people with COPD, SpO_2 tends to be lower than in healthy peers, and sudden drops often occur during exercise or at the start of an exacerbation (Spaccarotella et al., 2022, pp. 1-3). Because low oxygen levels are linked to higher risk of serious complications, regular monitoring of SpO_2 helps patients and their doctors detect hypoxaemia early. Clinical guidelines suggest that maintaining SpO_2 between 88% and 92% is a reasonable target for most COPD patients (BMJ Best Practice, 2025).

Recent studies have demonstrated that smartwatches can measure SpO_2 in a way that meaningfully reflects differences between stable COPD patients and those with worsening symptoms, even if the watch is not as precise as hospital equipment (Hermans et al., 2024, pp. 1-2; Zhang et al., 2025, pp. 1-2). For patients, this means they can track their oxygen levels in daily life and notice downward trends before they become severe, prompting a timely call to their healthcare provider.

Heart-Lung Stress Condition

Heart rate, heart rate variability, respiratory rate, and oxygen saturation do not operate in isolation. The cardiopulmonary system is highly coupled: lung function impairment affects cardiac autonomic regulation and right ventricular load, while cardiac dysfunction exacerbates respiratory symptoms (Simons et al., 2026, pp. 2259-2263). In COPD, greater lung function impairment is associated with poorer heart rate dynamics and altered parasympathetic response (Mazzuco et al., 2015, p. 1651), and significant differences in heart rate and respiratory rate variability exist between stable and exacerbating patients (Shah et al. 2025, pp. 5-6).

Recent research has moved towards combining multiple physiological parameters for more accurate COPD assessment. For example, the TOLIFE project combines heart rate, respiratory rate, and oxygen saturation into higher-level health indices for COPD monitoring (Tognetti et al., 2025). Similarly, a smartwatch-based study achieved 87.8% accuracy in determining COPD severity (GOLD grade) by combining HRV, respiratory rate, SpO_2, and cough sounds (Chen et al., 2025, p. 13).

Informed by this evidence, integrating HRV, respiratory rate, heart rate, and SpO2 into a composite Heart-Lung Stress Condition summary would help people with COPD quickly assess their overall physiological status without needing to interpret multiple individual metrics.This integrated indicator provides users with an at-a-glance understanding of whether their physiological state remains within a stable range or shows signs of deterioration, reducing the cognitive burden of interpreting multiple separate values.

2.5 Conclusion of Key Concepts from the Literature

In summary, the literature reveals that people over 65 with COPD face four interrelated challenges: physical management burden, communication gaps with healthcare providers, digital barriers specific to people 65 and older, and poor long-term adherence to self-management. These challenges are compounded by fragmented healthcare systems and a lack of accessible digital health tools tailored to aging users.

To address these challenges, this research adopts a harm reduction approach that prioritises small, manageable steps over abrupt behaviour change, supported by the concept of ego depletion, which suggests that self-control is a limited resource. Inclusive design principles, including WCAG 2.1 guidelines and multimodal feedback, are integrated to accommodate the diverse physical, sensory, and cognitive abilities of people 65 and older.

Clinical evidence supports the use of heart rate, heart rate variability, respiratory rate, and oxygen saturation as key physiological indicators for monitoring COPD progression and exacerbation risk. Modern smartwatches can collect these parameters passively, offering a low-burden solution for continuous monitoring and early detection of deterioration (Raju et al., 2023, pp. 328-330; Zhang et al., 2025, pp. 3-4, 7; Hermans et al., 2024, pp. 1-3). In the

LungMate prototype, these indicators are combined into a Heart-Lung Stress Condition summary, providing users with an at-a-glance understanding of their current health status.

Together, these theoretical and clinical foundations inform the design of the LungMate prototype, presented in the following chapter.

3.0 Design Overview

This chapter begins by examining existing mHealth applications to understand current design practices and identify gaps. Based on these findings and the key concept from the literature (section 2.0), a set of design requirements is developed, followed by the design rationale and the presentation of the LungMate prototype.

3.1 Content Analysis of Current Design Practices in Existing mHealth Digital Tools

After identifying the contextual background and core user needs through the literature, the next step in the design process is to understand the existing design landscape that people with chronic conditions are already familiar with or exposed to. Examining current health condition management applications provides critical insights into their structural patterns, feature configurations, and common usability limitations. Such an analysis helps ground the design process in real-world practices and user expectations. Therefore, a content analysis of existing mHealth apps was conducted as an integral first step of the design process.

This analysis examined health condition management applications across multiple chronic diseases (see Appendix F). Analyzing a broad range of mHealth apps from different chronic conditions provides a wider set of design insights, including common limitations, successful feature strategies, and usability patterns that may not be visible when looking only at COPD-specific tools. Moreover, design solutions developed for other chronic diseases, such as medication reminders in diabetes, activity tracking in heart disease, or report sharing in cancer care, often contain transferable elements that can inform and inspire COPD-specific inclusive design. Therefore, reviewing apps across multiple conditions allows this research to identify both gaps and opportunities that might otherwise remain unnoticed.

3.1.1 Scope of Review

This review focused on mobile health condition management applications developed for the top ten chronic illnesses most prevalent in Canada, as identified by national health statistics. The chronic conditions considered include Chronic Obstructive Pulmonary Disease (COPD), diabetes, heart disease, chronic kidney disease, arthritis, obesity, asthma, cancer, and Alzheimer's/dementia. The review excluded conditions where mobile self-management tools provide limited value to patients themselves. For example, stroke rehabilitation often requires extensive caregiver involvement, and many patients lose the capacity for independent self-management. In such cases, health management apps offer minimal direct benefit to patients, so stroke was not included. The review primarily examined apps available for download from the Apple App Store as of August 2025. In total, 57 apps were identified across platforms. From these, 11 representative apps were selected for in-depth review, chosen to reflect a diverse range of chronic conditions, design strategies, and user experience approaches.

3.1.2 Selection Criteria

Apps were prioritized based on three criteria. First, apps that are clinically relevant and widely used in chronic illness management were included, as they represent established solutions and demonstrate best practices in integrating medical data, symptom tracking, and patient education. Second, apps that showcase unique or innovative features that could inspire COPD app design were included, as these approaches illustrate techniques that may enhance patient motivation, treatment adherence, and self-management. Third, apps that expose gaps and limitations in current healthcare app design were considered, as these examples highlight opportunities for innovation, particularly in inclusive UI/UX design. By reviewing apps that combine established best practices, innovative engagement strategies, and clear design gaps, the selected sample provides a solid foundation for identifying opportunities to improve inclusivity and enhance usability in future COPD app design.

For most chronic conditions, only one representative mHealth app was selected. However, for heart disease and COPD, two apps were included instead. This decision was made because apps like MyCOPD and MyHeart are developed by the same company and share a similar system architecture and feature set. Relying on only one of them would have provided a narrow

perspective and introduced potential bias. By reviewing both apps, I was able to better evaluate how a unified system adapts its features to support different chronic illnesses, offering a more comprehensive comparison and ensuring that design insights are balanced and inclusive.

3.1.3 Limitations

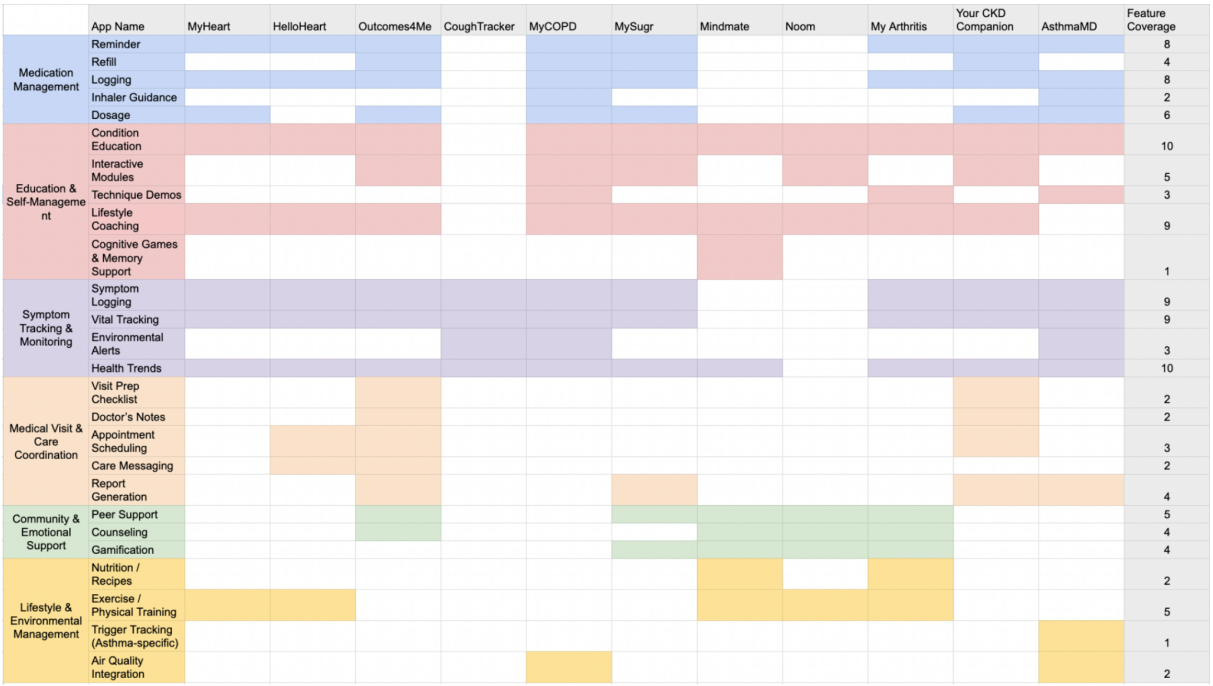
The review focused on apps available in the Apple App Store, with less emphasis on Android platforms. This decision is justified by market data showing that iOS maintains a strong share of the Canadian and North American smartphone market (StatCounter, 2025). While this approach ensures relevance to a large user base, the findings may not fully generalize to regions or populations where Android dominates. In addition, the review considered only patient-facing mHealth apps and excluded caregiver-only or clinician-focused tools.

3.1.4 Findings

To systematically compare the features across the reviewed applications, the analysis categorized functionalities into five core dimensions: medication management, education and self-management, symptom tracking and monitoring, medical visit and care coordination, and community and emotional support. Figure 1 summarizes the feature coverage across the 11 reviewed applications.

Figure 1:

Group and Categorize of existing mHealth apps



	App Name	MyHeart	HelloHeart	Outcomes4Me	CoughTracker	MyCOPD	MySugr	Mindmate	Noom	My Arthritis	Your CKD Companion	AsthmaMD	Feature Coverage
Medication Management	Reminder												8
	Refill												4
	Logging												8
	Inhaler Guidance												2
	Dosage												6
Education & Self-Management	Condition Education												10
	Interactive Modules												5
	Technique Demos												3
	Lifestyle Coaching												9
	Cognitive Games & Memory Support												1
Symptom Tracking & Monitoring	Symptom Logging												9
	Vital Tracking												9
	Environmental Alerts												3
	Health Trends												10
Medical Visit & Care Coordination	Visit Prep Checklist												2
	Doctor's Notes												2
	Appointment Scheduling												3
	Care Messaging												2
	Report Generation												4
Community & Emotional Support	Peer Support												5
	Counseling												4
	Gamification												4
Lifestyle & Environmental Management	Nutrition / Recipes												2
	Exercise / Physical Training												5
	Trigger Tracking (Asthma-specific)												1
	Air Quality Integration												2

As shown in Figure 1, while most applications provide basic medication management and symptom logging features, there is limited coverage of features that support medical visit preparation, care coordination, and emotional support. Notably, only two applications (MindMate and MyArthritis) include peer support or coaching elements, and voice narration or multilingual support is present in only two applications. Notably, voice narration or multilingual support, key accessibility features for people 65 and older appear in only two of the reviewed apps. These gaps are examined in detail below.

The analysis reveals an imbalance between data collection and meaningful system support. While most applications provide basic functionalities such as symptom logging and physiological tracking, these features are often not integrated into systems that help users interpret long-term health patterns or make informed decisions. Data are frequently collected but remain fragmented, offering limited support for understanding condition progression over time.

A consistent limitation across most applications is their reliance on manual data entry. Tools such as MyCOPD, AsthmaMD, and HelloHeart require users to regularly input symptom and physiological data, which increases interaction burden and may reduce long-term adherence,

particularly among people 65 and older. In addition, many systems provide limited adaptive or automated feedback in response to user behavior. For example, applications such as MyHeart and Your CKD Companion include medication reminders and data logging functions, yet do not adjust or respond when users miss entries. This lack of responsiveness constrains the system's ability to support sustained engagement in self-management practices.

Limitations are also evident in the way patient-generated data are communicated to healthcare providers. Although some applications allow users to export or share reports, the data are rarely synthesized into concise and clinically meaningful summaries. As a result, these tools provide limited support for ongoing clinical monitoring or coordinated care between patients and healthcare professionals.

Despite these limitations, several applications demonstrate alternative design approaches that extend beyond clinical tracking. Some applications, such as Noom, MySugr, and MindMate, integrate behavioral psychology, gamification, and community-based motivation to support long-term engagement. These innovative strategies, combining nutrition guidance, exercise modules, and habit-formation tools, illustrate transferable techniques that could inform COPD app design by enhancing user motivation, adherence, and sustained self-management.

Accessibility is inconsistently addressed across the reviewed applications. While some tools, such as MindMate, incorporate features like voice narration and large-font options, most rely on text-heavy interfaces with limited customization for users aged 65 and over or those with lower digital literacy. Features such as voice feedback, adjustable text size, and simplified navigation are implemented in only a small number of applications, suggesting a general misalignment with the needs of aging users. Beyond accessibility, the social and emotional dimensions of inclusivity are also underdeveloped. Only MyArthritis and Noom incorporate basic peer or coaching elements, indicating limited attention to psychosocial well-being in current mHealth app design.

While most mHealth applications attempt to address multiple user needs through comprehensive feature sets, one application offers a notable counterexample by demonstrating that a focused, single-feature design can be equally effective in bridging critical gaps in patient care. CoughTracker, an application designed for patients with chronic lower respiratory diseases, focuses on a single function instead: cough monitoring and documentation. It focuses

on a single function, which is cough monitoring and documentation. Its purpose is stated succinctly: "Document the frequency and triggers for your cough so you can get better treatment. Sometimes it is hard for doctors to really appreciate the magnitude of a problem cough. Use this app for a short time so you can show your doctor the exact pattern of your cough, whether you cough once an hour or twenty times an hour, only in the morning or 100 times a day. A picture tells a thousand words" (CoughTracker, n.d.).

