

Can digital communication technology reduce health system personnel time? An evaluation of personnel requirements and costs in a randomized controlled trial

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Abstract

Use of digital communication technologies (DCT) shows promise for enhancing outcomes and efficiencies in asthma care management. However, little is known about the impact of DCT interventions on healthcare personnel requirements and costs, thus making it difficult for providers and health systems to understand the value of these interventions. This study evaluated the differences in healthcare personnel requirements and costs between usual asthma care (UC) and a DCT intervention (Breathewell) aimed at maintaining guideline-based asthma care while reducing health care staffing requirements. We used data from a pragmatic, randomized controlled trial conducted in a large integrated health system involving 14,978 patients diagnosed with asthma. To evaluate differences in staffing requirements and cost between Breathewell and UC needed to deliver guideline-based care we used electronic health record (EHR) events, provider time tracking surveys, and invoicing. Differences in cost were reported at the patient and health system level. The Breathewell intervention significantly reduced personnel requirements with a larger percentage of participants requiring no personnel time (45% vs. 5%, $p < .001$) and smaller percentage of participants requiring follow-up outreach (44% vs. 68%, $p < .001$). Extrapolated to the total health system, cost for the Breathewell intervention was \$16,278 less than usual care. The intervention became cost savings at a sample size of at least 957 patients diagnosed with asthma. At the population level, using DCT to compliment current asthma care practice presents an opportunity to reduce healthcare personnel requirements while maintaining population-based asthma control measures.

Keywords

Short acting beta-agonist, Health care resources, Implementation, Digital communication technology, Technology intervention, Direct costs

INTRODUCTION

Currently, nearly 25 million adults and children have been diagnosed with asthma in the United States, representing greater than 7.5% of the population [1, 2]. Care for this population equates to more than \$50 billion in annual medical costs [3]. Improving asthma control, including reducing beta₂-agonist (BA) overuse and improving the use of asthma control medications (e.g., inhaled corticosteroids), has the potential to reduce these costs by approximately 20% [4–6]. However, implementing

Implications

Practice: Using digital communication technology (DCT) to compliment asthma management can lower personnel requirements and costs while maintaining guideline-based care.

Policy: Providers and health systems should consider expanded use of DCT to compliment current chronic disease management to potentially reduce personnel requirements and costs.

Research: Future research is needed to evaluate the patient health, personnel resources requirement, and cost impact of DCT in varied health system environments and chronic disease management programs.

and maintaining guideline-based asthma control processes in large asthma populations often requires significant healthcare personnel requirements and costs, leading to economic challenges for health systems [7]. Digital communication technologies (DCT) hold promise as a potential solution by automating components of health system workflow and consequently reducing labor requirements [8–10]. Current evidence of effective technology-based asthma control interventions are often lacking cost evaluations leaving little known about the interventions' impacts on health system personnel requirements and costs [11–14].

In Kaiser Permanente Colorado (KPCO), an integrated health care delivery system serving more than 600,000 members in Colorado, a registered nurse-based asthma care program has been in place for more than 15 years. The program was designed to improve asthma control. Over 5 years ago, an initiative was implemented within the registered nurse-based asthma care program to address beta₂-agonist overuse (BAO) in the population of KPCO patients diagnosed with asthma. BAO has previously been demonstrated to be predictive of asthma

exacerbations [15], particularly when asthma controller medication are being underutilized [16]. Outreach to patients at the time of a BA refill request has been shown to significantly reduce overuse [17]. The KPCO BAO initiative had pharmacy staff notify asthma care manager (ACM) nursing staff of patients with BAO electronically through staff inbox notifications in the electronic health record (EHR) system. ACMs then followed a guideline-based protocol, including reviewing medical records and outreaching to patients requiring further clinical evaluation per protocol. The program goal was to identify unmet needs in asthma care and increase asthma control. However, the process was labor intensive, and many times identified patients with no need for further clinical evaluation, such as patients reported filling the reliever medication to keep a spare in their gym bag, or other similar reasons.

We developed a DCT intervention (Breathewell), previously described in detail elsewhere [18], with a goal to reduce inefficiencies in service delivery of the ACM team while maintaining asthma control health outcomes. The Breathewell digital communication system contacted participants with BAO by email, phone, or text to identify those currently experiencing asthma symptoms. Breathewell was tested in a pragmatic randomized controlled trial finding that 41% of the BAO events were resolved through DCT without necessitating ACM follow-up [18]. Health outcomes including asthma medication ratio (AMR), controller medication use, and asthma exacerbations, did not differ between the Breathewell intervention and usual asthma care, indicating the program did not negatively impact patient health.

