Using Connected Devices to Monitor Inhaler Use in the Real World

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SUMMARY

Patients with chronic disease must balance the stress and responsibility of managing their illness amidst the requirements of everyday life. This is a significant burden that has been recently recognized as competing with efforts towards optimal care management. Here we propose that building reliable and useful connected inhaler devices can help to counteract this burden and foster better care management for patients with asthma and chronic obstructive pulmonary disease (COPD). Over the past five years, Propeller Health has developed inhaler sensors and digital engagement tools that enable reliable recording of inhaler medications and offer new insights and support to empower better management of asthma and COPD. Evidence is provided that the Propeller platform helps to improve outcomes for asthma and COPD across age groups and healthcare settings.

INTRODUCTION

All people have routines and responsibilities, but patients with chronic disease take on more, daily. From completing medical paperwork, traveling to and from appointments, taking and recording medication use, making suggested lifestyle changes, and remembering and reporting back about symptoms, patients have significant demands and responsibilities for managing their disease [1, 2].

Treatment options for chronic disease have improved over the past decade, but despite the development of more effective medications and the advice and education efforts of national clinical practice guidelines [3], fewer than one in three patients adhere to their prescribed asthma medications [4–6]. This suggests a meaningful gap between patient behavior and provider advice. What accounts for this gap? Most treatment plans fail to recognize the work required for patients to adhere to their provider’s recommendations. The “work of being a patient,” or treatment burden, has been negatively associated with adherence to therapeutic care [7, 8], hospitalization [9], and survival [10].
In order to better incorporate the real world circumstances of patients' lives into treatment regimens and subsequently improve patient care and outcomes, researchers have developed a framework called minimally disruptive medicine (MDM). MDM acknowledges the daily burden on both patients and caregivers required to manage chronic disease, and calls for fitting the overall therapeutic approach into the context of a patient's life [11]. It highlights limitations — such as inadequate communication and coordination — across health care and in provider–patient relationships that add to treatment burden [12, 13]. MDM suggests that normalizing and integrating the patient workload into daily life can improve adherence to therapy and calls for patients and their physicians to build pragmatic treatment plans that can be successful in the real world [14].

We believe MDM provides a valid framework for characterizing many limitations to optimal care for asthma and COPD. In this report, we use MDM to highlight the real world challenges that Propeller Health aims to address through digital technology that not only helps to streamline self-management and encourage communication and support, but also attempt to strengthen patient-provider relationships to accomplish the goals of therapy.

**Propeller Health Provides a Comprehensive Solution for Meeting Goals of MDM**

Founded in 2010, Propeller Health is the leading digital health solution for respiratory medicine. Propeller aims to provide better engagement, communication, and more insightful and personalized care. Through a combination of inhaler device sensors, mobile applications, analytics, and regular feedback, the Propeller platform is designed to reduce the stress and burden of disease management. Propeller starts by creating a custom view of each patient, allowing patients and caregivers to better understand the impact and management of their disease in daily life. This includes passive tracking of when and where each patient is using their inhaler medications. Reminders are sent to each patient to keep them on track with prescribed dosing instructions. Running in the background, our analytics platform helps to identify moments or patterns that patients, care coordinators, and caregivers want to know about such as asthma attacks or signals of worsening. Propeller provides personalized alerts about these events, providing an opportunity to intervene, change behavior, and improve outcomes.

Propeller Health has received FDA 510(k) class II clearance to measure and improve medication adherence, predict exacerbations, and help reduce the frequency of symptoms and exacerbations in asthma and COPD. Propeller's platform has been clinically validated in two randomized controlled trials and more than ten clinical studies involving over 1,400 patients. It has been used by patients in over 35 commercial programs across the United States, including major healthcare systems, payers, employers, and other commercial partners. Propeller's platform is compatible with the majority of commonly used asthma and COPD inhalers, including metered dose inhalers (MDIs), and other inhaler devices.

![Propeller MDI sensor and user app.](image-url)
(dry powder inhaler (DPI) and soft mist inhaler (SMI)). It works with controller medications such as GlaxoSmithKline’s (GSK) Flovent®, Merck’s Dulera®, Teva’s QVAR®, and others, as well as reliever medications such as GSK’s Ventolin® HFA, Merck’s Proventil® HFA, Teva’s ProAir® HFA, generic albuterol metered dose inhalers (MDIs), as well as GSK’s Diskus® DPI, and Boehringer Ingelheim’s SMI.