The application offers two methods of data collection. Users can manually log their cough frequency and time periods, or they can enable automatic recording through the phone's built-in microphone, where an algorithm identifies cough events from environmental sounds. This automated feature reduces user burden significantly, as patients do not need to remember or manually document each cough episode. The app then generates daily, monthly, and yearly reports that visualise cough patterns over time, which patients can share with their healthcare providers. However, the automatic recording feature has practical limitations. It requires the phone to be kept nearby, typically used during nighttime hours, and background noise, such as television or family conversations may affect accuracy. Despite these constraints, the core value proposition of CoughTracker remains compelling.

The key insight from CoughTracker is not its technical sophistication but its design philosophy. The application does not attempt to solve every challenge faced by patients; it simply helps patients document their cough patterns and share that data with their doctors. In doing so, it addresses a fundamental communication gap identified in the literature: patients often struggle to articulate the severity and pattern of their symptoms, and doctors may struggle to fully understand the impact of symptoms during a brief clinical encounter (Madawala et al., 2023, pp. 9, 11–13; Kaplan et al., 2024, pp.3-5). This finding carries important implications for the design of COPD self-management tools. For people over 65 with COPD who may have difficulty describing symptom fluctuations, whether due to cognitive load, forgetfulness, or the sheer complexity of their condition, a simple visual report generated from passive or low-effort data collection may be sufficient to transform a clinical encounter.

3.2 Requirement table

Based on the user needs identified in the literature (Section 2.1) and the specific design gaps revealed by the content analysis of existing mHealth apps (Section 3.1), such as excessive manual data entry, insufficient accessibility support, and fragmented patient-provider communication, a set of requirements was developed to guide the design of the proposed app. Table 1 presents these requirements, organised by user need. Each requirement includes the current situation, desired aspiration, functional specification, priority level (Must / Ideal / Possible), and source of evidence. Priorities are categorised as "Must" for essential features that will be implemented in this project, "Ideal" for highly desirable features that may not be fully realised within the current scope, and "Possible" for features that could be added in future iterations.

Table 1:

Requirement table of design implementment

Current Situation (what is happening currently when using static logic models)	Aspiration (the desired situation)	Functional Requirement (i.e., what the software needs to do)	Non-functional requirement (i.e., quality the software needs to possess)	Priority (must, ideal, possible)
Challenge 1: Input burden — Manual data entry creates input burden for people 65 and older, leading to inconsistent data and reduced adherence.	Enable effortless and continuous data recording.	The app automatically collects required data through Bluetooth-enabled wearable or fingertip sensor, minimizing manual input.	Support for sensor integration; error alert when connection lost; simple visual feedback to confirm data capture.	Must
Challenge 2: Communication gap — Doctors lack synthesized and structured data to make accurate, timely clinical decisions.	Provide doctors with clear, longitudinal insights.	The app generates an exportable report format for optional doctor review.	The report must be concise, structured, and exportable.	Must
Challenge 3: Long-term adherence — Patients cannot easily visualize long-term progress, reducing	Make progress and improvement visible and motivating.	Offer Visual Trend Graphs and milestone badges showing improvement over time.	Clear color contrast; large fonts; optional voice narration for accessibility.	Must

motivation.				
Challenge 4: Accessibility barrier — Accessibility features are not customizable for people 65 and older with visual limitations.	Enable personalization for diverse abilities.	Include a Personalization Center allowing users to adjust font size, contrast, and reminder frequency.	Follow WCAG 2.1 accessibility standards; retain settings across sessions.	Must
Challenge 5: Privacy concern — Users worry about privacy and how health data are stored or shared.	Build trust through transparent data practices.	Clearly state that the app does not collect or upload any personal health data; all data are stored locally on the device; data are shared only when the user explicitly exports them.	Clear consent flow reinforcing transparency of local-only storage (no data collection); compliant with PIPEDA principles.	Ideal
Challenge 6: Medication adherence — Patients often forget to take their medication, leading to gaps in monitoring.	Improve adherence through gentle, personalized reminders.	Add Medication & Check-in Reminder System with customizable frequency and tone.	Customizable reminder settings, including optional push alerts, voice notifications to reduce alert fatigue.	Ideal
Challenge 7: Emotional need — COPD patients need emotional reassurance and a sense of belonging to stay engaged.	Foster peer-to-peer support and shared motivation.	Add a Community Support Section where users can share progress, comment with encouragement, or join group challenges.	Easy-to-read layout; simple and clutter-free interface that supports emotional comfort.	Possible

These requirements inform the design implications discussed below.

3.3 From Identified Needs to Design Implications

Based on the requirements summarized in Table 1, this section translates the most critical user needs into concrete design implications. The discussion focuses on explaining why these needs emerged from the literature and how they shape the design direction.

3.3.1 Reducing Input Burden

The need to reduce input burden emerged from two key findings. First, the key concept from the literature (Section 2.0) shows that people over 65 with COPD experience fatigue, breathlessness, and cognitive load that make manual data entry difficult and unsustainable (Sumner et al., 2023, pp. e739-e740; Hardinge et al., 2015, p. 9). Second, the content analysis revealed that existing health management applications rely heavily on manual input, with very limited passive data collection options (Section 2.4.4). Therefore, the design prioritizes automatic data collection through wearable integration, requiring minimal effort from the user. This aligns with the harm reduction principle that small, manageable actions are more sustainable than demanding abrupt behavior change (Bickel et al., 2012, pp. 351-352; Baumeister et al., 1998, pp. 1259-1261).

3.3.2 Bridging Patient-Provider Communication

The communication gap between patients and healthcare providers is a consistent theme across the literature. Patients report difficulty articulating symptom severity and fear that their complaints may not be taken seriously (Madawala et al., 2023, p. 9). Clinicians, constrained by time, struggle to fully appreciate the magnitude of symptoms during brief consultations (Kaplan et al., 2024, pp. 7-9). The content analysis found that while some applications enable report sharing, none synthesize patient-generated data into concise, clinically interpretable summaries. Existing reports are often either too complex for patients to understand or lack the clinical relevance needed to inform medical decision-making. Inspired by CoughTracker, which states that "a picture tells a thousand words" (CoughTracker, n.d.), the design includes a report export feature that generates two versions: a patient-friendly summary with visual trends and simple language, and a clinical summary with structured data for healthcare providers. This allows patients to "show" rather than "tell" their condition, reducing cognitive burden during clinical encounters while supporting more accurate medical decision-making.

3.3.3 Supporting Long-Term Adherence

Maintaining consistent self-management over time is a significant challenge for people 65 and older with COPD. Research suggests that adherence to self-management interventions may

vary, particularly when comorbidities increase treatment burden, such as by requiring multiple external devices, which may reduce compliance over time (Hardinge et al., 2015, p. 9). Evidence from a randomized controlled trial found that while patients used core monitoring features consistently for a period, their engagement declined over time (Naranjo-Rojas et al., 2025, pp. 11-12).

Therefore, the design incorporates two strategies to support long-term adherence. First, daily check-ins and long-term data visualization, particularly a patient-side report that is easy to understand, allow users to see their daily status over time, which helps them stay engaged and continue monitoring their condition. Second, reducing input burden through wearable integration significantly improves adherence, as users only need to wear a device without manually entering data. These features reinforce positive behaviour without increasing cognitive load, drawing on the ego depletion framework that self-control is a limited resource (Baumeister et al., 1998, p.1253).

3.3.4 Incorporating Accessibility for Aging Users

People 65 and older face unique digital barriers, including poor eyesight, low technical literacy, and lack of personalized features (Zou et al., 2024, pp. 5-6). To address these barriers, the design embeds accessibility as a core feature rather than an optional add-on. Following the WCAG 2.1 guidelines (Naylor, 2025), the interface includes large touch targets, adjustable text size, and a clean layout that avoids information overload. In addition, the patient report incorporates a multimodal feedback model, allowing users to access their health data through visual charts, voice narration, or plain text. These features are integrated into the main interface, reflecting the universal design principle of equity (Hedvall et al., 2025, pp. 6752-6753, 6757).

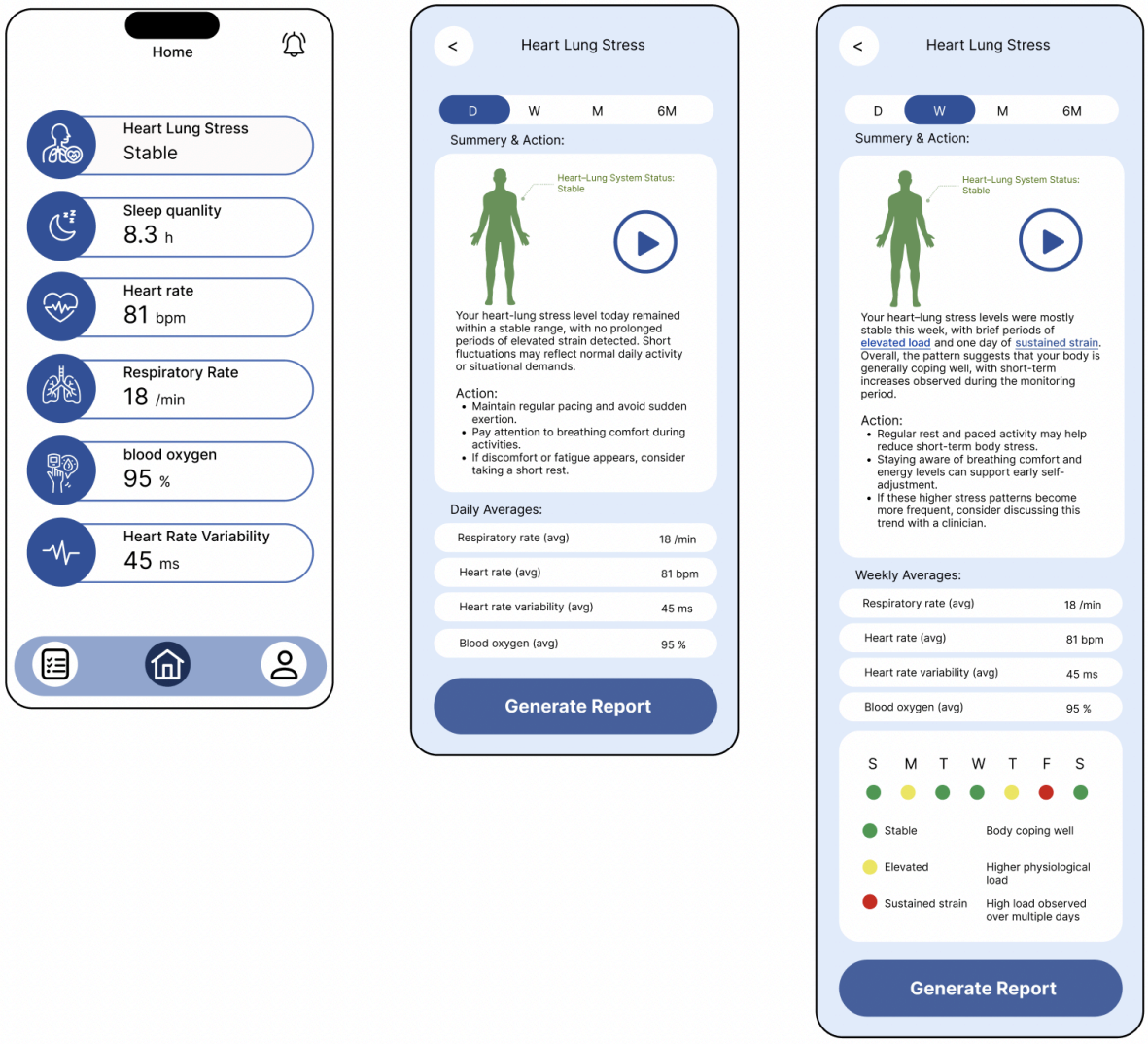
3.4 System Features

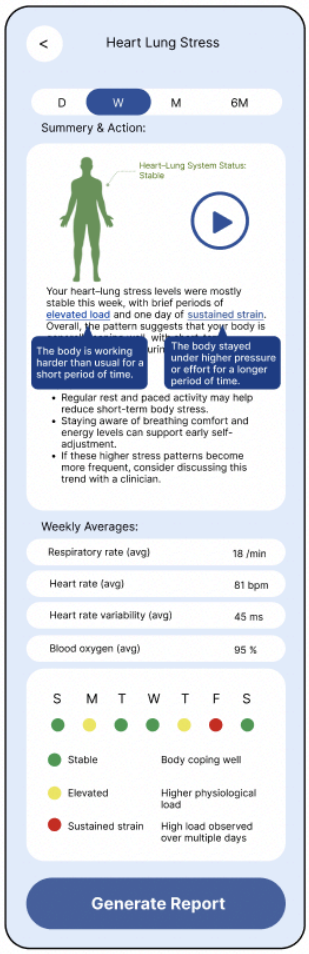
Based on the design requirements and implications discussed above, the LungMate prototype was developed with four core features: report export, daily check-in, multimodal feedback, along with text size adjustment. Each feature is described below with its design rationale and accessibility considerations.