To assess the personnel requirements and monetary outcomes of the Breathewell intervention, this study evaluated the difference in personnel requirements and cost between the Breathewell intervention and usual asthma care (UC). Specifically, we estimated differences between Breathewell and UC in BAO follow-up from the ACM personnel and in costs per asthma patient, per BAO event, and extrapolated to the total health system.

METHODS

Study overview and setting

Breathewell was a DCT BAO intervention evaluated as a randomized controlled trial between February 2017 and August 2018 at KPCO. Asthma patients at KPCO were randomized to receive phone or text communication, email communication, or UC. The Breathewell intervention (phone or text, and email communication) was based on an automated digital survey question screening for current asthma symptoms [18]. Following digital communication, patients identified for further evaluation (self-reported current asthma symptoms or clinical indicators in the EHR) were sent to the ACMs for BAO event follow-up. ACM BAO event follow-up was UC.

We examined differences in personnel requirements needed to address a BAO event between Breathewell and UC. Specifically, we assessed differences in proportion of BAO events that required no follow-up, only medical record evaluation (chart review), or patient contact. In events that required patient contact, we assessed the difference in type and frequency of patient outreach.

Using a health system perspective, we evaluated the costs attributable to the BAO event follow-up, intervention outreach, and intervention infrastructure maintenance in the Breathewell and UC arms. Difference in costs per asthma patient and per BAO event were evaluated between arms over the study time period. Costs were extrapolated to the full health system over a 1-year time period to assess differences in health system costs between Breathewell and UC. Development of the digital communication system (e.g., Interactive Voice Response and text messaging platform) was not included in the intervention costs. These upfront cost requirements will vary greatly based on current digital communication program availability within each health system, and thus would be difficult to accurately represent. However, the Breathewell DCT intervention infrastructure development and testing took approximately 385 hr with a digital communication system in place. This study was approved by the National Jewish Health Center and Kaiser Permanente Colorado Institutional Review Boards (IRB).

Study population

We identified 14,978 patients with a diagnosis of asthma. There were 9,999 participants randomized to the Breathe well arm (text/phone = 4,953, email = 5046) and 4,979 randomized to UC. As expected with randomization, no significant differences were identified between Breathewell and UC in demographics or clinically relevant factors [18].

Within the randomized population, patients became eligible to receive Breathewell or UC with the occurrence of a BAO event. BAO events were triggered by a BA refill and indicators of poor asthma control [19]. Indicators of poor asthma control included a previous BA refill within the last 60 days [20] and/or no asthma controller medication (most often an inhaled corticosteroid) refill in the last 4 months for persistent asthma patients [21]. Participants could have more than one BAO event in the follow-up period.

Breathewell intervention

The Breathewell intervention was run each weekday. The intervention included up to three phone, text, or email outreaches to participants with a BAO event requesting completion of the asthma symptom survey question. Participants' randomized to phone/text communication were sent a text messages with a link containing the survey. If their phone was not

