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Using the Consolidated Framework for Implementation Research (CFIR) to evaluate implementation effectiveness of a facilitated approach to an asthma shared decision making intervention

Lindsay Shade, MHS, PA-C^a , Thomas Ludden, PhD^a , Rowena J. Dolor, MD, MHS^b ,
Jacqueline Halladay, MD, MPH^c , Kelly Reeves, BSN, RN, UXC^a , Jennifer Rees, RN, CPF^d ,
Lori Hendrickson, BSN, RN, CCRP^e, Paul Bray, MA, LMFT^f, and Hazel Tapp, PhD^a

^aDepartment of Family Medicine Research, Atrium Health, Charlotte, NC, USA; ^bDepartment of Medicine, Division of General Internal Medicine, Duke University Medical Center, Durham, NC, USA; ^cDepartment of Family Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA; ^dSchool of Medicine, University of North Carolina at Chapel Hill, NC, USA; ^eDuke Vaccine and Trials Unit, Duke Human Vaccine Institute, Duke University School of Medicine, Durham, NC, USA; ^fVidant Medical Group, Vidant Medical Center, Greenville, NC, USA

ABSTRACT

Objective: To describe the evaluation of implementation effectiveness of an asthma shared decision making (SDM) intervention at the 10 individual facilitator-led primary care practices in the ADAPT-NC Study using the Consolidated Framework for Implementation Research (CFIR).

Methods: Practices were scored across 40 CFIR constructs within 5 domains using a previously published scoring system of -2 to +2. Based on overall construct scores, practices were then classified as high, medium, or low adopters. To evaluate clinical outcomes, changes in asthma exacerbations were assessed for emergency department (ED) visits, hospitalizations, and oral steroid prescription orders. Using regression analysis, the absolute change in percent for each outcome relative to the CFIR score for each practice was analyzed. (Trial registration #NCT02047929).

Results: Implementation effectiveness was reflected in CFIR score differences with 7 high, 1 medium, and 2 low adopter practices. High adopters mostly scored well across all domains. Weaknesses were consistent amongst the 2 low adopters with lower scores in the Inner Setting, Characteristics of Individuals, and Process domains. While no significant correlations were seen between the practices' CFIR scores and the absolute change in ED visits, hospitalizations, or oral steroid prescription orders, practices with higher percentages of children had greater improvements in clinical outcomes.

Conclusions: The CFIR was used to evaluate the asthma SDM intervention implementation at 10 facilitator-led practices. While there was no significant correlation between higher implementation effectiveness and greater improvement in clinical outcomes, practices with a higher proportion of pediatric patients did experience a significant reduction in overall exacerbations post-implementation.

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Introduction

Asthma is a common chronic lung disease affecting 1 in 13 Americans (1). Nearly half of those with asthma experience 1 or more exacerbations each year, amassing 1.6 million emergency department (ED) visits and over 439 000 hospitalizations annually (2). Given asthma's high prevalence and its associated high morbidity, improvement in clinically relevant outcomes is of utmost importance (3).

One such approach to improve asthma care involves shared decision making (SDM), a process in which patients and providers jointly engage in decisions

around treatment options (4). In SDM, both the patient and the provider share relevant health information. For example, the patient may describe their personal values and lifestyle choices, whereas the provider may discuss the risks and benefits of certain medications. Once each has had the opportunity to express their treatment goals and medication preferences, the two deliberate several evidence-based treatment options then agree upon a treatment plan (5,6). This deliberation process is more often triadic when SDM is performed with children, involving the child, their parent or caregiver, and provider. The sharing and transfer of asthma

Table 1. CFIR domains, definitions, and associated constructs.