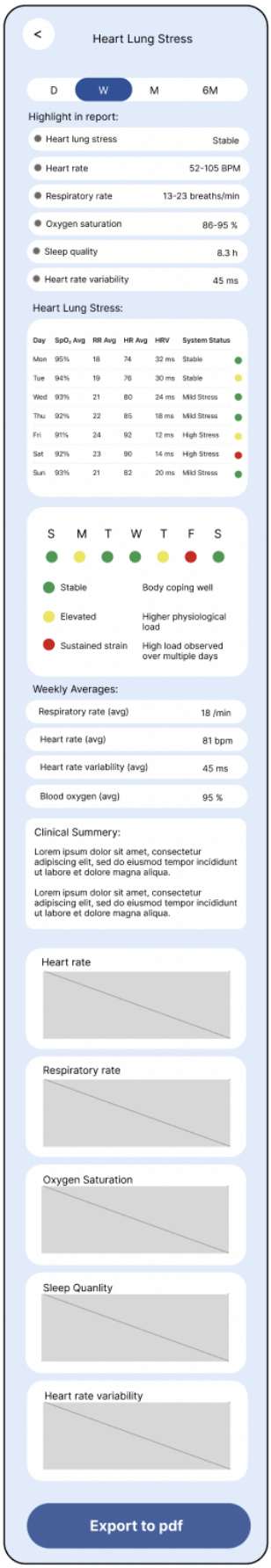
3.4.1 Report export

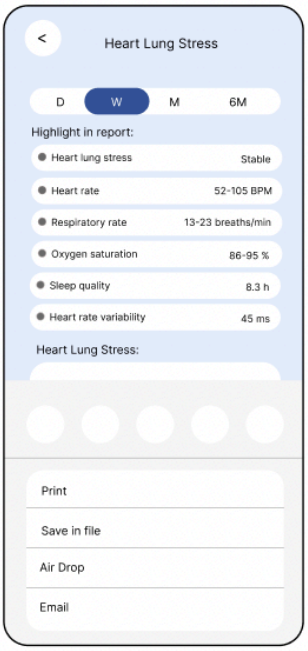
Figure 2:

Report export feature




Heart Lung Stress
D
W
M
6M
Summery & Action:
Heart-Lung System Status: Stable
Your heart–lung stress levels were mostly stable this week, with brief periods of elevated load and one day of sustained strain. Overall, the pattern suggests that your body is
The body is working harder than usual for a short period of time.
The body stayed under higher pressure or effort for a longer period of time.
• Regular rest and paced activity may help reduce short-term body stress.
• Staying aware of breathing comfort and energy levels can support early self-adjustment.
• If these higher stress patterns become more frequent, consider discussing this trend with a clinician.
Weekly Averages:
Respiratory rate (avg) 18 /min
Heart rate (avg) 81 bpm
Heart rate variability (avg) 45 ms
Blood oxygen (avg) 95 %
S M T W T F S
Stable Body coping well
Elevated Higher physiological load
Sustained strain High load observed over multiple days
Generate Report


Heart Lung Stress
D
W
M
6M
Highlight in report:
Heart lung stress Stable
Heart rate 52-105 BPM
Respiratory rate 13-23 breaths/min
Oxygen saturation 86-95 %
Sleep quality 8.3 h
Heart rate variability 45 ms
Heart Lung Stress:
Day SpO2 Avg RR Avg HR Avg HRV System Status
Mon 95% 18 74 32 ms Stable
Tue 94% 19 76 30 ms Stable
Wed 93% 21 80 24 ms Mild Stress
Thu 92% 22 85 18 ms Mild Stress
Fri 91% 24 92 12 ms High Stress
Sat 92% 23 90 14 ms High Stress
Sun 93% 21 82 20 ms Mild Stress
S M T W T F S
Stable Body coping well
Elevated Higher physiological load
Sustained strain High load observed over multiple days
Weekly Averages:
Respiratory rate (avg) 18 /min
Heart rate (avg) 81 bpm
Heart rate variability (avg) 45 ms
Blood oxygen (avg) 95 %
Clinical Summery:
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.
Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua.
Heart rate
Respiratory rate
Oxygen Saturation
Sleep Quanlity
Heart rate variability
Export to pdf


Heart Lung Stress
D
W
M
6M
Highlight in report:
Heart lung stress Stable
Heart rate 52-105 BPM
Respiratory rate 13-23 breaths/min
Oxygen saturation 86-95 %
Sleep quality 8.3 h
Heart rate variability 45 ms
Heart Lung Stress:
Print
Save in file
Air Drop
Email

The report export feature generates a one-page visual summary of the user's health data according to daily, weekly, monthly, or 6-month intervals, including heart rate, respiratory rate, oxygen saturation, sleep quality, and heart rate variability. As shown in Figure 2, the report includes a plain-language summary (e.g., "Your heart-lung stress levels were mostly stable this week") and actionable recommendations (e.g., "Maintain regular pacing and avoid sudden events"). Users can generate and share the report with their healthcare provider via email or save it to their device. To support patient understanding, the report includes an explainer function: tapping on terms such as "elevated load" displays a simple definition, helping users interpret clinical language without feeling overwhelmed.

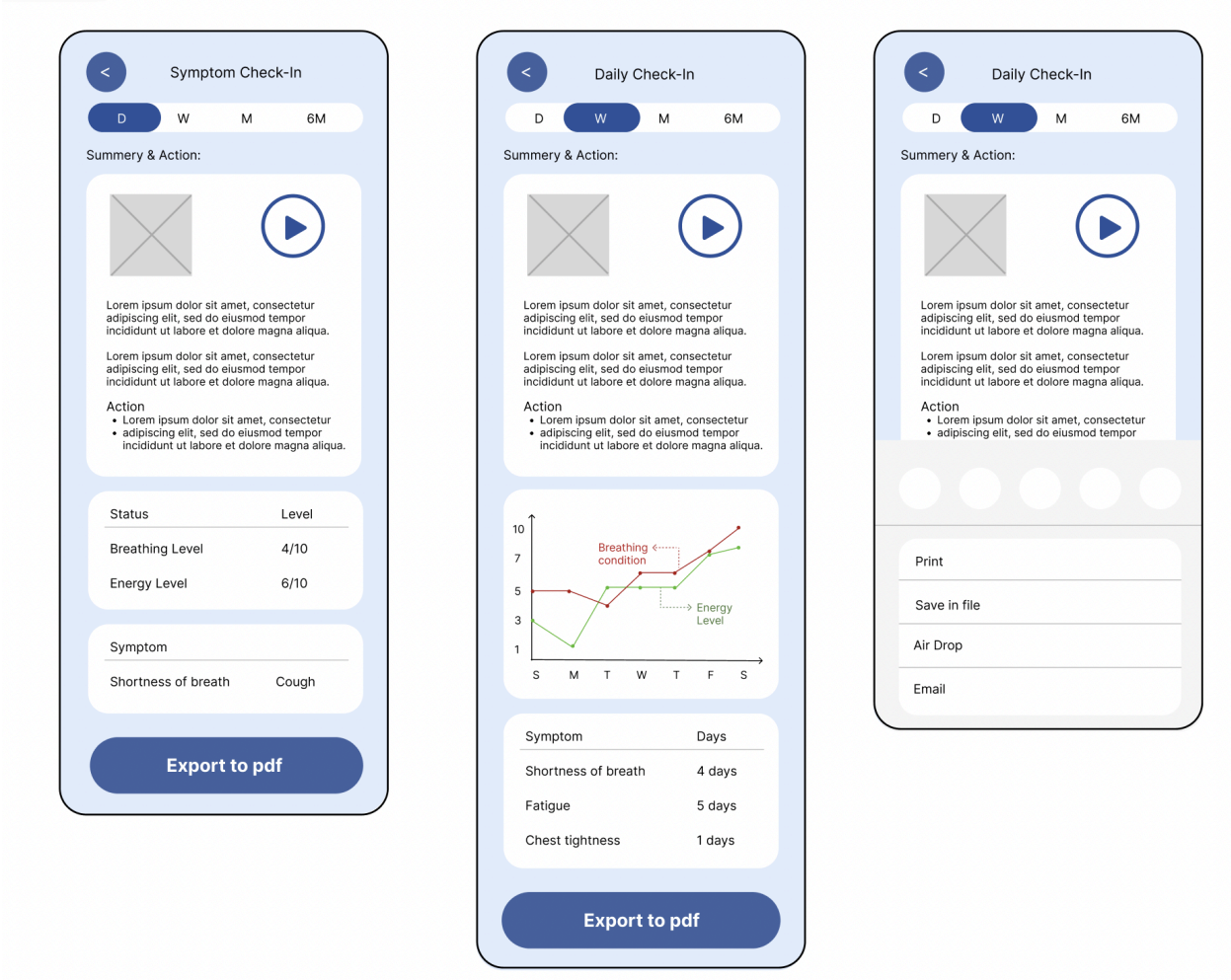
Design rationale: This feature directly addresses the communication gap identified in the literature, where patients struggle to articulate symptom severity and clinicians struggle to appreciate symptom patterns during brief consultations (Madawala et al., 2023, p. 9; Kaplan et al., 2024, pp.3-4). Inspired by CoughTracker, the design transforms raw health data into a concise, visual summary. The dual-report approach, a patient-friendly version with simple language and visual trends, alongside a clinical summary with structured data, responds to the content analysis finding that existing reports are either too complex for patients or lack clinical relevance.

Accessibility considerations: The report export feature incorporates several accessibility strategies beyond visual design. The plain-language summary reduces cognitive load by translating clinical data into actionable insights, avoiding information overload. An explainer function allows users to tap on complex terms to view a simple definition, supporting those with lower health literacy or cognitive limitations. In addition, the clean layout prioritizes essential information through visual hierarchy, guiding attention rather than presenting dense text or numbers. These features align with WCAG 2.1 guidelines on Understandability, ensuring that content is clear, predictable, and supported by definitions where needed (Naylor, 2025).

3.4.2 Daily check-in

Figure 3:

Daily check-in feature



The daily check-in feature (figure 3) allows users to record their symptoms and well-being through a simplified, low-effort interface. As shown in the figure, users could rate their breathing condition and energy level on a 1–10 scale and select from common symptoms, including shortness of breath, cough, fatigue, chest tightness, anxiety, and dizziness, by tapping on-screen options. Once submitted, the screen confirms "Check-in saved for today" and offers options to view the report or redo the check-in.

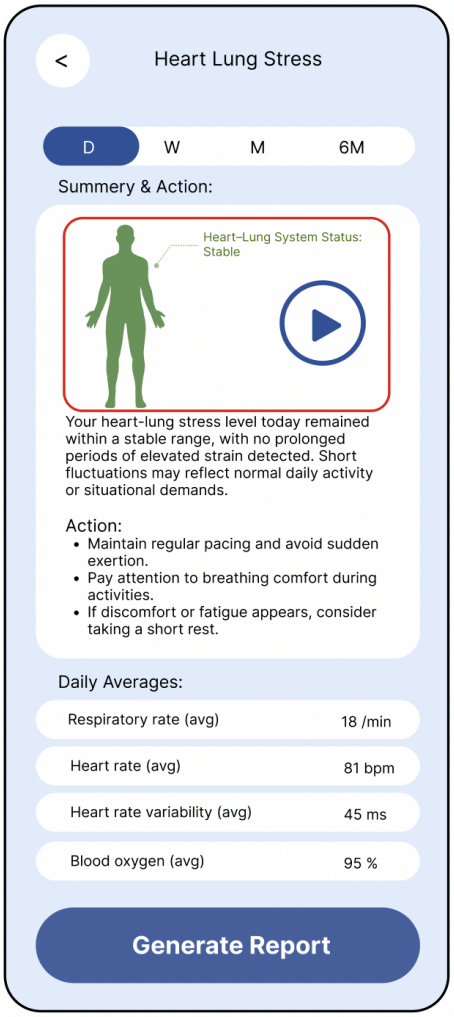
Design rationale: The symptom list was informed by the key concept from literature (Section 2.0), which identifies breathlessness, cough, and fatigue as the most prevalent and burdensome symptoms (Sumner et al., 2023, pp. e739-e740). The interface requires no more than three taps to complete, taking less than 30 seconds. This aligns with the harm reduction principle that small, manageable actions are more sustainable than demanding abrupt behavior change (Bickel et al., 2012, pp. 351-352; Baumeister et al., 1998, pp. 1259-1261), and supports long-term adherence by creating a daily routine (Hardinge et al., 2015, p. 5).

Accessibility considerations: Following WCAG 2.1 guidelines (Naylor, 2025), the interface uses large touch targets where possible, a clean layout with ample white space to avoid information overload, and clear visual feedback after submission. The 1–10 rating scale uses large buttons rather than sliders, which can be difficult for users with reduced fine motor control.

3.4.3 Multimodal Feedback

Figure 4:

Multimodal Feedback



The report screen provides users with three complementary ways to access their health information. As shown in Figure 3, a human-shaped icon changes colour according to the user's condition, green for stability, yellow for caution, red for warning, allowing users to immediately understand their current condition at a glance. Users can also view a plain-language action summary or listen to an audio narration of the same content using the audio icon, choosing any mode at any time based on their preference or immediate need.

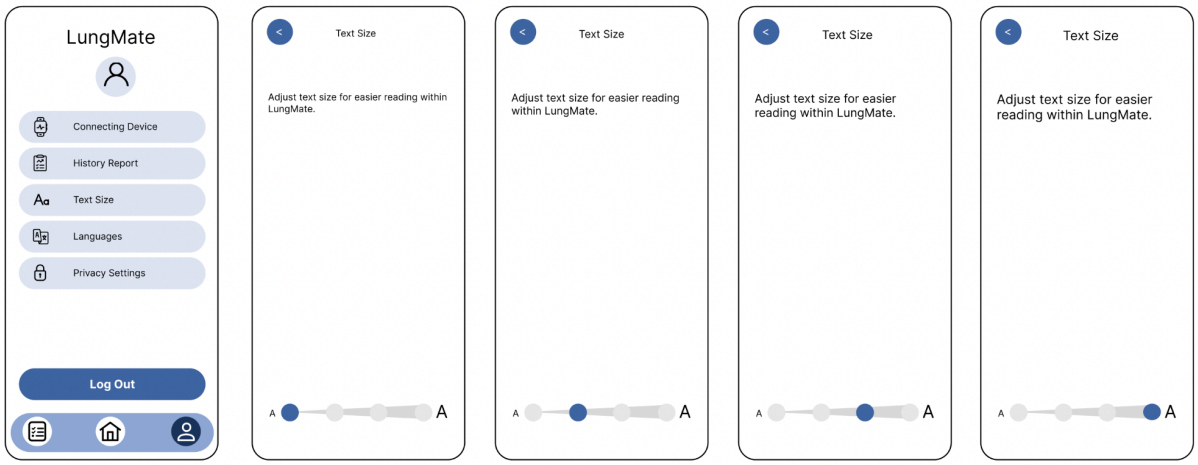
Design rationale: Multimodal feedback—combining visual and auditory channels, directly addresses the sensory declines commonly experienced by people 65 and older. For individuals with low vision, audio narration ensures that critical health information remains accessible; for those with hearing limitations, the visual display provides an alternative channel. By offering these options, the design does not assume a single "default" ability but instead accommodates the diverse and often overlapping sensory limitations of aging users (Bhattacharya et al., 2025 pp. 5-7; Murphy, 2016, p. 360).

Accessibility considerations: This feature was designed specifically to address the accessibility challenges identified in the literature. People over 65 with COPD may experience not only respiratory symptoms but also age-related hearing loss, declining vision, and reduced dexterity (Zou et al., 2024, p. 1). A purely visual interface would exclude users with low vision; a purely auditory interface would exclude users with hearing loss. The multimodal approach provides redundancy, the same information is delivered through multiple channels, so that if one channel is unavailable or difficult to perceive, another remains accessible. This aligns with the universal design principle of flexibility, which emphasizes providing multiple ways for users to access information (Hedvall et al., 2025, pp. 6752-6753, 6755-6757), and follows WCAG 2.1 guidelines on Perceivable content (Naylor, 2025).