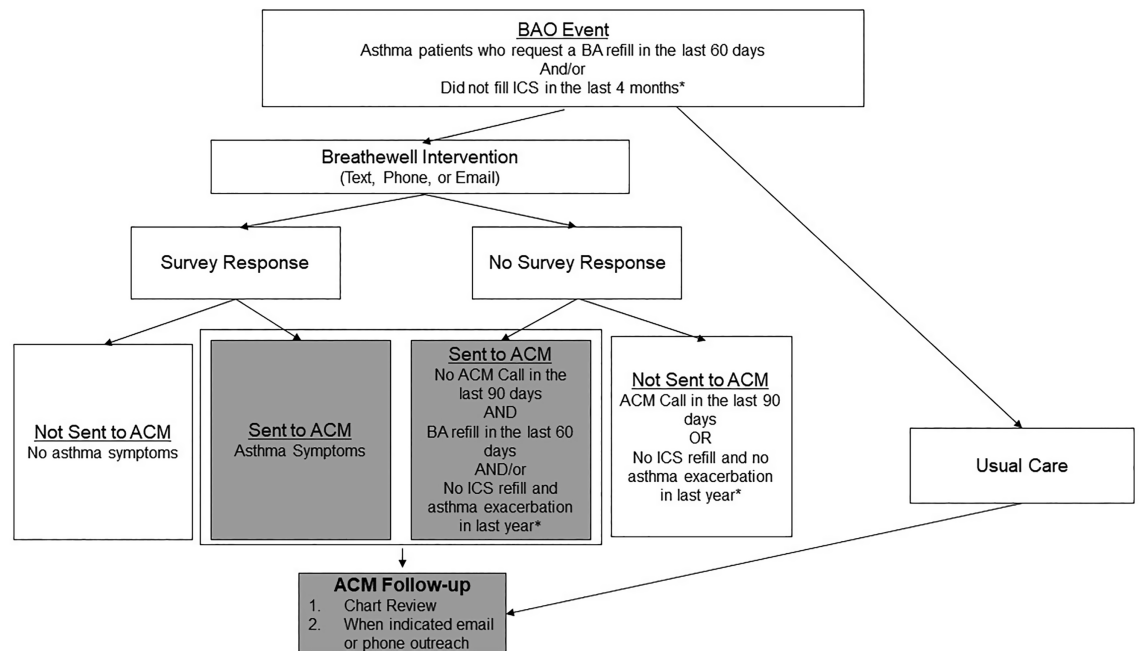


Fig 1 | Beta agonist overuse event follow-up criteria for the Breathewell intervention and usual care arms. *Only applies to those with persistent asthma. BAO, β_2 -agonist overuse; BA, β_2 -agonist; ICS, inhaled corticosteroid; ACM, asthma care manager.

text enabled the participant received an automated phone call with interactive capabilities for participant response. When the phone attempt was not answered, phone messages were left containing call-back information for completion of the automated survey. The survey question was a single item from the Asthma Control Test (ACT) shown to identify participants at risk of asthma exacerbations: “Other than when you’re getting ready to exercise, during the past 4 weeks have you used your quick reliever inhaler 2 or more times a week?” [22]. Participants not responding to the survey were electronically evaluated for clinical indicators of risks for asthma exacerbation (see Fig. 1 for details). Clinical indicators were based on the ACM guideline-based protocol described in more detail in BAO event follow-up below. Using an automated process, participants requiring ACM follow-up (yes to asthma symptom question or yes to clinical indicators) were identified and sent on to the ACMs for review through the same notification process used in UC by the pharmacy staff (staff inbox notification in the EHR). The automated intervention required weekly computer programmer maintenance.

BAO event follow-up (UC and Breathewell)

Participants in the Breathewell arm sent to the ACMs for review and all participants in UC received BAO event follow-up. Per BAO guideline-based protocol, follow-up to a BAO event included (see Fig. 1) an evaluation of the medical record (chart review). When necessary, based on the findings from chart review (clinical indicators), patient outreach occurred. Participant outreach consisted of contact

by phone, email, or both. ACM contact most frequently occurred only one time, but instances of multiple outreaches occurred for more complicated cases.

Personnel requirement and cost outcomes

Personnel requirements for BAO event follow-up

ACM personnel requirements for BAO event follow-up were assessed for both Breathewell and UC using data extracted from the EHR and study tracking. First, the BAO event date was identified using study tracking. The BAO event date was the date of BA refill associated with the BAO event. We then extracted all chart review, phone and email encounters in the EHR linked to the ACMs within 7 days on or after the BAO event date. EHR data capture was confirmed by chart review. Ninety-five percent of sampled charts identified the type and frequency of outreach (83 of 87) indicated from the data extraction. Each BAO event was given a binary measure for each of the following three follow-up outcomes: no follow-up (no EHR activity), chart review only (only chart review activity), and follow-up outreach (any phone or email outreach during follow-up). Outcomes were mutually exclusive and thus each BAO event had only one yes response in all three follow-up outcomes. To identify differences between Breathewell and UC in type and frequency of follow-up outreach, BAO events were limited to those with a yes for follow-up outreach. All BAO events with follow-up outreach were given a binary measure for each of the mutually exclusive four outreach outcomes: one or two phone contacts, one email contact, two or more email contacts,

and combination contacts (both phone and email contacts).

Costs to address a BAO event

Costs to address a BAO event for the Breathewell arm were the sum of registered nurse personnel time required to address BAO events, digital communication, and infrastructure maintenance for the Breathewell intervention. Cost to address a BAO event for UC was registered nurse personnel time required to address all BAO events. Cost inputs are detailed in [Table 1](#).