We aim to summarize three ways that Propeller Health bridges issues articulated by MDM and encourages better management of asthma and COPD. First, we describe how Propeller’s sensors are built to accurately and reliably monitor multiple inhaler delivery devices, and how we have designed the strategy required to surround patients with supportive digital interfaces and experiences in asthma and COPD. Then, we share important lessons from usability studies and surveys that led to product improvements and greater patient engagement over time. Finally, we provide a summary of clinical outcomes from our commercial programs that demonstrate user engagement and improved outcomes across patient demographics (age groups) and healthcare settings.

**Building Accurate and Reliable Sensors for Inhaler Devices**

The addition of electronics to an inhaler can compromise what is elegant about its design. Durable and robust, they carry large supplies of medication in a small and pocketable form and deliver precise amounts with each simple use. They are unique among our devices today in their disdain for electricity. And, in some cases, they are even resistant to water.

Couple that with the variety of marketed inhaler devices and the range of active ingredients and you find yourself with a significant set of challenges to the design and engineering of add-on sensors. Each has to be built to accurately and reliably record the specific pairing of medication and device, to accommodate diverse patterns of use, and to operate with negligible impact on the day-to-day life of people with chronic respiratory disease. In this section, we review some of the important lessons we have learned while building sensors for the inhaled medications and patterns of use today.

Inhaled medications need to fit into the lifestyle of the patients who use them. For example, inhaled rescue medications such as an albuterol MDI need to be readily available at all times so that they can be used to relieve symptoms if and when they occur. Most of the time, the inhaler is stored in a pocket, backpack, or a glove compartment. By contrast, inhaled steroids are typically stored in the home, and are available for use in the morning and night. How these inhalers are stored and used plays a direct role in the decisions about industrial designs and electronic components for sensors. Where similar devices, such as MDIs, can deliver both types of medications, add-on sensors designed to monitor the use of MDIs must be adaptable to both types of medication and use.

Add-on sensors must be discreet and unobtrusive. Already complex delivery systems, attachment of the sensor should not make the inhaler harder to use, nor negatively affect activation of the device, or the integrity of the delivered dose. Where the inhaler has a dose counter, it should remain visible to patients; even labels and branding can be commercially important. The enclosures of many of our add-on devices use a transparent material to provide ready access to these features. Neither can the device change how a person uses their inhaler, or demand much attention and upkeep. At Propeller Health, we work to make add-on sensors that can remain as passive as possible — asking no participation on the part of the patient beyond some minimal initial setup.
Nothing compares to the experience Propeller Health has gained from instrumenting medications and witnessing how these sensors work in the real world setting. Sometime this teaches us about miscalculations. Propeller’s initial sensors for MDIs were designed to be recharged once a month. Despite what we considered to be a generous battery life, we have found that recharging – even at this interval – presented an obstacle to ongoing use of the sensor. We now recognize that the general public had begun to build daily habits around recharging their smartphones, and the month-long intervals between charging limited our ability to build a similar habit. Over the intervening years, improvements in the size and efficiency of electronic components, including batteries, together with advances in low-energy radios and protocols, have allowed us to build sensors now that are significantly smaller than our original device, yet last for more than a year without ever needing to be recharged.

Propeller Health also recognized that sensors should be compatible with a wide range of the medications on the market. While we started with an MDI sensor, we have recently built and received FDA clearance for add-on sensors for DPIs and SMIs. In general, these devices can be more complicated to use. For example, unlike an MDI, these inhalers may have covers that slide out of the way, or that must be primed before inhalation. While the MDI sensor can be built with a mechanical switch, these types of inhalers require more elaborate and coordinated sensing and electronic processing to understand when the medication is being handled, prepared, and used. As a result, our add-on devices employ a set of sensors and electronics to detect actuation of the inhaler through a variety of means but with each additional piece we have to balance the incremental costs – both economic and electric – of the components against its marginal value.

When attached to regular anti-inflammatory medication, Propeller’s inhaler sensors provide audiovisual reminders that alert the patient when to take the next dose. These reminders, which signal a missed dose, have been shown to improve adherence in a number of trials [15-17]. These types of reminders join other electronic notifications, such as emails and text messages, in helping to encourage more regular and appropriate use of anti-inflammatory medication over time.