3.4.4 Text size adjustment

Figure 5:

Text size adjustment feature



As shown in Figure 4, the text size adjustment feature allows users to increase or decrease the font size across the entire app interface by selecting from four size options in the settings menu. The options are presented as a gradient of sizes, allowing users to see the progression from smallest to largest and choose more easily.

Design rationale: Older adults with COPD often experience age-related vision decline, making small text difficult to read (Zou et al., 2024, p. 6). The content analysis revealed that most existing health management applications lack customizable text size options, instead relying on fixed, small fonts that do not accommodate users with low vision (Section 2.4.4). By providing adjustable text size, the design ensures that users are not excluded simply because they cannot read small text.

Accessibility considerations: This feature follows WCAG 2.1 guidelines on Operable content, which require that users be able to resize text without losing functionality or readability (Naylor, 2025). Rather than hiding this option in a separate "accessibility settings" section, the text size adjustment is placed in the main settings menu alongside other personalization options, allowing users to find it more easily and understand its function. The interface uses a simple, clean layout with no unnecessary information, reducing cognitive load and enabling users to focus on adjusting their preferred text size.

With age, hand function declines due to progressive changes in the musculoskeletal, vascular, and nervous systems. As a result, complex gestures such as long pressing, dragging, or pinching become increasingly difficult for people 65 and older, as they require fine finger control and the ability to apply pressure precisely while maintaining hand stability (Elboim-Gabyzon & Danial-Saad, 2021, pp. 1-2, 6-7). Research has shown that tap-activated gestures are more suitable for elderly users, whereas operations like double-tap and drag-and-drop are harder to perform. (Salman et al., 2019, p. 673; Cheng, 2017). Therefore, when designing interactive interfaces for people 65 and older, prioritising simple, low-effort tap actions is more inclusive than relying on gestures that demand sustained force or precise trajectory control, such as sliding or dragging.

3.5 User flow

The user flow diagram below illustrates how a user navigates through the LungMate app to complete the core tasks identified in the design requirements. The flow begins at the Home screen, which serves as the central dashboard. From there, users can access three main functional paths via the bottom navigation bar: Daily Check-in, the health data display at home page, and the Personal Center.

In addition, the Home screen provides entry points to all individual health data metrics. Each metric is intended to be collected automatically from a smartwatch; however, this prototype does not include smartwatch integration. For the purpose of user testing, only the Heart-Lung Stress data section was made interactive. To reflect realistic usage scenarios and provide feedback for every user interaction, the flow diagram also includes alternative paths, such as error pages that indicate when a feature is not yet ready for testing. The flow is kept simple to avoid overwhelming users with complex branching, aligning with the inclusive design principle of reducing cognitive load.

3.5.1 Core User Journeys

1. **Report Export Journey**

The user accesses the Heart-Lung Stress section from the Home screen. They select a time range (Day / Week / Month / 6 Months) to view the corresponding health summary. After

reviewing the plain-language summary and recommendations, they tap Generate Report. The app then allows them to export the report as a PDF via email, save it to the device, or share it through other system options (AirDrop, print, etc.). During the report viewing, users can also tap on key terms (e.g., “elevated load”) to see a definition, supporting users with lower health literacy.

2. **Multimodal Feedback Journey**

While viewing a health report, the LungMate app presents the same information in three interchangeable formats, each designed to accommodate different user needs. A colour-coded human icon (green for stable, yellow for caution, red for warning) gives an immediate visual summary. For those who prefer or require plain language, a text summary explains the findings in simple terms. And for users with low vision or reading difficulties, an audio narration can be activated by tapping the audio button.

3. **Daily Check-in Journey**

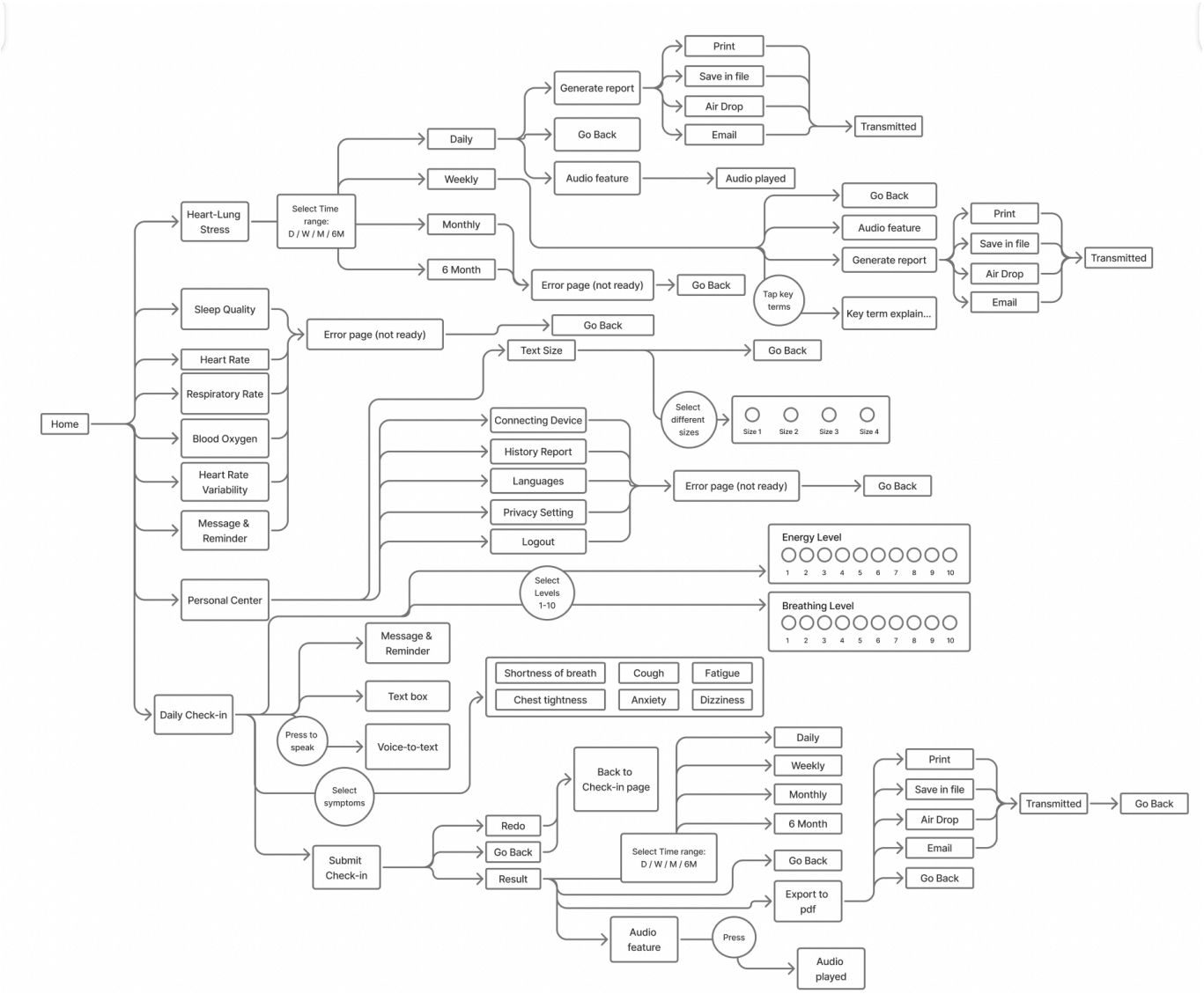
From the Home screen, the user taps the Daily Check-in button. They then rate their breathing and energy levels on a 1–10 scale and select any experienced symptoms from a list (e.g., shortness of breath, cough, fatigue). Optionally, they can use the voice-to-text feature to enter additional symptoms by speaking, or use the text box for logging other symptoms. After submitting the check-in, the app displays a confirmation page saying “Check-in saved for today” and offers the choice to either redo the check-in or view the results. The results screen shows the submitted data, and from there the user can return to the Home screen or proceed to generate a report.

4. **Text Size Adjustment Journey**

From the Home screen, the user opens the Personal Center and selects Text Size. Four size options are presented; the user taps the desired size, and the change applies immediately across the entire app. The selected size persists for future sessions.

Figure 6:

User Flow of LungMate prototype



4.0 Methodology and Methods

4.1 Inclusive design practices

This research adopted an inclusive design methodology grounded in the Knowledge Loop framework (Keates & Clarkson, 2004, p. 79). The following sections describe how each phase of the loop was operationalised in this study, including how the research was adapted to minimise burden on participants over 65.

4.1.1 Applying the Knowledge Loop Framework to This Research

This research applied the Knowledge Loop framework (Keates & Clarkson, 2004, p. 79) as an iterative guide throughout the entire research process. The following sections describe how each phase of the loop was operationalised in this study. The framework consists of three core activities: capturing information about end-users, translating that information into design solutions, and verifying the product against user needs.

Phase 1: Capture — Understanding User Needs

The first phase of the Knowledge Loop involves capturing information about end-users. In the original framework, this is typically done through direct engagement with users, such as interviews, focus groups, or observational studies (Keates & Clarkson, 2004, p. 79). However, this research adapted the Knowledge Loop by replacing the direct user "capture" phase with a literature review and content analysis. This adaptation was motivated by the fact that a substantial body of qualitative research already exists on the lived experiences of people 65 and older in relation to chronic disease self-management, digital health use, and age-related barriers such as poor eyesight, low technical literacy, and reduced dexterity (Sumner et al., 2023, p. e740; Madawala et al., 2023, p. 2; Zou et al., 2024, p. 2). Rather than duplicating efforts by collecting new primary data, this research synthesised existing evidence. This approach respects participants' time and energy while still capturing rich, evidence-based insights.

The output of this phase was a set of four core user needs: physical management burden, communication gaps, digital barriers, and poor long-term adherence (see Section 2.1).

Phase 2: Translate — From Insights to Design

The second phase of the Knowledge Loop involves translating user information into design solutions. Based on the user needs identified in Phase 1, four design implications were developed (see Section 3.2). These implications directly informed the design of a low-fidelity prototype focused on three core features: daily check-in, report export, and multimodal feedback. The daily check-in prioritises low-effort interaction (≤3 taps); the report export transforms health data into a one-page visual summary to bridge patient-provider communication; and multimodal feedback provides both visual and auditory access to accommodate users with varying sensory abilities. The design followed WCAG 2.1 accessibility guidelines (Naylor, 2025) and universal design principles (Hedvall et al., 2025, pp. 6750, 6757). The output of this phase was a functional mid-fidelity prototype ready for user testing (see Section 3.3).

Phase 3: Verify — User Testing

The third phase of the Knowledge Loop involves verifying the product against user needs. The mid-fidelity prototype was tested with five participants aged 65 and over to evaluate usability, accessibility, and perceived usefulness. Each session involved completing core tasks such as daily symptom check-in, report generation, text size adjustment, and using the audio narration feature. Feedback and observed difficulties were recorded through note-taking and audio recording. This phase identified several usability issues and user suggestions for improvement, which informed the iteration phase.

Phase 4: Iteration

Following the verify phase, the research completed one round of iterative refinement based on user feedback. However, a full second loop, which would require another round of user testing with the refined prototype, was not completed due to the scope and timeline of this Master's research project.

As a result, this research completed one and a half cycles of the Knowledge Loop — a full loop from capture to translation to verification to iteration, followed by half of a second loop where iteration was completed but verification was not repeated. This one-and-a-half-loop process demonstrates how the Knowledge Loop framework can be applied within the constraints of a graduate research project while maintaining an inclusive approach. Subsequent research can build on this foundation by completing additional loops with the same user group.

4.2 Study design

This study employed a user testing session that integrated task-based usability testing of a mid-fidelity prototype with a short semi-structured interview. The session was designed to balance efficiency and depth by combining hands-on testing with follow-up discussion, thereby reducing participant burden while generating both quantitative usability metrics and qualitative design insights. The study was approved by the OCAD University Research Ethics Board.

4.2.1 Participants and Recruitment

Two participant groups were targeted for this study: adults aged 65 and over, and healthcare providers (e.g., family physicians, nurses, respiratory therapists). Inclusion criteria for people 65 and older were: (1) aged 65 or over, (2) residing in Canada, (3) able to use a smartphone or tablet, and (4) comfortable communicating in English. Healthcare providers were required to currently or recently provide care to adult patients.

Initial recruitment efforts involved distributing recruitment posters (see Appendix E) on OCAD University campus and in surrounding community spaces. One possible reason is that posters may not have been an effective way to reach the target population, as people 65 and older may not frequent campus spaces or may have difficulty noticing or reading small text on posters. In addition, recruitment for vulnerable or hard-to-reach populations often requires more direct engagement than passive methods like postering (Keates & Clarkson, 2004, p. 79). Therefore, recruitment was expanded to include snowball sampling. The faculty supervisor shared the recruitment poster with her professional network via email, which resulted in four participants aged 65 and over and one healthcare provider. Each participant received a $5 gift card as a small token of appreciation for their time.

4.2.2 User Testing Sessions

Each session lasted approximately 30 minutes and was conducted in a senior residence in Ajax. Sessions were audio-recorded and screen-recorded with participant consent. The researcher also took observational notes during each session.

4.2.2.1 Task-Based Testing

Participants were asked to complete five core tasks using a mid-fidelity interactive prototype of the LungMate app. The prototype was presented on a smartphone. Before starting the tasks, participants were given a brief introduction to the purpose of the app and were encouraged to use a think-aloud approach, sharing what they saw, noticed, or felt as they navigated the interface (see user testing protocol in Appendix B).

The task sequence was as follows (see Appendix B for the full scenario):

1. **Find weekly report:** Locate and open the daily summary to review current heart-lung stress status.
2. **Generate report:** Generate a weekly summary report that could be shared with a clinician.
3. **Complete daily check-in:** Enter sample symptom data based on a provided scenario (breathing: 4/10, energy: 6/10, symptoms: shortness of breath and cough).
4. **Change text size:** Adjust the text size from the settings menu to improve readability.
5. **Use audio feedback:** Locate and use the audio narration feature to hear the health report aloud.

For each task, the researcher recorded task completion using a tracking sheet, along with time taken and any observed difficulties or errors. Participants were offered breaks at any time to minimise fatigue or eye strain.