Personnel time for Breathewell and UC were captured from the EHR, study tracking, and staff time tracking surveys. The quantity of chart review, phone and email encounters due to the BAO event were identified from the EHR as described above in personnel requirements for BAO event follow-up. Personnel time in minutes required for each type of encounter was captured using a staff time tracking survey completed by the ACM staff. Tracking included time spent on chart review, email outreach, and phone outreach. Time estimates for email and phone outreaches included preceding chart review. Mean time in minutes for each follow-up activity was calculated across all tracked events. To estimate costs for each type of encounter, average time was multiplied by the 2019 average wage rate for a registered nurse [23], including fringe benefits, and applied to the total number of encounters.

Cost inputs for the Breathewell intervention digital communication and infrastructure maintenance were extracted from study tracking and invoicing. Quantity of intervention digital communication outreach events was extracted from study event tracking. Intervention costs for each digital communication was extracted from invoicing (\$0.01 per outreach). This cost was applied to each intervention outreach event. Computer programmer labor estimates were captured using recorded time tracking from study cost captures. Using the recorded time, we calculated an average number of minutes per week for system maintenance. Computer programmer labor estimates included fringe benefits and were based

on the 2019 national wage rates from the Bureau of Labor Statistics for comparable position [23, 24]. System maintenance cost was applied as a fixed cost to total intervention costs.

Statistical analysis

In the full randomized population, we compared differences in personnel requirements to address a BAO event for each of the three follow-up outcomes (no follow-up, chart review only, and follow-up outreach) between study arms. In the population receiving follow-up outreach, we assessed type and frequency of outreach by comparing differences in each of the four types of outreach outcomes (one or two phone contacts, one email contact, two or more email contacts, and combination contacts) between study arms. We evaluated differences between Breathewell and UC using rates from a logistic regression model for repeated measures of multiple BAO events per participant. With no clinically significant differences in the randomized populations [18], no additional covariates were included in the model.

We evaluated difference in average cost to address each BAO event per asthma participant and per BAO event between Breathewell and UC. We used GLM with repeated measures assuming a gamma distribution and log-link function to evaluate differences in average costs between Breathewell and UC during the 18 month study period. Analyses was performed using SAS studio Version 3.8 (SAS Institute, Cary, NC).

Extrapolation of costs to full health system

To obtain the health system cost to address BAO events per study arm (including nursing time and intervention costs), the average cost per BAO event (excluding fixed costs) was multiplied by the total number of BAO events in the health system between February 2017 and February 2018. BAO events were extracted from the EHR and were not limited to the randomized population. In the Breathewell arm, fixed costs were then added to the total cost. Total health system costs to address a BAO event

Table 1 | Cost inputs and sources

Activity	Time/event Mean (range)	Source	\$/activity
BAO event follow-up: chart review only (min)	4.67 (3–6)	Nurse tracking Bureau of Labor Statistics [23]	\$4.59
BAO event follow-up: phone encounter ^a (min)	20.9 (8–50)	Nurse tracking Bureau of Labor Statistics [23]	\$20.55
BAO event follow-up: email encounter ^a (min)	24.69 (10–50)	Nurse tracking Bureau of Labor Statistics [23]	\$24.28
Digital communication	n/a	Study expense report	\$0.01
Annual digital communication management ^b	30 min/week	Study expense report Bureau of Labor Statistics [23, 24]	\$1,424.80

^aTime includes chart review.

^bFixed cost incorporated in total costs.

were compared between Breathewell and UC using a difference in total costs.

Sensitivity analysis

We conducted a sensitivity analysis to evaluate the impact of asthma population size on the cost difference between Breathewell and UC. Average cost per asthma patient (excluding fixed costs) for each study arm was multiplied by asthma populations ranging from 250 to 100,000. Fixed costs were added to the total cost in the Breathewell arm. The total cost was then subtracted between study arms to obtain difference in costs.

RESULTS

Overall, 1,933 participants experienced at least one BAO event (1,278 (13%) in Breathewell and 655 (13%) in UC), for a total of 2,874 BAO events in the Breathewell arm and 1,463 in the UC arm (Table 2). The frequency of BAO events was not significantly different between study arms ($p = .36$). In the entire health system (not restricted to the randomized population), there were 3,451 BAO events between February 2017 and February 2018.

Personnel requirements for BAO event follow-up

UC required significantly more personnel time to address a BAO event (Table 2). Almost half of the BAO events required no follow-up in the Breathewell arm (44.6%) compared to only 4.5% in the UC arm ($p < .001$). Similarly, 68.3% required follow-up outreach in UC compared to 43.6% in Breathewell ($p < .001$).