**User Feedback Has Driven Product Improvement**

Propeller Health is constantly iterating to improve the sensors and platform and optimize the patient experience. Upon completion of studies and programs, patients are asked to answer survey questions on a Likert scale about their experience and satisfaction using Propeller. Patients from a few recent programs were surveyed and 80% reported the platform was easy to use (n=127) and 94% were satisfied with the information that they received (n=101). Patients cited Propeller’s medication reminders, insights on triggers, and medication use trends as particularly useful for their self-management. COPD patients have reported similar levels of satisfaction as in our asthma programs.

Through talking with patients, we have learned which features provide the most value, preferences about frequency and communication style, and how the information is used with providers. Patients have shared how helpful the platform has been for identifying triggers that they had not known about before and how this new information has allowed them to be proactive in how they use their medication. Other patients have found the educational pages valuable. Propeller has received diverse feedback about the frequency of receiving email alerts and messages, which drove us to create an opportunity for individual users to customize how they would like to receive our information.
Examples of useful feedback from users have included: “I feel more supported. The system gives you a feeling of being more in control. It’s sort of like having someone around you all the time whose only job is to track your asthma.” We have also received feedback about how Propeller has been useful for talking with doctors: “I didn’t realize how much I was using my rescue [inhaler] and when I started seeing the emails [from Propeller], I was able to talk to my physician and discuss that I was actually less controlled than I thought.” Through talking with care managers, we found out that the Propeller platform can save time on outreach calls. Care managers found that they were able to have more meaningful and direct conversations about treatment and how to manage in daily life. Multiple patients have shared that they print out email summaries produced by Propeller to bring to their doctor’s appointments and describe how useful that has been for talking with their doctor about how they have been feeling since their last visit. Propeller has learned that caregivers receive information about their children or other family members with much greater ease. This has been especially valuable for parents who are interested in getting the full picture of their child’s experience with asthma by having access to medication use and symptoms while the child is at school.

Outcomes and Engagement Across Age Groups and Healthcare Settings

Does Propeller solve for the problems defined by MDM? And is it suitable in all healthcare settings? Here we share clinical results and engagement by age and program type. Propeller’s experience shows that we engage user groups across patient demographics and healthcare settings. We demonstrate important clinical outcomes such as reduction of asthma symptoms (rescue inhaler use decrease) and improvement of control (% of participants with short-acting beta-agonist medication (SABA) use on ≤ 2 days/week*).

We describe aggregated data for Propeller’s commercial programs. Across these programs, Propeller has enrolled asthma patients across a range of ages (2-90 years, mean 29.3, standard deviation = 19.6). Table 1 shows that patients participated in Propeller through three distinct healthcare settings: “Community” (community-oriented program without clinical integration and funded through a grant), “Payer” (commercial health plans), or “Provider” (programs with healthcare providers). We highlight three outcome and engagement metrics in Table 1. A reduction of SABA use to less than two days per week is an important component and indicator of asthma control [5, 18]. We include all person-days in the analysis and modeled data using mixed effects Poisson regression models with random intercepts, to account for the repeated observations for each person. The predictor was the number of days since each participant had started tracking rescue medication use with a Propeller sensor. The magnitude and statistical significance of this coefficient was the primary result that was assessed.

In a combined analysis, the quantity of rescue inhaler use decreased statistically significantly (p < 0.0001) the longer each participant was in the program, suggesting improving asthma control over time. These decreases were stable and durable over the course of one year of monitoring.
Consistent results were seen in all subgroups and healthcare settings (Table 1). A substantial increase in the percent of participants with ≤ 2 days/week of SABA uses in the community-based programs was notably lower than that seen in other program types, which was attributed to less clinical oversight for enrollment and execution than other programs. Early results from employer-based programs showed similar results to those from other program types.

The metric daily active user/monthly active user (DAU/MAU) is an important measure of patient engagement used by digital technologies across industries. Propeller’s DAU/MAU ratio is more than 70% across subgroups. In other words, we receive data from 70%+ patients every day. To put this in context, several smartphone and web-based games have a DAU/MAU between 20 and 30%, and Facebook has a DAU/MAU of 70%.

**CONCLUSION**

Over the past five years, Propeller has built technology and experience that empowers patients living with chronic respiratory disease. The company’s connected sensors and support platform meets the needs of a wide range of users and care settings. We have listened to patient and provider experience to fuel product development in a way that easily fits into patients’ lives. The result (simple interfaces, custom insights, and meaningful real-time data) is improved outcomes for a wide variety of asthma and COPD patients across the healthcare spectrum.

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REFERENCES