4.2.2.2 Short Interview

After completing the tasks, a short semi-structured interview was conducted to gather qualitative feedback. Participants were asked:

1. Do you have any questions or thoughts about today's session?
2. Is there anything else you'd like to share?

Responses were audio-recorded, transcribed, and analysed thematically alongside the observational notes. This interview was conducted to provide space for any final thoughts or spontaneous comments, without expecting participants to give detailed feedback.

4.3 Analysis of user testing

The user testing sessions generated both quantitative and qualitative data. Quantitative data included task completion rates, time on task, and the number of errors observed during each task. Qualitative data consisted of think-aloud comments, observational notes taken by the researcher during the sessions, and audio recordings of the post-session discussions.

A content analysis approach was employed to systematically analyse the transcribed qualitative data. The analysis proceeded through several stages. Each transcript was read multiple times to develop familiarity with the content. Initial codes were then generated to label meaningful segments of text related to usability, accessibility, and user suggestions. A hierarchical coding system was used, where each code was assigned a letter based on its thematic category, followed by a number to distinguish individual codes within that category. This approach allowed for flexible organisation of the data and helped avoid overly rigid or insufficient category structures. Related codes were subsequently grouped into broader categories based on thematic similarities.

To enable cross-participant comparison, a summary table was created to document each participant's observed difficulties and suggestions. The frequency of each type of suggestion was then calculated to identify patterns across the participant group. The results of this frequency analysis are presented in tabular form.

Observational notes taken during the testing sessions were used to supplement and contextualise the transcribed comments. All audio recordings were transcribed verbatim. To protect participant confidentiality, any identifying information was removed during transcription and replaced with unique participant codes (e.g., P1–P5).

4.4 Ethical Considerations

All participants provided written informed consent prior to the session (see an example of the consent form in Appendix C). The study complied with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2, 2022) and was approved by the OCAD University Research Ethics Board (REB #2025-86).

To ensure confidentiality, each participant was assigned a unique ID code (P1, P2, P3, P4, P5), and all identifying information was removed during transcription. Audio recordings and observational notes were stored on a password-protected, encrypted drive accessible only to the researcher and the faculty supervisor. Participants were informed that they could withdraw at any time without penalty.

Accessibility accommodations, including print materials and verbal instructions, were provided to ensure equitable participation.

5.0 Finding & Discussion

5.1 Key Findings from User Testing

This chapter presents the results of the user testing sessions conducted with five participants (four adults aged 65+ and one healthcare provider). One participant (P2) was unable to complete the task-based testing due to confidential issues, but her feedback from the post-session discussion is included in the relevant findings. The aim of the testing was to evaluate the usability, accessibility, and perceived usefulness of the LungMate prototype, with a focus on identifying barriers that affect people 65 and older' ability to self-manage COPD using a mobile health tool.

This chapter is organised into two main sections. The first section provides an overview of the participants' digital literacy levels and summarises the in-vivo suggestions raised by participants, showing each type of suggestion and the number of participants who mentioned it. This section also includes a breakdown of how participants interacted with the prototype based on their prior experience with smartphones and health apps. A thematic analysis was conducted using a coding scheme.

The second section presents the core user testing findings, organised around the key themes that emerged from the analysis. This includes a detailed comparison of words versus icons (see Chart 2), highlighting how participants performed on tasks that relied on text labels versus those that relied solely on icons.

Table 2:

Key finding from the user test with coding scheme

Group	Sub-group	Theme	Summary	Numbers of mention
A Language	A1	Needs text label	Requested text labels for icons (audio, daily check-in), otherwise the function was unclear.	2
	A2	Icon not intuitive	The audio icon was often misinterpreted.	4
B Content	B1	Data unrealistic for target users	Sleep data (8 hours) did not reflect people 65 and older' reality	1
C Experience with apps	C1	High digital literacy	Participants self-identified as confident smartphone and health app users	2
	C2	Don't use apps at all	Participants who don't use app at all	1
	C3	Low digital literacy	Participants self-identified as lacked confidence	2
D Interface	D1	Text size adjustment interaction mismatch	Participants expected to slide the control to change text size	3
	D2	Button too small	The button is too small to interact	1
	D3	Navigation clarity	Participants hard to find the daily check-in button	2
E Trust & Privacy	E1	Privacy concerns	Participants worried about financial loss and data privacy	1

To systematically analyse the qualitative data, a thematic analysis was conducted using a coding scheme. Table 2 summarises the coding framework, grouping the findings into five thematic groups (Language, Content, Experience with apps, Interface, and Trust & Privacy). Each group is further divided into sub-themes representing specific usability or accessibility issues, along with the number of participants who experienced each issue.

Participants' self-assessed digital literacy levels varied across the sample, ranging from low to high. However, these self-reports did not always align with observed performance, and participants across all levels encountered usability and accessibility issues. A detailed breakdown of each participant's self-assessed literacy level, session notes, and individual suggestions is provided in Appendix D.

Building on these themes, Table 3 presents the specific in-vivo suggestions raised by participants, organised by the number of participants who mentioned each suggestion.

Table 3:

Invivo suggestion

Invivo suggestion	Numbers of mentionFrequency (n=5)
Change the audio icon, or add a text label beside the audio icon.	4/5
Suggested that they are more familiar with sliding the control to increase text size, rather than tapping.	3/5
Suggested that the 'daily check in' icon is hard to find, maybe could add a text label.	2/5
Suggested that the button in 'daily check in' is too small.	1/5
Suggested that the home page is enough to be a short daily summary.	1/5
Suggested enhancing user trust.	1/5
Change the data of average sleep to more rational to target users, which is around 4-5h.	1/5

The most frequently mentioned suggestion was to change the audio icon or add a text label, noted by all participants (P1, P3, P4, P5) who participated in the prototype testing. Three participants' (P1, P3, P5) action suggested that they are more familiar with sliding the control to increase text size, rather than tapping. Other suggestions, such as adding a text label to the daily check-in icon, enlarging small buttons, adjusting unrealistic sample data, and enhancing user trust, were each mentioned by one or two participants. The following sections discuss the main themes that emerged from the analysis.

5.1.1 Icon Comprehension

The most frequently observed issue is related to icon interpretation. All participants (P1, P3, P4, P5) who attended prototype testing misinterpreted the intended meaning of the icons related to the audio feature. One participant (P1) described the arrow-shaped icon as a “back” button rather than a sound control: “That symbol (icon) tells me, go back. It doesn’t tell me it’s the sound” (P1). Two participants (P1 & P3) repeatedly tapped the notification bell, expecting it to trigger the audio feature. Another participant (P5) looked for the audio function inside the Personal Center, assuming it was a system-wide accessibility setting. Two participants (P1 & P3) explicitly requested that icons be accompanied by text labels.

These misunderstandings reveal a deeper issue: different age groups may operate with fundamentally different icon mental models. To a younger user, an arrow-shaped icon might intuitively represent “play” or “audio”; to a senior, the same arrow often signifies “back” or “navigation”. Two participants (P1 & P3) explicitly stated that the icon should be a speaker icon, not an arrow. This suggests that people 65 and older bring a distinct icon lexicon shaped by years of experience with different interface conventions. When designers assume that icons carry universal meanings, they risk excluding users whose mental models diverge from the designer’s own generation.

The same icon comprehension problem also affected the daily check-in button. Two participants (P3 & P5) had difficulty locating it. One participant (P4) assumed that only the health data displayed on the upper part of the Home screen (e.g., heart rate, respiratory rate) were part of the test, and did not realise that the bottom navigation bar was also interactive. As a result, she repeatedly attempted to tap the data fields above, even though she had seen the buttons at the bottom. One participant (P3) saw the daily check-in icon but could not quickly recognise that it meant “daily check-in”; suggested that adding a text label underneath would make it more identifiable. In contrast, the healthcare provider, who uses mobile apps daily, found the interface “streamlined” and easy to navigate.

For experienced users, bottom navigation bars are expected to contain additional functions. However, people 65 and older may have internalised different interface logics, when a critical feature is placed in a location that violates their learned expectations, and when it lacks a descriptive text label, it effectively becomes invisible (Ávila-Muñoz et al., 2026, pp. 2, 5, 7).

Visual placement or icon semantics alone may not be sufficient for all users, as individuals interpret these cues through diverse, experience-dependent mental models. Text labels, in contrast, provide an explicit, low-ambiguity signal that can bridge individual differences in icon recognition and spatial navigation expectations. Therefore, adding descriptive text labels is a more robust and inclusive strategy for ensuring that key functions are discoverable across a heterogeneous population aged 65 and over.

5.1.2 Interaction Mismatch

Three participants(P1, P3, P5) attempted to slide the text size control instead of tapping the discrete numbers. Only one participant (P4) immediately tapped the buttons. Of the three who tried sliding, two quickly switched to tapping after a failed attempt. However, one participant (P1) remained confused, stating that the slider-like control “does not move” when she tried to slide it, and concluded that it was “not working”.

This confusion arose as the control was designed with a visual progression of button sizes to indicate increasing text size levels, which unintentionally made it resemble a slider. Participants therefore expected a sliding interaction based on what they saw, even though the control was designed to be operated by tapping. Users’ initial attempts to slide were not errors but logical inferences based on the visual appearance.

The decision to use tapping rather than sliding was intentional. As explained in Section 3.4.4, for people 65 and older with reduced hand strength and fine motor control, precision sliding gestures are more physically demanding than simple taps. Sliding requires sustained force and higher motor precision, whereas tapping is easier, more forgiving, and therefore more inclusive for users with age-related dexterity decline (Elboim-Gabyzon & Danial-Saad, 2021, pp. 1-2, 6-7). Thus, the problem is not that tapping is the wrong interaction, but that the visual design did not communicate the intended interaction clearly.

5.1.3 Content Realism

One participant (P1) noted that the prototype’s example data (e.g., average sleep of 8 hours) did not reflect the reality of people over 65: “There’s no way I can sleep eight hours. Normally I

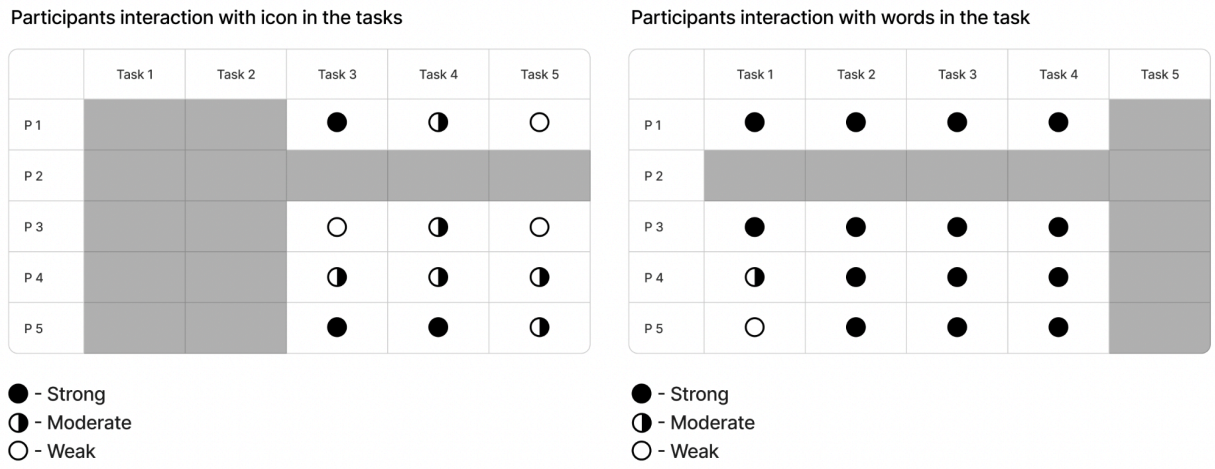
sleep for three hours. I'm good if I get four or five" (P1). This suggests that default or sample data should be adjusted to match the target population's actual experiences. When placeholder data misaligns with users' lived reality, it can undermine the perceived credibility of the app.

5.1.4 Privacy and Trust Concerns

One participant (P2) expressed strong concerns about sharing confidential information on her phone, stating that she refuses to download any health apps because of a past negative experience. Although only one participant raised this issue directly, it represents a significant barrier that may prevent some people 65 and older from adopting mHealth tools, independent of interface design.

5.2 Words vs Icons

Figure 7:
Words Vs Icon



The user testing revealed a clear pattern: participants performed significantly better when tasks relied on text labels rather than icons alone. Chart 2 summarises each participant's interaction quality with icons versus words across the five tasks. P2 did not complete the task-based testing, but the remaining four participants showed consistent behaviour.

As shown in the chart, tasks with clear text labels, such as Task 2 ("Generate Report") and Task 4 ("Text Size"), were completed successfully by most participants, regardless of their digital literacy level. In contrast, tasks that relied solely on icons, such as locating the audio feature

(Task 5), caused significant difficulty. For example, P1 and P3 easily found the “Generate Report” button because it included the text label “Generate Report”; however, the same participants repeatedly failed to recognise the audio icon, which had no accompanying text. P5, a healthcare provider, also did not recognise the audio feature at first.

Furthermore, tasks that contained both text and icon elements (e.g., Task 3 and Task 4) revealed a clear pattern: participants performed well on the text components but struggled with the icon components, even within the same task. This suggests that some people 65 and older may rely more on text than on icons when navigating mobile interfaces.

This pattern aligns with established research on ageing and digital interfaces. Studies have found that users over 65 face specific challenges in interpreting icon meanings, and that the visual style of icons is the most important factor. Icon comprehension difficulty has been identified as a major barrier for people 65 and older when using smart devices (Ávila-Muñoz et al., 2026, pp. 1-2, 6-7).

One key reason is semantic distance, the gap between an icon’s appearance and its intended meaning. A touchscreen experiment compared how older and younger users process icons during navigation tasks, examining the effects of interface type (icon alone, text label alone, or a combination) and semantic distance (close vs. far). Their results showed that people 65 and older users needed significantly more time to select icons, specifically when the semantic distance was far. When an icon’s meaning is not immediately obvious from its appearance, people 65 and older take longer to interpret it, increasing cognitive load and error rates. By contrast, younger users control their activity more frequently and adapt more quickly to abstract representations (Dosso & Chevalier, 2021). In this study, the arrow-shaped audio icon had a large semantic distance for participants: they interpreted it as “back” or “navigation” rather than “audio”.

In this study participants struggled with icons. In contrast, tasks with clear text labels were completed successfully by most participants. This indicates that people 65 and older may rely more on text than on icons when navigating mobile interfaces.