Domain and definition	Associated constructs
Intervention Characteristics: core components or essential elements of the innovation being implemented into a particular organization	Evidence strength and quality • Relative advantage • Adaptability • Trialability • Complexity • Design quality and packaging • Cost
Outer Setting: includes the economic, political, and social context within which an organization resides	Needs and resources of those served by the organization • Cosmopolitanism • Peer pressure • External policy and incentives
Inner Setting: includes features of structural, political, and cultural contexts through which the implementation process will proceed	Structural characteristics • Networks and communications • Culture • Implementation climate • Tension for change • Compatibility • Relative priority • Organizational incentives and rewards • Goals and feedback • Learning climate • Readiness for implementation • Leadership engagement • Available resources • Access to knowledge and information
Characteristics of Individuals: features of targeted users involved with the intervention and/or implementation process	Knowledge and beliefs about the innovation • Self-efficacy • Individual stage of change • Individual identification with organization • Other personal attributes
Process: methods by which the implementation is accomplished	Planning • Engaging • Opinion leaders • Formally appointed internal implementation leaders • Champions • External change agents • Key stakeholders • Innovation participants • Executing • Reflecting and evaluating

CFIR = Consolidated Framework for Implementation Research.

management responsibility is complex in children, particularly those of school age (7,8). Nonetheless, SDM has been shown to improve clinical outcomes for patients, particularly children, with asthma (6,9).

Implementation, or adoption, of an intervention is defined as the decision to commit to, initiate, and integrate an evidence-based innovation within a practice setting (10,11). Subsequently, implementation research has evolved to address the challenges associated with incorporating evidence-based interventions into practice. Over the past decade, the science of implementation has advanced toward the use of theoretical frameworks to better explain how and why implementations succeed or fail (11). One such meta-theoretical framework used to measure implementation effectiveness is the Consolidated Framework for Implementation Research (CFIR) (12).

The CFIR provides a menu of constructs, or important traits, that have been associated with effective implementation. These constructs can be used in a variety of applications including to systematically assess the barriers and facilitators of an innovation. The CFIR consists of 40 constructs organized into 5 domains: Intervention Characteristics, Outer Setting, Inner Setting, Characteristics of Individuals, and Process (Table 1). The Intervention Characteristics domain represents core components or essential elements of the innovation being implemented. The practice's economic, political, and social context are included in the Outer Setting domain, while the Inner Setting domain includes features of structural, political, and cultural contexts through which the implementation process proceeds. The Characteristics of Individuals domain comprises features of targeted users involved with the intervention and/or implementation process. Finally, the Process domain

includes methods by which the implementation is accomplished.

The CFIR has been used to guide planning and evaluation of dissemination and implementation programs to bring evidence-based research into practice (11,13–17). Additionally, the CFIR has been used to gauge the level of implementation effectiveness in primary care practices and to identify barriers and facilitators to implementation (17–20). There is, however, little current evidence supporting how well application of the CFIR correlates with changes in clinical outcomes.

Through the ADAPT-NC (Asthma Dissemination Around Patient-centered Treatments in North Carolina) Study we disseminated a previously studied asthma SDM toolkit intervention across 30 primary care practices (4,9,21–25). The asthma SDM toolkit intervention entailed health coaches assessing patient's perception of asthma control and medication adherence, providing asthma education, establishing treatment goals and medication preferences, then negotiating several evidence-based treatment options to improve control, all culminating in an updated asthma action plan (21,22). The study's objective was to determine which of 3 dissemination methods yielded higher patient perceptions of SDM and improved patient-oriented outcomes: facilitator-led dissemination, traditional lunch-and-learn dissemination, or usual care control with no dissemination (21,22). The 10 practices randomized into the facilitator-led arm of the study, where a practice facilitator (PF) worked closely with each practice to tailor the intervention to their unique setting, had significantly higher patient perceptions of SDM occurring during asthma visits (75% vs 66%, $p = 0.001$), compared with the 10 practices randomized to receive a traditional approach to dissemination involving a lunch-and-learn intervention, where an overview of the SDM toolkit was given (21). The facilitator-

Table 2. ADAPT-NC facilitator-led practices baseline patient level data.

Practice #	Practice setting	Practice type	# Providers	# Medicaid asthma patients	% Children	% Female	% African American	% Caucasian	% Hispanic
1	Healthcare System	Family Medicine	2	25	57.8	60.0	17.8	80.0	2.2
2	Healthcare System	Pediatrics	6	272	97.3	41.2	26.4	71.4	15.1
3	Healthcare System	Pediatrics	9	153	98.3	35.4	78.2	14.4	7.0
4	Private Practice	Family Medicine	6	116	67.3	58.0	53.7	41.4	3.1
5	Private Practice	Pediatrics	34	220	96.5	38.8	35.7	59.1	5.5
6	Private Practice	Family Medicine	7	131	92.9	41.8	9.8	86.4	3.3
7	Private Practice	Pediatrics	9	221	95.0	46.6	53.0	36.2	11.4
8	Healthcare System	Family Medicine	8	89	66.7	55.3	52.7	42.7	5.3
9	Healthcare System	Family Medicine	6	101	59.2	64.0	74.0	16.8	6.4
10	Healthcare System	Pediatrics	3	175	97.3	36.6	63.4	34.8	6.3
Average			9	150.3	82.8	47.8	46.5	48.3	6.6
Total			90	1503					