Of BAO events requiring follow-up outreach, no significant differences were found in the percentage of outreach for one email message ($p = .423$) or a combination of both phone and email outreach ($p = .831$) (Table 3). However, UC was significantly less likely to include a phone call ($p = .029$) and more often included two or more emails, though not significantly ($p = .066$).

Costs of BAO event follow-up

Time tracking surveys were completed by 88% (7 of 8) of ACM staff. Nursing experience in asthma at KPCO ranged from 1 to 19 years. Nurses tracked time spent addressing each BAO event on an average day in the year. There were 33 BAO events on the tracking day, representing a slightly higher than average number of events (annual daily average = 23.8). As found in Table 1, on average, ACMs spent the most time completing BAO event follow-up email at 24.69 min, followed by phone at 20.9 min, and chart review at 4.67 min. Based on study time tracking, the computer programmer worked an average of 30 min per week maintaining the Breathewell intervention.

Breathewell had significantly lower costs to address BAO events than UC (Table 4). There was

Table 2 | Rates of personnel requirements needed to address BAO events

EHR activity for each BAO event	Breathewell (N= 2,874) (%)	Usual care (N= 1463) (%)	p value
No follow-up	44.6	4.5	<.001
Chart review only	11.7	26.7	<.001
Follow-up outreach	43.6	68.3	<.001

Table 3 | Rates of type and frequency of personnel outreach requirements needed to address BAO events

EHR activity for each BAO event	Breathewell (N= 1,231) (%)	Usual care (N= 965) (%)	p value
One email	50.5	52.4	.423
Two or more emails	15.2	18.5	.066
One or two phone calls	29.3	24.3	.029
Combination (phone and email)	4.5	4.7	.831

a cost savings of \$1.33 per asthma patient ($p < .001$) and \$4.59 per BAO event ($p < .001$) due to the Breathewell intervention. Average costs were slightly lower in the Breathewell arm when fixed costs were removed at \$2.18 ($SE = .05$) per asthma patient and \$7.76 ($SE = .20$) per BAO event. Costs extrapolated to the KPCO system to address a BAO event (Table 5) were \$16,278 lower in the Breathewell arm.

In the sensitivity analysis across asthma population sizes ranging from 250 to 100,000 (Table 5), we found health system costs to address a BAO event ranged from a cost increase of \$1,052 to a cost savings of \$147,575. The threshold at which the Breathewell intervention became cost saving was 957 asthma patients (a cost reduction of \$1.13). At 83,319 asthma patients, Breathewell cost savings could support a reduction in one full-time registered nurse.

DISCUSSION

Breathewell significantly reduced personnel requirements in the KPCO health system, saving \$16,278 in annual health system costs to address 3,451 BAO events. The DCT removed the need for outreach to patients not experiencing a gap in asthma care, freeing additional personnel time. The cost savings represents approximately half a full-time registered nurse's time that could be used to address additional asthma population care needs or gaps in other chronic disease management. In a larger health system, with just under 85,000 asthma patients,

Table 4 | Average patient and event costs to address BAO between UC and Breathewell over 18 months

Cost assessment	Breathewell (N = 9,999)	UC (N = 4,979)	Difference	p value
	Mean (SE)	Mean (SE)		
Per asthma patient	\$2.34 (0.06)	\$3.67 (0.13)	-\$1.33	<.001
Per BAO event	\$8.31 (0.20)	\$12.90 (0.33)	-\$4.59	<.001

SE, standard error.

Breathewell provides enough additional nursing time to cover one registered nurse position. The intervention demonstrates an effective use of technology to compliment chronic disease management and minimize health system personnel resources and costs.

Additionally, the intervention impacted the way in which follow-up outreach occurred. As the patients requiring outreach for the intervention were limited to those with symptoms or indicators of gaps in asthma care, follow-up outreach was more likely to occur by phone in Breathewell compared to UC. It may also be expected that follow-up in the Breathewell arm was more complicated and would require multiple back and forth outreaches. However, the opposite was found. While not significant, usual care trended towards more follow-up requiring two or more email communications, indicating the intervention reduced the need for back and forth email communication. This finding could be due to the more complicated cases requiring phone outreach or due to unknown factors, such as the intervention priming patients for more efficient communication. An additional implication for efficiency was found in email communication. Well over 50% of outreach still occurred by email in both study arms. Interestingly, time tracking surveys found, on average, email follow-up communications took more time than phone communication at 20 min versus 25 min. Addressing follow-up outreach efficiencies could be an additional source of cost reduction.