5.3 Design Recommendations

Based on the user testing findings, several critical issues were identified, including confusion with the audio icon design, difficulty locating the daily check-in button, overly small touch targets on the daily check-in page, and unrealistic sample sleep data. The following design improvements are recommended to address these issues.

5.3.1 Audio Icon

All participants who completed the prototype testing either misinterpreted the audio icon or could not find it at first. The current arrow-shaped icon should be replaced with a more intuitive icon, as several participants (P1 & P3) suggested a speaker icon, and accompanied by a descriptive text label (e.g., “Audio” or “Read aloud”). This change directly addresses the semantic distance problem and aligns with the target user group's expectation.

5.3.4 Daily Check-in Icon

Two participants (P3 & P5) had difficulty locating the daily check-in icon, and one explicitly requested a text label. A text label (e.g., “Daily Check-in”) should be added below the icon to improve discoverability, especially for users who do not recognise the icon.

5.3.2 Daily Check-in Page

One participant (P3) reported that the rating buttons (1–10) on the daily check-in page were too small, and the buttons in the symptom selection section were also small. The original design placed all ten number buttons in a single row to save vertical space, which inadvertently reduced their touch target size. This issue can affect users with reduced fine motor control. All interactive elements on the daily check-in page should be enlarged to at least 44×44 points, following WCAG 2.1 guidelines. If necessary, the layout can be adjusted to accommodate larger touch targets while maintaining usability.

5.3.3 Sample Data

One participant (P1) noted that the prototype's example sleep data (8 hours) did not reflect the actual sleep patterns of people over 65. Even for a prototype, unrealistic sample data can undermine the perceived credibility and relevance of the app. Therefore, the default sleep value should be changed to 4–5 hours to better align with the target population's lived experience. Additionally, other sample data throughout the prototype should be reviewed to ensure they are realistic and appropriate for the target user group.

5.3.5 Text Size Control

Three participants (P1, P3, P5) attempted to slide the text size control because its visual design (a gradient of sizes) unintentionally resembled a slider. To eliminate this confusion, the control should be redesigned to clarify the intent of communicating font size options. For example, four discrete buttons, arranged vertically or horizontally, each representing a different font size option (e.g., Size 1, Size 2, Size 3, Size 4) could be developed for further testing. This visual change will communicate the intended tap-based interaction more effectively.

The decision to keep tapping rather than sliding is retained, as tapping is less physically demanding for people over 65 with reduced hand strength and fine motor control (Elboim-Gabyzon & Danial-Saad, 2021, pp. 1-2, 6-7). By making the controls look like buttons rather than a slider, future users will be more likely to tap without confusion, while still benefiting from the more inclusive tap interaction.

6.0 Follow up research

This research identified a range of user needs and design opportunities. While the current iteration of the LungMate prototype addressed the most critical usability and accessibility issues identified in user testing, the requirement table (Section 3.2) also identified several additional features that were not implemented within the scope of this project. These include trust-building measures, medication adherence support, emotional and social support features, and personalised pulmonary rehabilitation guidance. The following sections outline potential future

directions based on these identified needs. Exploring these features in subsequent iterations could further enhance the app's inclusivity and long-term impact for people over 65 with COPD.

6.1 Trust and Privacy Enhancements

One participant (P2) explicitly refused to use health apps due to a previous bad experience, highlighting that trust can be a complete barrier to adoption independent of usability. Future versions should explore multiple trust-building strategies. Partnering with trusted institutions such as local healthcare providers, COPD patient organisations, or government health agencies could provide official endorsements within the app, reassuring users of its legitimacyRegarding data handling, a jargon-free privacy statement could be presented during onboarding, explaining that all health data remains stored locally on the device and is never uploaded to the cloud unless the user explicitly exports a report.

6.2 Medication Adherence Support

Although medication reminders were not implemented in the current prototype, they were identified as a possible feature (marked "Ideal" in the Requirement Table). Future iterations could introduce a customisable reminder system that allows users to set schedules for inhalers or oral medications. To avoid alert fatigue, the system should offer adjustable reminder frequency and tone, such as gentle vibrations or voice notifications. A "snooze" option could be provided for moments when taking medication is temporarily inconvenient, along with simple visual confirmation of adherence, such as a checkmark or streak counter, without excessive notifications.

6.3 Emotional and Social Support Features

Emotional well-being was identified as a desirable feature (marked "possible" in the Requirement Table), with only a few existing apps offering peer support. Future work could explore moderated peer support communities, such as a forum or group chat where users can share experiences, coping strategies, and encouragement. This would require careful moderation to prevent misinformation and maintain a safe environment, ideally with input from healthcare professionals. Another direction is caregiver involvement: a companion mode could allow family members or caregivers to view anonymized progress summaries (with user

consent) and receive alerts if symptom patterns worsen, fostering shared management without overburdening the people 65 and older. Additionally, an AI-powered personal coach could be developed to provide emotional support through daily check-ins, motivational messages, and gentle guidance based on the user's reported mood and symptoms, offering a scalable and always-available complement to human interaction.

6.4 Personalised Pulmonary Rehabilitation Guidance

Evidence-based pulmonary rehabilitation, including simple walking exercises, breathing techniques, and resistance training with minimal equipment, has been shown to improve quality of life for COPD patients (Gloeckl et al., 2013, pp. 178-179 ; Cheng et al., 2023, pp. 1-2). While not part of the current design, a future module could offer adaptive exercise recommendations based on the user's daily symptom reports and physiological data. For example, on days with mild symptoms, the system could suggest a short walking routine; on days with elevated breathlessness, it could recommend paced breathing exercises. Heart rate and SpO_2 trends could also be used to automatically adjust exercise intensity. Such a feature would require careful validation with clinicians to ensure safety and effectiveness.

6.5 Extended Accessibility and Usability Testing

The current testing involved five participants. Future work should conduct larger-scale usability studies with a more diverse group of people aged 65 and over, including those with varying levels of COPD severity, different comorbidities, and from different cultural and linguistic backgrounds. Additionally, formal accessibility audits using tools such as the WCAG 2.1 Evaluation Methodology could be performed to systematically identify and fix remaining barriers, particularly for users with low vision or cognitive impairments.

7.0 Conclusion

This major research project set out to explore how an accessible mHealth tool could improve symptom tracking and patient-clinician communication for adults aged 65+ living with COPD. Through key concepts from literature, a content analysis of eleven chronic disease apps, and user testing of the LungMate prototype, the study found that most existing tools rely heavily on

manual data entry, offer fragmented support for clinical communication, and lack accessibility features tailored to aging users. From these findings, four core user needs were identified: reducing physical management burden, bridging communication gaps, addressing digital barriers, and supporting long-term adherence.

User testing with five participants confirmed several critical issues. The audio icon was misinterpreted by every participant who completed the prototype testing. The daily check-in button was reported as hard to locate, and the rating buttons on the check-in page were considered too small. One participant noted that unrealistic sample data (8 hours of sleep) undermined the app's credibility, and another expressed strong privacy concerns rooted in negative prior experiences.

Based on these findings, the design recommendations prioritise replacing the audio icon and adding a descriptive text label, enlarging touch targets on the daily check-in page, adjusting sample sleep data to 4–5 hours, and adding a text label to the daily check-in icon. The text size control remains tap-based, but a brief instructional hint ("Tap to adjust") can be added to reduce initial confusion.

Follow up research could explore trust-building measures (e.g., endorsements from healthcare organisations, clear local-only data storage statements), medication reminders, emotional support features (moderated peer forums or AI-driven coaching), and personalised pulmonary rehabilitation guidance. Larger-scale usability testing with more diverse senior populations and formal WCAG audits would further strengthen the app's inclusivity.

Overall, the LungMate prototype suggests that a simple, low-effort design may help people 65 and older with COPD monitor their symptoms and share meaningful health data with their doctors. This design could represent a "small staircase" toward better self-management and more equitable digital health care.

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Appendix A: Research Protocol

Project Title: Designing an Accessible mHealth Tool for people 65 and older with COPD

Session Length: approximately 60 minutes per participant

Format: In-person usability testing session (one on one)

Location: OCAD University meeting room

Recording and Data Management Notes:

Audio recording and observation notes will be collected with participant consent. Each participant is assigned a unique ID code. All recordings will be transcribed, de-identified, and securely stored.

Part 1. Introduction (10 minutes)
Researcher actions:

- Welcome the participant and introduce yourself and the purpose of the study.
- Explain that the goal is to improve the accessibility and usability of mobile health tools for people over 65 living with COPD (Chronic Obstructive Pulmonary Disease), not to evaluate them personally.
- Set expectations by explaining that honest feedback is valuable, and that if something feels confusing or difficult, it helps improve the design.
- Mention that the session will collect both qualitative feedback (e.g., thoughts and feelings) and quantitative data (e.g., time on task, number of errors, and satisfaction rating).
- Explain session structure, duration, voluntary nature, and the right to withdraw anytime.
- Review and collect signed consent forms.

Part 2. Pre-Test Questions: Semi-structure interview (10 minutes)
Aim: Build comfort and understand participants' digital habits.

- Audio recording begins (with consent).

- Begin with casual, open-ended questions:
    - "How often do you use your smartphone?"
    - "Have you ever used a health-related app before?"
    - "What do you usually find easy or difficult about mobile apps?"
- Use this discussion to build rapport and understand baseline familiarity.

Part 3. Prototype Usability Testing (20-30 minutes)

Aim: To evaluate how people over 65 can navigate, understand, and complete different types of tasks in the prototype, from simple interface exploration to simulated health data entry.

- The researcher presents a low-fidelity prototype (mobile mock-up or printed interface).
- Participants begin with simple, exploratory tasks to get familiar with the interface, and gradually move to more complex, goal-oriented tasks.
- Each participant receives a short, fictional scenario.
- Participants will be encouraged to use a think-aloud approach, sharing what they see, notice, or feel as they navigate the app. This helps the researcher understand how users interpret and experience the interface.
- The researcher will observe and take notes.

Task sequence:

- Find Weekly report
- Generate report
- Complete Daily Check-in
- Change Text Size
- Find and use audio feature

Part 4. Post-Session Discussion (5 minutes)
Aim: To provide space for any final thoughts or spontaneous comments after the usability session, without expecting participants to give detailed feedback.

- Ask open-ended questions:
    - Do you have any questions?
    - Is there any information you would like to share?

Part 5. Closing and Appreciation (5 minutes)

- Thank participants sincerely for their time and valuable feedback.
- Provide the $5 gift card as a token of appreciation.
- Remind them that their responses will remain confidential and that anonymized results will be used for academic purposes only.

Appendix B: Task based scenario

1. **Task 1 Find Weekly report**

You want to check your current health status and see how your body is doing today. Using LungMate, find and open your daily summary to review your current Heart–Lung Stress condition.

2. **Task 2 Generate report**

You are now at the clinic for your appointment. Your doctor asks you to share a weekly summary report of the health information you have been tracking at home. To support the discussion, you want to generate a weekly report using LungMate that clearly summarizes your recent condition and can be shared with your clinician.

3. **Task 3 Daily Check-in**

Today, your breathing feels a bit worse than usual. When walking, you felt more short of breath. Your energy level feels okay, but not great. You also had a mild cough.
Please complete a daily check-in using the app based on how you feel today:

- Breathing: 4 out of 10
- Energy: 6 out of 10
- Symptoms: Shortness of breath and cough

After submitting your check-in, confirm that your information has been saved successfully.

4. **Task 4 Change Text Size**

While reading the content on the screen, you notice that the text is too small and difficult to read. You want to see if the app provides an option to increase the text size so that the interface becomes easier to navigate.

5. **Task 5 Multi feedback model**

You recently heard from your doctor that LungMate includes a feature that can read health reports aloud. Today, you want to check your heart–lung condition, hear your current status, and try using this audio feature.

Appendix C: Example of Consent Form

Consent Form

Date: 2025.01.01
Project Title: Designing an Accessible mHealth Tool for Older Adults with COPD

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PURPOSE

This study aims to explore how an easy-to-use mobile health tool can help older adults with Chronic Obstructive Pulmonary Disease (COPD) track their symptoms and communicate better with their doctors. Many existing apps are too complicated and require too much typing. This study looks at ways to make a simpler tool that reduces the need for manual data entry and creates clear reports that both patients and doctors can understand.

We are looking for 1–3 participants and 1–2 healthcare providers (e.g., nurse practitioners, personal support workers, or family doctors). To take part, participants must be over 65 years old and able to use a smartphone.

Participants will test a simple prototype of the app in a 60 minute session and share feedback about what features are helpful or difficult to use. Their comments will guide improvements in accessibility and communication design.

This project is part of the researcher's Master's Major Research Project (MRP) in Inclusive Design at OCAD University. There is no commercial funding or conflict of interest involved.

WHAT'S INVOLVED

As a participant, you will be asked to take part in a one-on-one usability testing session at a community or retirement center. You will first answer a few short questions about your smartphone use, then try a mobile health app prototype by completing simple tasks. The session will be audio-recorded (with consent) and followed by a short Post-Session discussion. All data will be anonymized and stored securely.Participation will take approximately 60 minutes of your time.

Basic demographic information (age range, gender, and prior experience using smartphones or health-related apps) will be collected before and during the usability testing. No identifying personal or medical information will be collected.

POTENTIAL BENEFITS

This study may help improve the design of mobile health tools for older adults living with COPD by identifying accessibility and usability needs. The findings could inform future development of more user-friendly digital health solutions.

I cannot guarantee, however, that you will receive any direct benefits from participating in this study.

POTENTIAL RISKS

There also may be risks associated with participation

The risks of participating in this study are expected to be very low. Some participants may experience mild fatigue, frustration, or eye strain while completing the usability tasks on a mobile device. To minimize these risks, breaks will be offered at any time during the session, and the researcher will monitor participants' comfort levels throughout. Participants will be reminded that they may skip any question or stop the session at any time without penalty.

CONFIDENTIALITY

All information collected during this study will remain strictly confidential. Each participant will be assigned a unique pseudonym or ID code instead of their real name. No personally identifying information will appear in any report, presentation, or publication.

Audio recordings and notes will be securely stored on password-protected, encrypted drives accessible only to the researcher and supervising faculty. All data will be de-identified during transcription, and any quotes used in publications will be attributed to pseudonyms only.

Audio- or video-recording:

With participant consent, each session will be audio-recorded to ensure the accuracy of feedback. Recordings will be stored on a password-protected, encrypted drive accessible only to the researcher and supervising faculty. Transcriptions will be de-identified, and only pseudonyms will be used in any report or presentation.