ADAPT-NC = Asthma Dissemination Around Patient-Centered Treatments in North Carolina; PBRN = Practice-based research network.

The percentages listed above reflect the proportion of the number of Medicaid asthma patients at the practice that are Children, Female, African American, Caucasian, and Hispanic.

led arm also had the lowest proportion of patients visiting the ED post-implementation (14% decrease for facilitator-led, 12% decrease for traditional lunch-and-learn, and 9% increase for the 10 control practices) (21).

While as a cohort, the 10 facilitator-led practices in the ADAPT-NC Study successfully incorporated SDM into their asthma visits, we were interested in determining what barriers and facilitators influenced implementation and whether each individual practice's level of implementation effectiveness correlated to changes in clinical outcomes.

Here we describe evaluation of the implementation effectiveness of an asthma SDM intervention at the 10 individual facilitator-led practices in the ADAPT-NC Study using the CFIR (17,26). Our research questions were: 1) What barriers and facilitators to implementation emerged from the CFIR analysis?; and 2) Did practices with higher levels of implementation effectiveness show greater improvements in clinical outcomes? We hypothesized that practices with higher CFIR scores would show improved clinical outcomes.

Methods

Study setting and design

Four practice-based research networks (PBRNs) widely distributed across the state of North Carolina participated in the ADAPT-NC Study: (1) the Mecklenburg Area Partnership for Primary Care Research (MAPPR), the lead group, affiliated with Atrium Health (formerly Carolinas HealthCare System) in Charlotte; (2) North Carolina Network (NCnet) affiliated with the University of North Carolina at Chapel Hill; (3) Primary Care Research Consortium (PCRC) affiliated with Duke University in Durham; and (4) Eastern Carolina Association for Research and Education (E-CARE) affiliated with East Carolina University and Vidant Health

System in Greenville. The ADAPT-NC Study compared the dissemination of an asthma SDM intervention across 3 arms: facilitator-led dissemination, traditional lunch-and-learn dissemination, and usual care control with no dissemination (21,22). Ten of the 30 practices from the 4 participating PBRNs were cluster-randomized into each arm of the ADAPT-NC Study (21,22). This manuscript focuses on the 10 practices randomized into the facilitator-led arm of the intervention.

At baseline, all practices had a high proportion of asthma patients, including children and/or adults, with North Carolina (NC) Medicaid as their primary source of insurance. Since the PBRNs and practices utilized different electronic medical record systems, Medicaid claims data, collected and reported out at the practice level as a percentage of patients, was used as the unifying data source for clinical outcomes analysis. Half of the practices were Pediatric and half were Family Medicine practices; 60% were affiliated with a healthcare system. Practice size ranged from 2 to 34 providers. Overall practices had high percentages of children, which per Medicaid's definition includes young people up to 21 years of age, ranging from 57.8% to 98.3% (Table 2).

The ADAPT-NC Study received research approval from the Institutional Review Board at Atrium Health on August 7, 2013 and was registered at <https://clinicaltrials.gov/> on January 27, 2014 (# NCT02047929). Because this study took place at the practice level, no patient consent was required. The first participant was enrolled on March 19, 2014.

ADAPT-NC study – facilitator-led dissemination intervention

The asthma SDM toolkit was comprised of tools utilized by health coaches to gather patient information including asthma symptoms, perceptions of control,

goals for treatment, and medication preferences; educational materials around asthma, allergies, and smoking cessation; and decision support aids to facilitate a conversation while selecting an evidence-based treatment regimen to improve asthma control (toolkit, implementation resources, and training video available at: <https://asthma.atriumhealth.org/>) (27). An experienced Lead PF from the research team trained PFs from each of the 4 participating PBRNs in the asthma SDM toolkit intervention. The PBRN PFs then in turn trained the 10 practices in a participatory approach to implementation, partnering with them in a collaborative process to involve them in all aspects of the intervention.

