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Clinically-enhanced digital health program for respiratory care associated with better medication use and retention

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Digital health platforms for asthma self-management have demonstrated promise in improving clinical and quality of life outcomes. However, few studies have examined such an approach in a real-world, fully remote setting. As such, we evaluated the benefit of an evidence-based digital self-management platform for asthma—both on its own and when integrated into an established virtual clinical service. We compared six-month outcomes of a digital self-management program plus virtual clinical oversight, called a therapeutic resource center, (DP + TRC) with a digital self-management-only (DP) program in patients with uncontrolled asthma. The DP included electronic medication sensors that captured the date and time of both short-acting beta agonist (SABA) and controller medication usage. The TRC included remote care oversight to promote inhaler adherence and address symptom worsening. SABA usage, controller adherence and program retention were assessed retrospectively using regression models controlling for age, enrollment year, controller/SABA use, and baseline asthma control status.18,584 DP patients (mean age (SD): 33 (14.6) yrs; 89.9% uncontrolled asthma) and 3440 DP + TRC patients (mean age (SD): 43.7 (15.6) yrs); 48.6% uncontrolled) were assessed. We observed significantly better six-month program retention (55% vs. 41%, $p < 0.001$) and controller adherence (54% vs. 45%, $p < 0.001$), but no statistically significant differences in mean SABA use (0.76 vs. 0.87 mean puffs/day; $p = 0.158$) for the DP + TRC vs. DP groups, respectively. From baseline to six months, both groups had similar reductions in mean daily SABA use (both $p < 0.001$) and improvements in the percent of SABA-free days (both $p < 0.001$). The proportion of patients with ≥80% controller adherence declined in both groups, but a larger relative decline was noted in the DP vs. DP + TRC group. A digital self-management platform for asthma management combined with virtual clinical oversight may offer a scalable solution that not only achieves reduced SABA use, but also promotes medication adherence and increases program retention.

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INTRODUCTION

Asthma affects more than 25 million children and adults living in the United States. An asthma diagnosis can have a significant physical and psychosocial impact on individuals and their families, especially if symptoms are not well controlled[1,2]. Treatment for adults with persistent asthma (step 2 and above) often includes a rescue inhaler (short-acting beta agonist (SABA)) for acute symptoms, plus a controller inhaler (either a daily inhaled corticosteroid (ICS) or a combination ICS/LABA (long-acting beta-agonist)) prescribed as needed or daily for long-term management[2,3]. However, adherence to such daily controller medications is often suboptimal, with less than half of prescriptions filled as prescribed[4].

Digital health platforms for asthma self-management have become increasingly popular to help promote medication adherence. Today, a growing body of evidence suggests that digital health platforms not only help promote daily controller medication use, but may also help patients better manage their asthma symptoms, including exacerbations, and reduce the frequency of SABA medication usage[4–6].

Despite the growing evidence around the value of digital health platforms, questions still remain on how to effectively integrate these platforms into healthcare systems and workflows[5]. One proposed solution is to adopt a hybrid approach, combining elements of successful clinical workflows with targeted improvements in areas that could benefit from digital health support[7]. For example, a major goal of asthma management is reducing emergency department visits[5]. By integrating digital platforms into clinical workflows, clinicians can remotely monitor medication use and worsening asthma symptoms between in-person visits, facilitating earlier clinical interventions that may prevent costly healthcare resource utilization.

But the success of a hybrid approach in a fully remote, real-world setting has rarely been studied. As such, we conducted a retrospective analysis to assess the impact of an evidence-based digital self-management platform for asthma—both on its own and when integrated into an established virtual clinical service. We specifically examine and compare outcomes related to rescue and controller inhaler medication usage and platform retention over a six-month period.

METHODS

Setting

This retrospective analysis compares outcomes for patients enrolled in a digital self-management platform only (DP) and patients enrolled in a combined digital self-management platform and virtual therapeutic resource center (DP + TRC). Patients in the DP were recruited via social media campaigns and health fairs, and patients enrolled in the DP + TRC were recruited through a series of web and mail-based campaigns within a pharmacy benefit management organization. Patients enrolled in the respective programs between January 2018 and December 2019.

Digital Self-Management Platform (DP). The digital self-management platform included SABA and controller inhaler sensors to capture the date and time of inhaler usage. Inhaler usage data was

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shared with patients via a smartphone app that also included medication reminders, evidence-based asthma education and feedback based on recorded medication usage, and insights on self-reported triggers and symptoms (Propeller Health, Madison WI)[8]. During enrollment, baseline symptom control and condition management was assessed in-app with the Asthma Control Test (ACT)[9].