Increasing asthma control has positive impact on both patient health outcomes and health system costs [4]. However, improving asthma control often comes with a cost of additional staffing requirements in an already overworked nursing staff. As the gap in available staff continues to grow [7], finding innovative solutions to maintain asthma control while minimizing labor requirements for disease management is needed. Breathewell reflects a DCT approach that can be used to address this need and be easily adapted to assist with other chronic disease management programs.

There are several limitations to this study. The intervention assessed was designed for a specialty

Table 5 | Annual difference in health systems costs to address BAO between UC and Breathewell

Population size	Breathewell	UC	Difference
KPCO health system costs ^a	\$28,205	\$44,483	-\$16,278*
250 asthma patients ^b	\$1,970	\$918	\$1,052
100,000 asthma patients ^b	\$219,425	\$367,000	-\$147,575*

*Negative difference values indicate cost savings.

^a n = 3,451 BAO events. Cost calculated using cost per BAO event + fixed costs in the Breathewell arm.^bCost calculated using cost per asthma patient + fixed costs in the Breathewell arm.

program at a single health system that may not be generalizable to other institutions. However, it does present an example of use of technology in conjunction with usual care that could be adapted to multiple types of programs with potential to see similar results.

Similarly, while the Breathewell intervention reduced personnel requirements, the scope of the intervention was limited, reducing the overall impact on health system personnel time and costs. Breathewell did not reduce health system costs until there was an asthma population of at least 957 patients, with a cost savings of only \$1, less than an hour of a registered nurses time. In the larger KPCO population, additional personnel time available due to the intervention was less than one full time staff member for a population of nearly 15,000 asthma patients. The modest impact may present challenges to implementation. However, health systems are also experiencing challenges retaining nursing staff and unnecessary tasks have been shown to decrease nurses quality of life [25]. As in the case of Breathewell, working with providers to identify tasks that could be lessened by technology may present an opportunity for staff empowerment. In addition to increasing available registered nursing time, this could lead to additional job satisfaction by giving providers some control in their work activities [26]. Thus, employing such interventions in a limited scope has potential to increase staff quality of life in addition to modest cost/time reduction. Gains in provider time allows them to focus their efforts on other important areas of asthma care with potential to positively impact patient health outcomes. Additionally, in larger health systems (83,319 asthma patients and more) the reduction in personnel requirements provides enough additional personnel time for elimination of a registered nurse position providing a cost savings opportunity.

The costs for development and implementation of the intervention were not incorporated in this evaluation. Since the DCT available within healthcare systems vary greatly, incorporating this cost reduces the ability to generalize cost reduction values. This is an important implementation consideration as the costs

could be substantial for health systems without DCT programs in place and potentially modest for those with systems in place. However, maintenance costs also need to be considered when evaluating benefits of implementation. After implementation, the maintenance costs are low (<\$2,000 a year) potentially increasing the value of an upfront investment.

The labor estimates were derived from staff time tracking and may not represent the time requirements in other environments and circumstances. However, the time estimates used for nursing staff came from staff with varied levels of experience and had a wide range indicating the average is likely to reflect the type of variation that could be expected in different environments over an annual period.

Lastly, we did not collect participant satisfaction information. However, participants were given an opportunity to opt-out of receiving the intervention at every contact. Only 73 participants (<1%) chose to opt out [18]. While there was cost savings in the program, a change in communication and contact with the ACM staff could have led to differing program satisfaction between study arms.

The Breathewell intervention was an effective use of DCT to increase available healthcare personnel time to address asthma disease management. Breathewell demonstrated a rare opportunity to provide cost savings in a health system without negatively impacting patient health. To explore further opportunities to obtain the cost benefit of DCT, additional research is needed to evaluate patient satisfaction, patient health, personnel resources requirement and cost impact of DCT in varied health system environments and chronic disease management programs.

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Compliance with Ethical Standards

Conflict of Interest: Dr Bender serves on the advisory boards for Teva, Sanofi, and Propeller Health. None of these companies played a role in this research and he does not receive research funding from these groups. All other authors have no relevant financial relationships to report.

Human Rights: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent: We received approval from the Kaiser Permanente Colorado Institutional Review Board for a waiver of signed informed consent, as the procedures conducted for the study were within the scope of usual care. Participants were given an opportunity to opt-out of the study. All data presented in this article is aggregate with no identifiable information.

Welfare if Animals: This article does not contain any studies with animals performed by any of the authors.

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