The intervention, which took place at the practice level, consisted of a 12-week rollout with hour-long meetings once a week at the practice's convenience. During these meetings, the PF met with key personnel from the practice including a provider champion, practice manager, health coach, nurses, and registration staff (4,22). The PF worked closely with the practice to adapt and adopt the toolkit from the previous pilot study (27) into a version that suited their practice's unique culture and specific needs. Each week the PF led the practice through a new training topic with the goal of incorporating SDM utilizing a health coach and the toolkit into their asthma visits. During a typical SDM encounter, after the being roomed by the nurse, the patient and parent/caregiver if applicable would work with the health coach to go through the toolkit. The health coach would collect patient-specific information including their symptoms assessment, establish their perception of current asthma control, identify a personalized goal for treatment as well as preferences around medications, provide asthma education, and finally negotiate several evidence-based treatment options to improve their control. Then the health coach would present pertinent findings from their session to the provider, who would in turn wrap up the visit by performing a physical examination, confirming understanding of the new treatment plan through teach back, prescribing medications, and updating an asthma action plan.

The following year the PFs returned to the practices for "refresher" training sessions. Intervention sustainability was the focus of this one hour-long meeting. The PFs were also available for additional training or consultation as requested by the practices throughout the project.

CFIR evaluation

The CFIR is comprised of 40 constructs, or key attributes thought to influence implementation, categorized

into 5 domains: Intervention Characteristics, Outer Setting, Inner Setting, Characteristics of Individuals, and Process (Table 1).

PBRN researchers retrospectively evaluated implementation of the asthma SDM intervention at the 10 facilitator-led practices using the CFIR in November 2016, within one year of clinical outcomes data collection. The 10 traditional practices and 10 control practices were not able to be evaluated as these study arms lacked PF involvement necessary for scoring.

Implementation effectiveness was evaluated using a previously published scoring system of -2 to $+2$ with score descriptions as follows: -2) the construct had a negative influence in the practice, explicit examples of negative manifestations are described; -1) the construct had a negative influence in the practice, general statements of negative manifestations are made; 0) the construct had neutral influence in the practice; $+1$) the construct had a positive influence in the practice, general statements of positive manifestations are made; $+2$) the construct had a positive influence in the practice, explicit examples of positive manifestations are described (17). Using this scoring system, the overall construct scores could range from a low of -80 to a high of $+80$.

The Lead PF coordinated CFIR evaluation with each PBRN's PF and principal investigator (PI). Collectively, these PBRN PF and PI teams provided a knowledgeable perspective from direct observation of their practices over the course of the 3-yearlong study. Based on the CFIR Codebook which provides construct definitions and criteria as a guide (16,26,28), the Lead PF facilitated a conversation with each PF and PI team on each of the 40 CFIR constructs for their individual practices. Four semi-structured interviews were conducted during conference calls with the Lead PF and each PBRN's PF and PI team. The Lead PF read each construct's brief definition aloud from the CFIR Codebook, for example: "Tension for Change – the degree to which stakeholders perceive the current situation as intolerable or needing to change." Additionally, the Lead PF gave examples from Damschroder's MOVE! weight management program manuscript on how scores might be chosen (17). The PBRN PF and PI openly discussed implications of each construct at each of their practices, then decided upon a score. For some constructs, CFIR scores varied between the PF and PI; for example, the PF scored the construct a $+2$ and PI scored a $+1$. When these scoring discrepancies were encountered, deliberations took place between the PF and PI until a consensus was achieved. As construct scores were finalized, the

Lead PF collected the scores for all 40 constructs for each practice in a spreadsheet. Important barriers and facilitators to successful implementation were written down in narrative form by the Lead PF.

To further define implementation effectiveness, the research team classified practices into terciles based on overall construct scores: practices in the upper third (overall construct scores from +27 to +80) were classified as high, middle third (−26 to +26) as medium, and lower third (−27 to −80) as low adopters.

Verification of scoring results was accomplished during internal research team conference calls with the 4 PBRNs together. There was a general discussion between PBRN teams on how they scored their practices based on each construct's definition and criteria. As a triangulation technique, the scoring results and adopter classifications were relayed back to the PBRN PFs and PIs and agreement was confirmed.