Recordings will not be used for educational or public display purposes. All audio files will be securely deleted after the completion of the study. A separate checkbox for audio-recording consent will be included on the consent form, allowing participants to opt in or out.

Data collected during this study will be stored on a password-protected, encrypted drive located on OCAD University's secure server. Only the researcher and supervising faculty will have access to the raw and transcribed data. Data will not be shared with or released to any outside parties, organizations, or sponsors. As required by Canadian law, if a participant discloses information suggesting a risk of harm to themselves or others, or involving abuse or neglect, the researcher has a legal and ethical duty to report it to the appropriate authorities. Access to this data will be restricted to Yawen Deng (researcher), Nancy Snow (supervisor).

INCENTIVES FOR PARTICIPATION

Participants will receive a $5 gift card as a token of appreciation for their time and contribution. This incentive will be provided at the end of the session, regardless of whether the participant completes all parts of the study or chooses to withdraw early.

VOLUNTARY PARTICIPATION

Participation in this study is entirely voluntary. You may choose not to answer any questions or to skip any part of the study. You may also withdraw from the study at any time during the user testing session without any penalty or loss of benefits to which you are entitled. If you withdraw during the session, your data will not be included in the analysis. However, once the session is complete and the data have been anonymized, it will no longer be possible to withdraw your data. Your decision to participate or not will not affect your relationship with OCAD University or with the investigators, Yawen Deng and Nancy Snow.

Sample confidentiality statements

Confidential

All information you provide is considered confidential; your name will not be included or, in any other way, associated with the data collected in the study. Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research.

PUBLICATION OF RESULTS

Results of this study may be published in the student thesis, academic reports, or presentations at professional or scholarly conferences. In any publication, data will be presented in aggregate forms. Quotations from interviews or surveys will not be attributed to you without your permission.

Feedback about this study will be available to participants upon request. Participants who wish to receive this summary may contact Yawen Deng by email at yawendeng@ocadu.ca after the completion of the study, anticipated by **April 2026**.

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please ask. If you have questions later about the research, you may contact the Principal Investigator Yawen Deng or the Faculty Supervisor (where applicable) Nancy Snow using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at OCAD University #7255.

If you have questions regarding your rights as a participant in this study please contact:
Research Ethics Board c/o Office of the Vice President, Research and Innovation
OCAD University

100 McCaul Street
Toronto, M5T1W1
416 977 6000 x4368
research@ocadu.ca

AGREEMENT

I agree to participate in this study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name: _____

Signature: _____ Date: _____

Thank you for your assistance in this project. Please keep a copy of this form for your records.

BELOW ARE SUGGESTIONS ONLY: PLEASE REMOVE TEXT BELOW FROM YOUR FINAL VERSION.

Audio- or video- recording

☐ I agree to be [audio-/video-recorded] for the purposes of this study. I understand how these recordings will be stored and destroyed.

☐ I do not agree to be recorded for the purposes of this study.

_____ _____

Signature of Participant Date

Appendix D: Key finding & notes from the user test

	Level of digital literacy (Self-determined)	Feedback for apps	Related notes	Suggestion
P1	Moderate digital literacy	- Noted that the average sleep hour is not rational to her real life situation. "There's no way I can sleep eight hours. Normally I sleep for three hours. I'm good if I get four or five hours of sleep. " -Expected a sliding interaction to increase text size. -Misunderstood the meaning of the audio icon, suggesting using the microphone symbol (speaker icon) or adding text beside it. "That symbol (icon) tells me, go back. It doesn't tell me it's the sound."	-Struggled with information overload -"I get confused with symbols. I go by symbols. So the symbols have got to be really clear."	-Suggested that to change the data of average sleep to more rational to target user, which is around 4-5h -Suggested to change the audio icon to a speaker icon, or add a text label beside the audio icon. -Suggested to change the increasing text size control from pressing to sliding.
P2	Low digital literacy	N/A	-Perfer tablet over a smartphone due to visibility issues. -Not trusting apps, confidential concerns.	-Suggested enhancing user trust.
P3	Moderate digital literacy	-Hard to find the icon of 'daily check in', (Thinking the report for heart lung stress could also record symptoms) -Button in daily check in page is too small -Expected a sliding interaction to increase text size. -Misunderstood the	-The participant currently relies on doctor-mediated data collection. -Always forget passwords, when using apps. -The data from the app he used is structured for clinical use, not for patients.	-Suggested that the 'daily check in'icon is hard to find, maybe could add a text label. -Suggested that the button in 'daily check in' is too small -Suggested to change the

		meaning of the audio icon, suggesting using speaker icon. “it doesn’t look like audio for me.”	“the doctors are putting out information, I mean, they understand it, but it's hard to understand for a normal person”	increasing text size control from pressing to sliding. -Suggested to change the audio icon to a speaker icon
P4	High digital literacy	-Trying to increase text size within the report part, couldn’t find it at first -She assumed the audio feature required device connection and went to the Personal Center, despite having pressed it before, indicating the icon was not recognizable to her.	-She struggled to find the daily check-in button, as she did not realize the bottom buttons were part of the task.	-Suggested to change the audio icon, or add a text label beside the audio icon. -Suggested that ‘daily check in’ is hard to find
P5	High digital literacy	-She thinks the homepage is the daily summary report -She assumes that the audio feature is located in the Personal Center, similar to system settings on an iPhone that enable text-to-speech. -Expecting to slide to change the text size	-She also used a mHealth app, only collecting her health data.	-Suggested that the home page is enough to be a short daily summary -Suggested to change the audio icon, or add a text label beside the audio icon. -Suggested to change the increasing text size control from pressing to sliding.

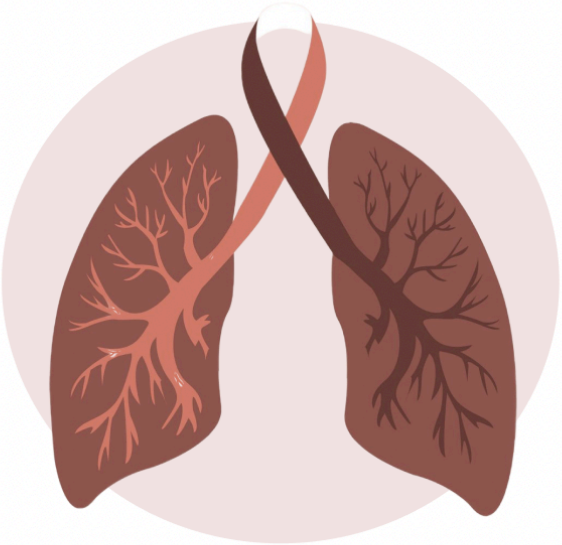
Appendix E: Recruitment materials

Are you over 65?

Would you like to make a difference in healthcare?

Help Us Improve a Health App for People Living With COPD (Chronic Obstructive Pulmonary Disease)

We are inviting participants to join a one-time in-person workshop to test an early version of a mobile health app designed to support COPD symptom tracking and doctor–patient communication.



Who Can Join

- Aged 65 years or older
- Able to use a smartphone or tablet

Where

Location: OCAD University, Toronto
Duration: About 60 minutes
Appreciation: $5 gift card for your time

During the user testing session (approximately 60 minutes), you will try out a prototype of a mobile health app designed to support older adults living with COPD. You will be asked to complete a few simple tasks.

If you're interested, please contact:
Yawen Deng (Daisy)
OCAD University
Email: yawendeng@ocadu.ca

This research has received clearance for user testing from OCAD University's Research Ethics Board.

Letter for recruitment request

Subject: Research Collaboration Opportunity – Study on Accessible Mobile Health Design for Older Adults

To whom it may concern,

My name is Yawen Deng, a graduate researcher in the Master of Inclusive Design program at OCAD University. I am currently conducting a study on accessible mobile health tools for older adults, aiming to improve the usability and accessibility of health apps for Canadians aged 65 and older.

I am writing to request permission to post a recruitment poster for this study on campus bulletin boards or other designated areas. The research involves a 60 minute in-person session at a convenient OCAD campus location, where participants will test a simple prototype and provide feedback. Each participant will receive a $5 gift card as appreciation for their time.

Attached are the recruitment poster and participant invitation letter for your review. Please let me know if any additional information is needed or if I should make adjustments to meet departmental requirements.

Thank you very much for your time and support.

Warm regards,
Yawen Deng
Master of Inclusive Design, OCAD University

Appendix F: Content analysis of existing chronic mHealth apps

Apps	Features	Features Description (How to use each feature)	Goals	Gaps	Idea/opportunities related to my project
1. Heart Disease: MyHeart https://mymhealth.com/myheart?utm_source	Activity Diary	Tracks activities like walking, cycling, swimming, and rehab sessions. Users can log activities manually or automatically via connected devices. Clinicians can review logs to adjust care plans.	Help users track daily activities and share them with clinicians for better rehabilitation management.	Lacks motivational feedback, visual dashboards, and goals to keep patients engaged.	Consider integrating activity tracking into my COPD app and visualize progress using charts and goal streaks. Add adaptive recommendations based on symptom severity.
	Medication reminder	Records prescribed medications, schedules reminders, and tracks dosage history to help users maintain consistent treatment routines. (Similar to iPhone's Reminders)	Prevent missed or incorrect doses by setting reminders and tracking adherence.	Lack of adverse reaction tracking, problems or side effects may go unnoticed	Medication adherence is important for chronic disease management. My COPD app could build on this by adding personalized reminders, side-effect alerts, and refill notifications to make it easier for users to stay on track.
	Patient-doctor contact	Central inbox for alerts, updates, and reminders from clinicians or the app.	Keep users informed with notifications and clinical updates.	Lacks filtering, priority sorting, or response options; important messages may get lost.	It inspired me to make notifications more personalized and context-aware in my app (e.g., "Air quality is poor today," or "Your symptom pattern changed.") These targeted nudges can

					improve engagement.
	Logging	Securely store and view your uploaded ECG and ECHO reports.	Centralize medical reports for easy access and sharing.	Lacks automatic analysis of reports and advanced sharing options (e.g., selecting what to share).	I realized the importance of centralizing medical data for elderly users, it allows patients and clinicians to see trends easily.
	Rehabilitation	When you start the Cardiac Rehabilitation module, the program is personalized upfront based on your diagnosis, medical reports, and clinician-provided data. The app then gives you a pre-set rehab pathway. When you log activities manually or sync them from devices, these logs do not automatically update your rehab plan. Clinicians can review your activity data and manually adjust the rehab program if needed.	Provide cardiac rehab programs to speed up recovery and improve quality of life.	Limited Personalization, not automatically personalized. The plan change needs to go through Clinicians.	Create personalized modular COPD rehab plans with daily breathing exercises, milestone unlocking, and stage-based guidance.
	Education module	A structured library of videos and illustrated guides on diet, exercise, medication, and symptom management.	Educate users about heart health and treatment to improve self-management.	Limited interactivity and personalization; no saved learning progress or custom recommendations.	Provide microlearning for COPD: short videos, interactive summaries, and personalized learning pathways based on user level.
	Monitoring connection	Connects with Omron BP monitors and weight scales for automatic data uploads. Supports Bluetooth BP	Simplify health tracking by syncing data from supported devices.	Device compatibility is limited; no abnormal data alerts; lacks integration with	The potential of seamless device integration: My COPD app should expand

		monitors, allows manual inputs; smartwatch data integration is limited to activity.		broader ecosystems like Apple Health or Google Fit. It can't automatically connect or share data.	to support smartwatches for automatic tracking and alerts.
2. Heart Disease: Hello Heart https://www.hellohheart.com/individuals#steps-start	Tracking	Tracks blood pressure, heart rate, and trends over time. It provides an FDA-cleared Bluetooth blood pressure monitor when you sign up for the program through your employer or insurance plan for accurate BP and heart rate tracking. Smartwatches are optional and mainly used for activity data.	The primary goal is to provide clinically reliable, real-time monitoring of cardiovascular indicators. By offering precise and continuous data collection, Hello Heart helps users detect early signs of hypertension, irregular heartbeat, or abnormal fluctuations before they develop into severe cardiovascular risks. Additionally, the system encourages proactive health management rather than reactive treatments.	The feature depends entirely on the provided Bluetooth blood pressure monitor, meaning users must have the device nearby and functional for each measurement. There is no option for continuous, passive heart rate monitoring via wearables.	Design personalized measurement and recording plans for COPD patients for doctors' reference. At the same time, gamified incentives or adaptive reminders can boost measurement frequency, while accessibility features like voice feedback and large-font interfaces enhance usability and inclusivity for older and visually impaired users.
	Symptom Tracking	Users can log symptoms directly in the app. By correlating subjective experiences with objective data like blood pressure readings, the system creates a more holistic view of the user's cardiovascular health over time.	The goal is to support early detection of potential cardiovascular events by combining biometric and experiential data. It also provides doctors with a more comprehensive health profile,	As symptom tracking is entirely manual, many users either forget to log their symptoms or underestimate mild discomforts, leading to incomplete datasets. There is no passive	My project could explore integrating wearable-based symptom detection through real-time monitoring of heart rhythms, skin temperature, or blood oxygen levels. This

			facilitating more accurate diagnosis and personalized treatment plans.	detection of physiological stress signals, such as abnormal heart rhythms or respiratory changes.	would reduce the dependency on manual logging and improve data completeness.
	Logging (Doctor Report Sharing)	Users can generate detailed reports summarizing their blood pressure trends, heart rate readings, symptom logs, and medication adherence.	These reports can be shared with healthcare providers, enabling better-informed medical consultations.	Reports are often designed for clinicians and may be too technical or data-heavy for patients to understand fully. There is also limited integration with electronic medical record (EMR) systems, requiring manual sharing instead of seamless syncing.	My project could consider dual-layer reports: one simplified and highly visual for patients, and one clinically detailed for doctors.
	Personalized tips	Hello Heart provides AI-driven, personalized lifestyle recommendations based on individual health data such as blood pressure, heart rate, weight, and activity levels. The feature functions like a digital coach, turning raw measurements into understandable, actionable advice without requiring users to manually write daily diaries.	Its aim is to bridge the gap between health monitoring and effective behavior change. By providing personalized coaching, it encourages habit change, reduces cardiovascular risks, and promotes self-awareness regarding health management.	The tips rely mainly on biometric data, ignoring behavioral, environmental, or cultural contexts, which can make some recommendations generic, irrelevant, or less inclusive.	My project could use multi-dimensional personalization, combining sleep, stress, environment, and user goals, while enabling follow-up questions and preferences. Localized, multilingual, and culturally sensitive content would further boost inclusivity and engagement.
	Medical Records	Consolidates all medical records into an easy-to-read report. Upload or authorize	Provide a comprehensive overview of patient health	The import process can be cumbersome.	Medication tracking and reminder system for