Therapeutic Resource Center (TRC). The Therapeutic Resource Center is a remote pharmacy benefits manager (PBM) service (Express Scripts, St. Louis, MO) that provides patients with virtual clinical management support. Allied health professionals like nurses, respiratory therapists and clinical pharmacists connect with patients via telephone calls, secure messaging systems, and video visits[10]. For this study, the goal of the TRC was to provide virtual support to patients with asthma who had low controller medication adherence and/or worsening asthma symptoms. Eligible patients within the PBM system were invited to enroll in the digital self-management platform (DP) which included sharing their medication usage data with the TRC clinicians. Clinicians then accessed the data via a secure web dashboard. The dashboard highlighted patients with worsening asthma symptoms (as defined by objective SABA use trends per the NHLBI guidelines for worsening control)[11] and/or patients with poor controller adherence (defined as four or more days of controller non-use).

Eligibility and outcomes

To be included in the analysis, patients needed to have a self-reported history of uncontrolled asthma (ACT < 20), have completed the setup of one or more medication sensors ("sync"), and have had at least 187 days of data for each outcome of interest (the first 7 days of DP use were considered a training period and excluded from analyses).

The study examined three outcomes among patients with uncontrolled asthma (ACT < 20): SABA use, controller medication use, and program retention. SABA use was defined as mean daily puffs per person, the number and percentage of days without SABA use ("SABA-free days"), and the percentage of high SABA use days (days with ≥6 puffs/day). Controller medication use was assessed by mean daily adherence (defined as the percent of daily puffs taken divided by the total number of puffs prescribed × 100), the percentage of days with ≥80% adherence, the percentage of days with 100% adherence, the odds of achieving ≥80% adherence, and the odds of achieving ≥80% days with 100% adherence. Program retention was defined as the percentage and odds of patients syncing with the digital platform at 180 days.

Analyses

Descriptive characteristics between groups were compared using chi-square tests for categorical variables and t-tests for continuous variables. Regression analyses compared average SABA use, controller medication use and program retention rates over 180 days between the two study groups (DP vs DP + TRC). Mixed effects linear and logistic regression models compared the change in SABA use and controller medication use from baseline (days 7–37) to study end (days 157–187). All models adjusted for age, enrollment year, baseline ACT score, and any SABA/controller use among patients with initially uncontrolled asthma.

The retrospective analysis plan was submitted to Copernicus IRB (now WCG IRB) and was determined to be exempt from further review (PRH1-18-132).

RESULTS

22,024 patients were considered for analyses, with 16,573 meeting inclusion criteria: 15,834 DP patients (mean age (SD): 33.8 (14.1) yrs, first ACT score 12.2 (3.8)), and 739 DP + TRC patients (mean age (SD): 44.5 (15.3) yrs, first ACT score 14.7 (3.5)) (Table 1).

Table 1. Patient characteristics.

	Total Population			Uncontrolled (ACT < 20) Only		
	DP	DP + TRC	p-value	DP	DP + TRC	p-value
n	18,584	3,440		15,834	739	
Age, mean (SD)	33 (14.6)	43.7 (15.6)	<0.001	33.8 (14.1)	44.5 (15.3)	<0.001
Age, n (%)			<0.001			<0.001
4 to 11	1365 (7.3)	1 (0.0)		977 (6.2)	0 (0.0)	
12 to 17	1170 (6.3)	232 (6.7)		708 (4.5)	40 (5.4)	
18 to 39	10349 (55.7)	1065 (31.0)		9151 (57.8)	214 (29.0)	
40 to 59	4839 (26.0)	1554 (45.2)		4252 (26.9)	353 (47.8)	
60+	861 (4.6)	588 (17.1)		746 (4.7)	132 (17.9)	
First ACT score, mean (SD)	13.1 (4.6)	18.6 (4.6)	<0.001	12.2 (3.8)	14.7 (3.5)	<0.001
First ACT score category, n (%)[a]			<0.001			
Uncontrolled (ACT < 20)	15834 (89.9)	739 (48.6)		N/A	N/A	
Controlled (ACT ≥ 20)	1784 (10.1)	782 (51.4)		N/A	N/A	
Enrollment year[b], n (%)						0.001
2018	9788 (52.7)	1962 (57.0)	<0.001	8555 (54.0)	445 (60.2)	
2019	8796 (47.3)	1478 (43.0)	<0.001	7279 (46.0)	294 (39.8)	
Medication Type						
SABA	17133 (92.2)	3278 (95.3)	<0.001	14733 (93.0)	723 (97.8)	<0.001
Controller	7298 (39.3)	1730 (50.3)	<0.001	6033 (38.1)	390 (52.8)	<0.001
Both	5847 (31.5)	1568 (45.6)	<0.001	4932 (31.1)	374 (50.6)	<0.001

DP patients enrolled in the digital self-management platform only, *DP + TRC* patients enrolled in both DP and virtual therapeutic resource center, *ACT* Asthma Control Test, *SABA* short-acting beta agonist, *N/A* not applicable.
[a]Percentage calculated with non-missing data.
[b]Year in which the medication sensor was first synced.