Clinical outcomes

In order to evaluate change in clinical outcomes, the patients' change in asthma exacerbations were assessed for ED visits, hospitalizations, oral steroid prescription orders, and overall exacerbations (defined by the research team as one or more of these three markers of exacerbation) before and after the randomization date of each PBRN. De-identified practice level data detailing the total number of patients experiencing each type of exacerbation for each practice were collected. Variables representing the number of

Medicaid asthma patients with ED visits, hospitalizations, and oral steroid prescription orders as well as overall exacerbations were summarized. These variables were analyzed for a 12-month period prior to the randomization date and the last 12-month period before data collection ended (21).

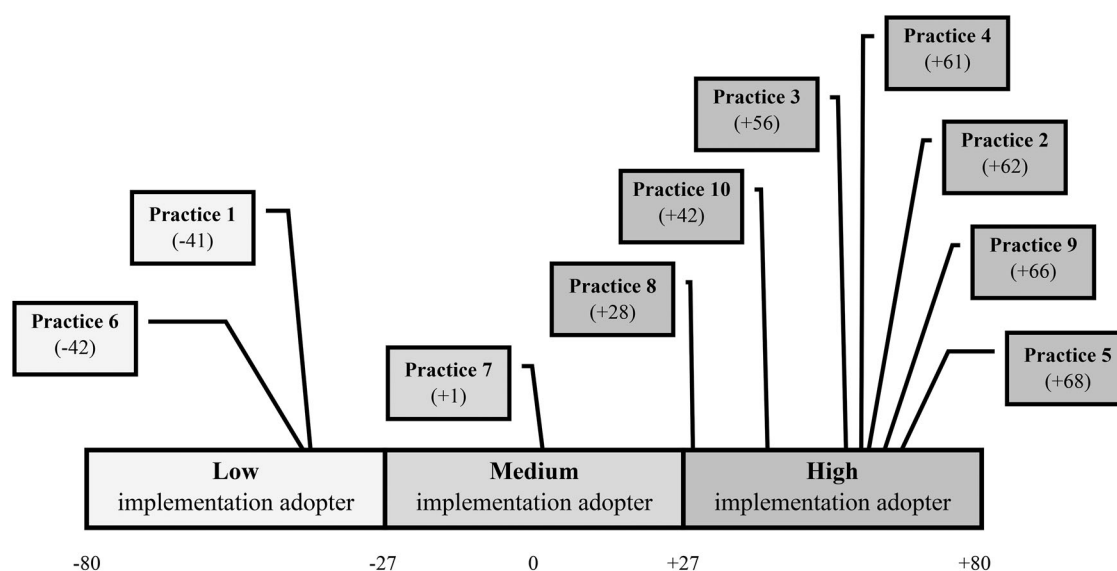
Statistical methods

Descriptive statistics were calculated at the practice level. Using multiple linear regression analysis, the absolute change in percent for each outcome at the practice level (the dependent variable) to the CFIR overall construct score for each practice was analyzed. Additional covariates from the baseline practice level data including percentages of children, African Americans, Caucasians, and Hispanics were included in the analysis to control for practice characteristics. *P* values <0.05 were considered significant. All analyses were conducted using R v3.43 (R Foundation for Statistical Computing, Vienna, Austria) (29).

Results

CFIR evaluation

Across the 40 CFIR constructs within the 5 domains, implementation effectiveness was reflected in CFIR score differences amongst the 10 practices, with 7 in the high, 1 in the medium, and 2 in the low adopter ranges (Figure 1). High adopters mostly scored well



The CFIR score in parentheses below the practice number refers to the overall construct total.

CFIR = Consolidated Framework for Implementation Research

Figure 1. Facilitator-led practice CFIR scores and implementation adoption classifications.

across all domains and constructs. Weaknesses were consistent amongst the 2 low adopters with lower average domain scores in the Inner Setting, Characteristics of Individuals, and Process domains as described in detail below with distinguishing barriers and facilitators. Table 3 represents the CFIR scores by domain and sums up the overall construct score. For complete CFIR scoring details, refer to Additional File 1.