		import of medical records; system organizes them.	information.		COPD inhalers and oral medications.
3.Outcomes4Me (Cancer) https://apps.apple.com/us/app/outcomes4me-cancer-care/id1404382419?utm_source	Hospital Finder	Matches patients with clinical trials relevant to their condition and location. Fill in your diagnosis and location; the app recommends nearby trials.	Help patients access the latest clinical trials.	Trial database updates may be slow; geographic coverage limited.	Local resource finder for pulmonary rehab, COPD support groups, or respiratory therapists.
	Treatment plan	Provides FDA-approved personalized treatment options, including drugs and surgical alternatives based on your diagnosis and medical history, generating recommended treatment pathways.	Help patients understand treatment options and improve communication with doctors.	Limited support for rare cancers; relies on users to input detailed data.	Personalized care pathway suggestions based on symptom severity and GOLD stage.
	Healthcare team support	Allows patients to ask oncology nurses questions for professional advice.	Enhance patient support and care management.	Response time is uncertain; scope limited to nursing guidance.	Messaging function with respiratory therapists or COPD educators.
	Symptom Management & Tracking	Tracks symptoms and treatment responses to observe trends over time.	Help patients self-monitor and share trends with doctors.	Recording may feel repetitive; lacks reminders.	Add visualized charts, AI trend analysis, and intelligent reminders.
4.Chronic LowerRespiratory Diseases: CoughTra	Logging (Audio stays on the device, uploaded only with user consent.)	Users can manually log their cough frequency and time periods.	Enhance patients' self-awareness (when and why they cough). Provide doctors with records of patients' subjective experiences	Cumbersome, requires frequent interaction; elderly users may forget or be unwilling to record; data can be easily missed or inaccurate.	In my project, manual logging would increase the burden for elderly COPD patients and is not very practical.
		Cough events can be automatically recorded by the app; it records	Reduce user burden (no manual input	Can only record short-term and must be kept	Using the microphone is not suitable for

cker https://apps.apple.com/us/app/cough-tracker-reporting/id1556860606		the environmental sounds using the phone's built-in microphone, and the algorithm identifies coughs.	required; no need to own a smartwatch)	nearby; background noise (TV, family conversations) may affect accuracy.	long-term monitoring; it can only be used at night and requires placing the phone nearby, which is inconvenient.
		A wrist-worn device that monitors cough events 24 hours a day, recording continuous audio and cough timestamps.	Capture key health signals such as nighttime coughs, providing data to support doctors' long-term trend analysis.	High device cost; elderly users need to learn how to wear and charge it; potential adherence issues (forgetting to wear it or finding it inconvenient).	Wrist-worn device data can be integrated with telemedicine access, allowing doctors to review continuous data before appointments to help decide whether to adjust medication or follow-up frequency. Meanwhile, the app can remind patients, 'Based on recent cough patterns, consider scheduling a doctor's visit.
	Symptom tracking	Record and monitor COPD symptom changes, such as shortness of breath or cough.	Detect early changes in condition and adjust treatment accordingly.	Requires manual input; data may be incomplete.	Introduce automated data collection (e.g., cough detection via microphone) to reduce user effort.
	Patient-doctor contact	Central inbox for alerts, updates, and reminders from clinicians or the app.	Keep users informed with notifications and clinical updates.	Lacks filtering, priority sorting, or response options; important messages may get lost.	It inspired me to make notifications more personalized and context-aware in my app (e.g.,

5. Chronic Obstructive Pulmonary Disease: Mycopd https://mymhealth.com/mycopd					"Air quality is poor today," or "Your symptom pattern changed.") These targeted nudges can improve engagement.
	Medication Reminders	Set reminders to help patients take medications on time.	Improve medication adherence and reduce missed doses.	Poor UI/UX design: too much text to read and a lack of visual elements.	One idea to consider is automatically linking medical records and collaborating with hospitals, allowing automatic setting of medication reminders.
	Education module	Provides COPD-related knowledge, including anatomy, exercise, and smoking cessation. Step-by-step instructional videos showing correct inhaler use.	Ensure correct inhaler use and improve medication efficacy. Increase patient understanding and self-management capabilities.	May not be suitable for patients with lower literacy or cognitive challenges.	Offer multi-language support, simplified content, and voice guidance for elderly patients.
	Rehabilitation module	Provides expert-designed video courses for patients to complete at home.	Improve respiratory function, endurance, and overall health.	The intensity may not suit every condition and lacks personalization.	Could make it personalized according to the current condition
	Pollution forecasting	Provides local weather and air quality information to help plan daily activities.	Avoid exposure to unfavorable conditions and reduce symptom exacerbation.	Information may not be fully accurate or real-time.	Considering whether pollution elements like Canada's frequent wildfires。
	Checklist	A structured checklist where patients can tick off daily or weekly COPD management tasks, such as taking medication, doing breathing exercises	Provide patients with a structured routine to help them remember key aspects of self-management ; improve	Checklist relies on manual completion, which may be forgotten or inconsistently done, especially	Add more interactive components or motivational elements.

			adherence to daily health routines; reduce risk of exacerbations.	for older adults. The checklist does not provide automated feedback or escalation if tasks are missed.	
6. Diabetes: My sugar https://www.mysugr.com/en	Blood Glucose Logging	Manually enter or automatically sync it via Bluetooth device to log blood glucose levels, insulin doses, meals, carbs, activity, medications, and more. Customize the dashboard to suit individual therapy needs .	to track meals' impact on blood glucose levels, aiding in better carb counting and meal planning .	Manual entry can be tedious.	COPD needs to track oxygen saturation, breathing rate, and symptoms.
	Motivation	Engage in motivational challenges to stay committed to diabetes management goals.	Improve long-term usage		Adding Motivation elements may help improve long-term usage
	Share records	Users can share data with healthcare providers. It will ensure data privacy and security, complying with GDPR standards .	Facilitate medical decisions and remote guidance	Sharing may not be real-time; security concerns; limited customization of reports	Need to consider security concerns.
7.Alzheimer's	Daily activity	Provides users with daily recommended activities such as brain games, cognitive training, physical exercise, nutrition tips, recipes, and health articles/videos. Users can browse and complete tasks directly in the app. Personalized recommendations are adapted to user preferences and health conditions	Promote brain and physical health, maintain cognitive function, support healthy aging, and encourage daily engagement.	May not be realistic for all users to complete multiple tasks daily. (Potential cognitive overload)	Bite-sized daily tasks (e.g., breathing exercise, energy-saving tip, short walk) to support gradual habit building without cognitive overload.
	Brain	Offers memory,	Maintain or		Gamify

Disease & Dementia: mindmate https://www.mindmate-app.com/?utm_source	Games	attention, speed, and problem-solving games. Users select games to complete as part of their daily routine.	improve cognitive performance, delay decline, and enhance engagement through gamification.		breathing exercises or medication routines
	Exercise	Offers structured exercise plans categorized by intensity (aerobic, strength, flexibility). Users track their workouts.	Promote physical health, mobility, and independence.	Exercises may be too generic, lacking adaptability for users with physical limitations.	Personalised, adaptive pulmonary rehabilitation plans based on initial assessment and symptom changes over time.
	Nutrition advice and recipes	Provides healthy diet guidance and searchable recipe suggestions with step-by-step instructions.	Encourage healthier eating habits and support overall well-being.	Recipes may not reflect diverse cultural diets or accessibility needs. Preparation steps can be time-consuming for users with limited energy.	Simple, low-energy meal tips for COPD patients with fatigue.
8. Obesity: Noom Link 1 Link 2	Personalized plan	Upon sign-up, users take detailed questionnaires about goals, habits, lifestyle to generate personalized plans. Adaptive over time.	Create individualized, evolving plans to support engagement and motivation.	Large questionnaires can be burdensome	Personalised, adaptive pulmonary rehabilitation plans based on initial assessment and symptom changes over time.
	Log meals & Color-Coded Food System	Users log meals, exercise, hydration, weight, etc. via database or manual entry; integrates with fitness trackers. Classifies foods into categories: green (nutrient-dense), yellow (moderate), red (calorie-dense), without banning any food.	Encourage mindful, balanced eating choices and moderation rather than restriction.	Categorization can oversimplify; may not align with specific dietary needs Logging can be tedious; food database inaccuracies; repeatedly switching screens to log	Could adapt similar visual guidance for tracking symptoms (e.g., green/yellow/red zones for symptoms severity).

				multiple items.	
	One-on-One Coaching & Group Circles	Users receive support from health coaches via in-app messaging; join small peer groups (“Circles”) for community support.	Provide accountability, motivation, and emotional support.	Some users feel that coach replies sound like automatic, generic templates instead of personalized answers.The community features don’t work the same on all devices or systems (for example, iOS vs. Android), and some options may be missing.	Simplified coaching for COPD with caregiver/family involvement; community groups for elderly COPD patients to share tips, e.g., breathing exercises.
	Psychology-Based Daily Lessons (CBT-driven)	Users complete bite-sized daily lessons (5–10 min) with quizzes and reflections based on behavioral psychology and cognitive-behavioral therapy.	Foster long-term behavior change by addressing emotional triggers and habit formation.	Not many people will practice it due to lack of motivation	Lightweight, bite-sized motivation or habit-building tips to support long-term adherence.
9. Arthritis: My	Tracking	Enables users to log symptoms, flares; track diet, exercise, pain, sleep, mood, stress.	Help users recognize patterns; facilitate better self-management; support understanding triggers and remission periods.	Manual entry may create a data entry burden.	Symptom tracking focused on COPD-specific indicators (breathing, energy, cough, fatigue) without manual entry burden.
	Education	Provides trustworthy news, articles, and resources via NRAS and other expert bodies; library of information about living with arthritis.	Inform users; help them stay updated with best practices; increase health literacy; empower decision-making.	Information may be too generic; might not be tailored to specific user circumstances; reading articles can be time and effort consuming	Excellent source of content that can be adapted; content could be tailored by user input.
	Linking with	Users can link their app to Apple Health or	Leverage existing data	May be privacy concerns	Passive data collection from

Arthritis https://apps.apple.com/us/app/my-arthritis/id1431862637?utm_source	Apple Health / Google Fit	Google Fit to share lifestyle data (read-only access) with clinical team	collection; reduce duplication; allow lifestyle metrics (steps, activity) to inform care; enhance insights.		wearables to reduce manual input burden for COPD patients.
	Questionnaire	Users maintain records of health information such as operations, test results, medical history, to share with their clinical team.	Enable better continuity of care; provide documentation that can help in clinical visits; empower users to track their own health.	May cause user burden	GOLD-based self-assessment questionnaire to help patients understand their COPD severity and track changes over time.
	Build positive habits	Users can enroll in courses (single-day or up to 28 days) on topics like sleep, medication, wellbeing, physical activity, etc. Includes videos, guided audio, expert advice.	Help users build better self-management habits; improve their knowledge; support behaviour change; provide structured guidance over time.	Content may be generalized rather than personalized.	Good model for structuring self-management education
	Health record	Users maintain records of health information such as operations, test results, medical history, to share with their clinical team.	Enable better continuity of care; provide documentation that can help in clinical visits; empower users to track their own health.	Require manual information entry; possible data-overload issues	Could use simplified interfaces for record-keeping, possibly with guided input.
10. Chronic Kidney Disease:	Tracking	Users log key health metrics such as weight, blood pressure, potassium, phosphate, and eGFR.	Monitor and track CKD progression and treatment effectiveness.	Requires manual entry; may not integrate seamlessly with all health devices; limited to CKD-specific parameters.	Consider make the tracking automatically
	Meal Diary	Users record meals and track intake of nutrients like protein, potassium, sodium, and phosphate.	Manage diet to prevent complications related to CKD.	Logging meals can be time-consuming; food databases may be limited for local	Simple nutrition tips for COPD patients (e.g., energy-dense meals, hydration).

Your CKD companion https://play.google.com/store/apps/details?id=com.Carealytix.Miku&hl=en_GB				cuisines; no barcode scanning or quick input features.	
	Hospital Finder	Allows users to locate dialysis centers worldwide, aiding in travel planning.	Facilitate travel for dialysis patients by identifying suitable centers.	May not cover all regions comprehensively.	Find local pulmonary rehab programs, COPD clinics, or respiratory therapists.
	Medication reminder	Users set up personalized medication plans with reminders and track daily intake.	Improve medication adherence and manage complex regimens.	Reminders are generic; no verification if medication is actually taken; lacks adaptive alerts when doses are missed.	Considering varying medication schedules and incorporating adaptive reminders based on symptom logs.
	Education module	Offers articles and tips tailored to the user's CKD stage, validated by medical professionals.	Educate users about managing CKD and improving quality of life.	Information may be text-heavy; not interactive; lacks multimedia (videos, infographics); content might be overwhelming for elderly users.	educational content is also very important for copd patients
11. Asthma: AsthmaMD https://www.asthmamd.org/	Logging	Users can define and log asthma triggers, e.g. environmental or personal triggers. Users can customize triggers	Make asthma control more transparent; allow real-time tracking; empower users with structured logging	Logging is manual, hence subject to omissions or inaccuracies	Simplify logging (e.g. presets, templates), minimize effort of logging
	Chart Severity	The app presents graphical views of peak flow, severity over time, “at-a-glance” visualizations of trends.	Help users see trends, compare to “personal best,” understand when they deviate from baseline	Charts may be complex; context (e.g. triggers, symptoms) might not always be displayed alongside	A good example of visual feedback; opportunity to simplify charts, overlay contextual data (symptoms,

?utm_source				graphs.	triggers)
	Doctor Report Sharing	One-step process to send asthma logs & peak flow charts securely to physicians.	Improve doctor-patient communication; allow clinicians to see up-to-date data; better decision making; reduce reliance on memory.	Data sharing may depend on user's initiative (no always-on or automatic sync)	Shows value of shared reporting; indicates opportunity for integrated summary dashboards for clinicians.
	AsthmaMD Peak	The app supports a portable Peak Flow Meter device which users can buy, and log peak flow values in the app.	Enable users and clinicians to monitor lung function trends; detect deteriorations in airflow	Dependency on external hardware (users must buy meter); manual entry or syncing issues	If the hardware link is robust, it can reflect how important seamless device integration is.