Six-month outcomes

Among patients with uncontrolled asthma at baseline (ACT < 20), we observed significantly better program retention (55% vs. 41%, p < 0.001) in the DP + TRC group compared to DP group at six months.

Patients also had better mean daily controller medication adherence (respectively, 54% vs. 45%, p < 0.001), but there were no differences between groups over six months for mean daily SABA use (0.76 vs 0.87 puffs/day; p = 0.158), the percentage of days without SABA use (80% vs. 79%; p = 0.599) and the percentage of days with high SABA usage (3.77% vs. 4.70%; p = 0.119) (Table 2).

The odds of patients being retained in the program at six months was 77% higher in the DP + TRC group compared to the DP group alone (OR (95% CI): 1.77 (1.51, 2.07), p < 0.0001). Patients in the DP + TRC group were also ten percent more likely to achieve ≥80% mean daily adherence versus the DP group (OR (95% CI): 1.1 (1.04, 1.16), p = 0.001). (Supplement Table 1s).

Table 2. Six-month outcomes among patients with initially uncontrolled asthma.

	n	Estimate	Lower 95% CI	Upper 95% CI	P-value
Retention at six months (%)[a]					
DP + TRC	739	54.75	50.90	58.60	<0.001
DP	15834	41.15	40.37	41.93	
Mean daily controller adherence (%)					
DP + TRC	219	54.10	49.82	58.37	<0.001
DP	2406	44.96	43.71	46.20	
SABA use (mean puffs/day)					
DP + TRC	437	0.76	0.61	0.91	0.158
DP	5832	0.87	0.83	0.91	
SABA free days (mean total)					
DP + TRC	437	143.69	139.72	147.67	0.599
DP	5832	142.58	141.53	143.63	
SABA free days (%)					
DP + TRC	437	79.83	77.62	82.04	0.599
DP	5832	79.21	78.63	79.80	
High SABA days (>6 puffs/day (%))					
DP + TRC	437	3.77	2.65	4.90	0.119
DP	5832	4.70	4.41	5.00	

Analyses adjusted for age, baseline ACT, enrollment year, any controller/SABA use.
[a]First 180 days following the training week.

Change over Six Months

For change in outcomes from baseline to six months, both the DP + TRC and DP groups had similar relative improvements in mean daily SABA use (Δ = −47.1% vs. −50.0%, respectively (both p < 0.001)) and the percent of SABA-free days (Δ = +21.9 days vs. +21.3 days, respectively (both p < 0.001)).

We also observed that the proportion of patients with ≥80% controller adherence declined in both groups, but that a smaller relative decline was noted in the DP + TRC vs. DP group (Δ = −30.3% vs. −39.4%, respectively) (Table 3).

DISCUSSION

This retrospective analysis of real-world data examines how asthma medication usage and retention rates may differ between a digital self-management platform adopted on its own (DP) and when integrated as part of a virtual clinical care workflow (DP + TRC). At six months, patients with uncontrolled asthma in the DP + TRC group had better average controller inhaler adherence, and better program retention compared to patients in the DP group. While we observed no statistically significant differences in average SABA usage between groups at six months, both groups had similar significant improvements in SABA usage between baseline and six-month follow-up. Over time, controller adherence declined for both groups, but larger relative declines were seen in the DP vs. DP + TRC group. Overall, these results suggest that integrating digital self-management tools within a virtual clinical care workflow may enhance retention and controller adherence, while promoting similar positive changes in SABA usage, compared to using a digital self-management platform alone.

These results align well with a growing body of literature supporting the use of digital health for chronic disease management and improved clinical outcomes, including lower SABA usage and improved controller adherence[3–6,12]. Beyond the positive clinical benefits of digital health approaches, studies have also demonstrated that digital health can improve quality of life by reducing symptom-related disruptions at work and at school, possibly lowering rates of presenteeism and absenteeism in asthma[13,14]. Additionally, when thoughtfully designed and adopted, digital health approaches have the potential to bridge inequities with hard-to-reach communities and older populations, creating opportunities for easier and more regular access to healthcare providers[5,13,15].