Barriers and facilitators to implementation effectiveness

After CFIR scoring was completed for each practice by the PBRNs, the Lead PF met with the Lead PI to synthesize the results and the implementation barriers and facilitators that emerged.

Inner setting domain

Within the Inner Setting domain, high adopters were more likely to facilitate effective communication, have a culture supportive of change, and desire to improve their current asthma care model. Additional facilitators highlighting compatibility were when the practice already had an established asthma specialty clinic, prioritized the program, and had a feedback delivery process. Other facilitators were willingness to experiment, such as with group visits, and resource allocation, such as staff and space to support the intervention.

In contrast, the low adopters were more like to have barriers such as: smaller numbers of providers and asthma patients; the practice being less invested; no existing asthma care model or referral system in place; and a tendency to treat asthma more as an acute illness rather than a chronic disease. Other barriers were a low desire to change, expressing no need for the

project, competing priorities, and fewer resources that reduced their attention on this asthma project.

Characteristics of individuals domain

Within the Characteristics of Individuals domain, facilitators of high adopters were individuals who formed successful teams with strong positive beliefs about the program, as well as staff with high self-efficacy and enthusiasm for change. Conversely, the low adopters were more likely to have barriers including individuals who struggled with the intervention, for example a physician champion who never fully embraced the program, and teams that never came together to place value on the program.

Process domain

Within the Process domain, high adopters were more likely to facilitate planning for the program and be engaged in the process. Additional facilitators included strong leadership involvement and inclusion of key stakeholders in the project. On the other hand, low adopters encountered barriers including little emphasis placed on executing the program and a lack of reflection or evaluation of the intervention.

Clinical outcomes

Table 4 summarizes the clinical outcomes results at the 10 practices for the change in ED visits, hospitalizations, oral steroid prescription orders, and overall exacerbations along with the practices' CFIR scores. The regression analysis showed there was no significant correlation between the practices' CFIR scores and clinical outcomes (Table 5).

Table 3. CFIR evaluation results for facilitator-led practices.

Domain Practice #	Total domain score									
	1	2	3	4	5	6	7	8	9	10
Intervention Characteristics	−4	+7	+11	+10	+9	−8	−2	+5	+10	+4
Range: −14 to +14	(−0.6)	(+1.0)	(+1.6)	(+1.4)	(+1.3)	(−1.1)	(−0.3)	(+0.7)	(+1.4)	(+0.6)
Outer Setting	+1	+5	+4	+2	+4	−2	+2	+3	+5	+5
Range: −8 to +8	(+0.3)	(+1.3)	(+1.0)	(+0.5)	(+1.0)	(−0.5)	(+0.5)	(+0.8)	(+1.3)	(+1.3)
Inner Setting	−16	+20	+14	+24	+25	−15	−3	+8	+24	+15
Range: −28 to +28	(−1.1)	(+1.4)	(+1.0)	(+1.7)	(+1.8)	(−1.1)	(−0.2)	(+0.6)	(+1.7)	(+1.1)
Characteristics of Individuals	−6	+10	+10	+9	+10	−4	+1	+4	+8	+3
Range: −10 to +10	(−1.2)	(+2.0)	(+2.0)	(+1.8)	(+2.0)	(−0.8)	(+0.2)	(+0.8)	(+1.6)	(+0.6)
Process	−16	+20	+17	+16	+20	−13	+3	+8	+19	+15
Range: −20 to +20	(−1.6)	(+2.0)	(+1.7)	(+1.6)	(+2.0)	(−1.3)	(+0.3)	(+0.8)	(+1.9)	(+1.5)
Overall construct score	−41	62	56	61	68	−42	1	28	66	42
Range: −80 to +80										
Adopter classification	Low	High	High	High	High	Low	Medium	High	High	High

The 10 facilitator-led practices were scored across 40 constructs within 5 domains using a scoring system of −2 to +2 for each construct. Scores were totaled to give the total domain score, with domain score ranges displayed (e.g. −14 to +14, variable dependent upon the number of constructs within the domain) as well as the average for each domain in parentheses (from −2 to +2). Practices in the upper third were classified as high (overall construct scores +27 to +80), middle as medium (−26 to +26), and lower as low (−27 to −80) adopters.

CFIR = Consolidated Framework for Implementation Research.