Table 3. Six-month change among initially uncontrolled patients.

	Baseline	Follow-up (6 months)	Absolute Change	Percentage Change (%)[a]	p-value
DP + TRC					
Daily SABA use, mean puffs/day	1.19	0.63	−0.56	−47.08	<0.001
% SABA-free days	69.03	84.15	15.12	21.90	<0.001
% days with >80% controller adherence	54.45	37.98	−16.47	−30.25	<0.001
% days with 100% controller adherence	54.36	37.77	−16.59	−30.52	<0.001
DP					
Daily SABA use, puffs/day	1.28	0.64	−0.64	−49.97	<0.001
% SABA-free days	69.52	84.34	14.82	21.32	<0.001
% days with >80% controller adherence	47.54	28.82	−18.72	−39.37	<0.001
% days with 100% controller adherence	47.34	28.66	−18.68	−39.45	<0.001

Analyses adjusted for age, baseline ACT, enrollment year, any controller/SABA use.
[a]Percentage change (%) = 100*(Follow-up - Baseline)/Baseline.

Despite success at the patient level, dissemination and scaling of digital tools and platforms into real-world clinical practice varies widely. Hybrid program design which combines digital management tools with the standard of care, is often influenced by factors such as the target population, financial constraints, staffing resources, clinical workflows, and general healthcare system readiness for the adoption of digital health tools. In a recent review on the state of digital interventions in respiratory care, the authors further refine these considerations by setting type - highlighting the differing needs in an acute setting versus remote care versus an in-office visit, for example[16]. As such, careful program implementation design coupled with considerations for the population served can minimize digital implementation challenges, while virtual solutions have the potential to scale digital platforms and maintain favorable clinical outcomes.

In our assessment of the DP + TRC group, both the patient and virtual clinical team had access to the patient's medication use data, as well as tracked symptoms and triggers. This shared knowledge likely supported more nuanced clinical discussions and timely interventions. Shared decision-making can be a central part of successful chronic disease management, allowing patients to take on a more active role in their care and working with their healthcare provider to account for all aspects of chronic condition management[17,18]. Such approaches have been an effective tool in asthma management to date, with studies demonstrating improved adherence, clinical outcomes, and patient satisfaction, both in person and virtually.

The findings of this analysis should be interpreted in the context of its limitations. First, this study was an observational study of real-world data. As such, bias may have been introduced due to the volunteer nature of the programs and the propensity of enrolled patients for digital modalities. Further, we had limited demographic and clinical data to describe the populations. As such, the generalizability of the results may be limited. Second, while we hypothesized that both groups likely experienced similar natural fluctuations in medication usage over time, it is possible that the changes observed in both cohorts may partly reflect a regression to the mean. More robust study designs with a randomized control group may help confirm the findings observed. Third, the study compares outcomes from two different real-world programs, which had significantly different baseline characteristics. For example, the digital-only program had almost double the proportion of patients with uncontrolled asthma compared to the virtual care program, and were also significantly younger. While our analyses controlled for these differences, again robust study designs with a control arm may be warranted. Future real-world studies should consider not only the inclusion of a comparison or matched group, but also consider capturing broader sociodemographic (e.g., race, gender, socioeconomic status), quality of life, and clinical (e.g., exacerbations, acute care visits) measures to help assess generalizability. Data and assessment of the frequency, type and quality of virtual care interactions may also support an improved understanding of the mechanisms of change as well as the scaling of such programs.

While digital platforms have demonstrated promise in asthma management, questions remain on how best to expand these platforms into real-world clinical practice. A digital self-management platform for asthma management, combined with virtual clinical oversight, may offer an opportunity to further enhance patient outcomes while efficiently scaling digital health and reducing barriers to care. Future research is needed to confirm the results observed in this large real-world study, as well as to better understand the long term and economic benefits of such a scaled approach in asthma management.

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AUTHOR CONTRIBUTIONS

L.K., V.V., and M.A.B. developed the manuscript concept. V.V. completed all analyses. L.K., V.V., and M.A.B. wrote the first draft. L.K., V.V., U.P., D.M., and M.A.B. commented and reviewed the data. L.K., V.V., U.P., D.M., and M.A.B. reviewed the final manuscript draft. L.K., V.V., U.P., D.M., and M.A.B. provided manuscript approval.

COMPETING INTERESTS

L.K., V.V., and M.A.B. were employed at ResMed at the time of manuscript development. L.K. and M.A.B. are former employees of Propeller Health. U.P. and D.M. are employees of Evernorth Health Services, the parent company of Express Scripts.

ADDITIONAL INFORMATION

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