Table 4. CFIR scores (low to high) and changes in absolute asthma exacerbation outcomes.

Practice #	CFIR score	Absolute change in % ED visits	Absolute change in % hospitalizations	Absolute change in % oral steroid prescription orders	Absolute change in % overall exacerbations
6	−42	−2.57	0.00	−5.93	−8.08
1	−41	−2.00	0.00	10.00	13.33
7	1	−2.94	−0.88	−2.74	−5.43
8	28	−0.93	0.00	2.32	3.23
10	42	−2.76	0.44	−15.91	−17.69
3	56	1.53	1.38	−7.57	−6.61
4	61	−4.44	0.64	−2.02	1.52
2	62	−0.43	1.32	−5.51	−6.30
9	66	5.47	−0.45	−9.06	−2.36
5	68	−0.88	−1.27	−7.08	−16.71

Table 4 is arranged by CFIR scores, from low to high, in order to show the relationship between CFIR scores to clinical outcomes. CFIR = Consolidated Framework for Implementation Research; ED = Emergency Department.

Table 5. Regression results of asthma exacerbation outcomes, CFIR scores, and practice characteristics.

Predictors	Absolute change in % ED visits		Absolute change in % hospitalizations		Absolute change in % oral steroid prescription orders		Absolute change in % overall exacerbations	
	B (SE B)	p-value	B (SE B)	p-value	B (SE B)	p-value	B (SE B)	p-value
(Intercept)	0.18 (0.82)	0.84	0.00 (0.00)	0.18	0.45 (0.63)	0.84	0.19 (0.86)	0.84
CFIR score	0.00 (0.00)	0.79	−0.00 (0.00)	0.82	−0.00 (0.00)	0.55	−0.00 (0.00)	0.29
% Children	−0.05 (0.08)	0.52	−0.00 (0.00)	0.96	−0.26 (0.13)	0.13	−0.48 (0.14)	0.02*
% African American	−0.16 (0.51)	0.77	0.00 (0.00)	0.18	−0.25 (0.87)	0.79	0.15 (0.96)	0.88
% Caucasian	−0.18 (0.47)	0.72	0.00 (0.00)	0.18	−0.25 (0.87)	0.79	0.14 (0.87)	0.87
% Hispanic	0.15 (0.37)	0.69	0.00 (0.00)	0.49	0.31 (0.67)	0.67	0.73 (0.66)	0.34
N	10		10		10		10	
R ²	0.34		0.43		0.65		0.80	

* = $p < 0.05$; B = Coefficient Estimate; SE B = Coefficient – Standard Error; R² = Multiple R-Squared. CFIR = Consolidated Framework for Implementation Research; ED = Emergency Department.

While there were no correlations between CFIR scores and the absolute change in percentages of ED visits, hospitalizations, oral steroid prescription orders, or overall exacerbations, Practice #5 notably had the highest CFIR score and the greatest reduction in hospitalizations, as well as large declines in oral steroid prescription orders and overall exacerbations. In contrast, Practice #1 had one of the lowest CFIR scores and the highest increase in oral steroid prescription orders and overall exacerbations.

Although there were no overall significant correlations, the percentage of children at the practice level did, however, show a statistically significant relationship to the overall exacerbation change rate ($B = -0.48$, $p = 0.02$). In other words, for every 1% increase in the percentage of children at the practice, there was a decrease of $\sim 0.5\%$ in overall exacerbations. This result suggests that the higher the percentage of children in a practice, the greater the improvement in clinical outcomes based on the reduction in asthma exacerbations.

Discussion

The CFIR provided a pragmatic structure for implementation evaluation of the facilitator-led arm of the

ADAPT-NC Study. Results across the 10 practices showed 7 high, 1 medium, and 2 low adopter practices. The high adopters were found to have more highly functioning teams, established and maintained effective working relationships, and welcomed a process of ongoing evaluation and feedback. Practices with challenges scored lower in all domains, particularly the Inner Setting, Characteristics of Individuals, and Process domains, suggesting that focusing attention on these domains may improve implementation effectiveness. While no significant correlations were seen between the practices' CFIR scores and the absolute change in ED visits, hospitalizations, oral steroid prescription orders, or overall exacerbations, practices with higher percentages of children had greater improvements in clinical outcomes as seen by reduced asthma exacerbations.

Use of the CFIR to guide the evaluation of facilitator-led implementation revealed multiple specific contextual factors most associated with implementation effectiveness. Recent studies of other practice implementations of large-scale evidence-based programs using the CFIR to code and rate qualitative data such as the BETTER 2 program for chronic disease prevention (20) and MOVE! study for implementation of a weight management program (17) also identified key

elements within the 5 CFIR domains that emerged as barriers and facilitators within each program. Likewise, results from the present study show the Inner Setting domain is particularly distinguishing between high and low adopters. Three of the Inner Setting constructs, leadership engagement, available resources, and relative priority, highlight the importance these influential roles play in implementation effectiveness (30–32). Together, these findings support the use of this framework involving a systematic approach and consensus-based process (17). The ADAPT-NC Study adds to the knowledge of implementation evaluation demonstrating that the CFIR can be used to analyze large-scale implementations such as through practice facilitation.

Although the retrospective CFIR evaluation did not correlate with improved clinical outcomes, practices with over 90% children did experience a significant reduction in overall asthma exacerbations in the ADAPT-NC Study. Similar results were seen in the ACE Study where improved outcomes for pediatric patients, but not adults, with asthma followed implementation of the evidence-based SDM intervention (9). Asthma is one of the most common chronic illness among pediatric patients (33), and therefore a common focus of population management and metric monitoring for quality improvement. Placing more emphasis on improving asthma control in practices with a greater number of children may in part explain why practices with a higher proportion of pediatric patients saw fewer asthma exacerbations over time. We speculate that parents' involvement in their children's asthma care, as well as involving the child in their own care, may have made an impact. It is also possible that SDM interventions may be most acceptable to pediatric patients, their families, and the providers that care for them.

Limitations

Our study had several limitations. The CFIR evaluation of implementation effectiveness was a retrospective analysis, not originally planned as part of the ADAPT-NC Study design. Therefore, the CFIR knowledge gained could not be used to guide the intervention, which could have improved implementation effectiveness. Each CFIR construct was given equal weight in the scoring process, however certain constructs may have been more influential or distinguishing than others at the practices. We were most likely underpowered to assess implementation differences with a sample size of 10 practices randomized into the facilitator-led

arm of the study, therefore further research is warranted. The PBRN PFs who trained their practices in the intervention and PIs who oversaw the project were the same individuals who evaluated implementation effectiveness through the CFIR. This lack of blinding is a possible source of reporting bias in the evaluation process. Medicaid was our unifying source of data for outcomes analysis of the 10 practices within the 4 PBRNs across the state of North Carolina. The pragmatic implementation took place at the practice level, impacting asthma patients of all payor types including those with commercial insurance and Medicare. Because only Medicaid asthma patients were analyzed with regards to exacerbation outcomes, our results may not be generalizable to populations of asthma patients with other insurance types.

Conclusions

The CFIR was used to evaluate the asthma SDM intervention implementation at 10 facilitator-led practices in the ADAPT-NC Study, revealing multiple specific contextual factors most associated with implementation effectiveness. While there was no significant correlation between higher adoption and greater improvement in clinical outcomes, practices with a higher proportion of pediatric patients did experience a significant reduction in overall exacerbations with fewer combined ED visits, hospitalizations, and oral steroid prescription orders post-implementation. These results contribute to the literature supporting the use of CFIR evaluation to show which constructs and domains positively influence implementation. Through comparisons with implementations in other contexts and settings, the CFIR results can be used by providers, practices, researchers, and policymakers to advocate for ways to fully implement programs such as through practice facilitation. More studies are needed to evaluate the application of the CFIR when used in the planning, implementation, and evaluation phases of interventions.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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ORCID

Lindsay Shade  <http://orcid.org/0000-0002-0342-4365>
 Thomas Ludden  <http://orcid.org/0000-0001-5217-0229>
 Rowena J. Dolor  <http://orcid.org/0000-0001-7317-9468>
 Jacqueline Halladay  <http://orcid.org/0000-0002-1300-353X>
 Kelly Reeves  <http://orcid.org/0000-0003-0729-2192>
 Jennifer Rees  <http://orcid.org/0000-0001-6852-4140>

Data availability

All data generated and analyzed during this study are included in this published article.

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