Effect of Electronic Medical Record Alerts on Pediatric Asthma Providers

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Abstract

There is a gap in primary care providers' prescribing practices for spacers and masks among pediatric asthma patients. High-quality evidence gathered from a comprehensive literature review revealed several potential interventions to improve pediatric asthma control. Research findings suggest electronic medical record (EMR) alerts are cost-effective, easy to use and evaluate, and influence clinical decision-making and prescribing practice. The purpose of this paper is to investigate the effect of EMR alerts on pediatric primary care providers' (PPCPs) prescribing practices of spacers. Concepts from the Technology Acceptance Model and the Plan-Do-Check-Act cycle were applied to guide the implementation framework for this project. A well-designed EMR alert and PPCP education on its use and purpose were implemented in a pediatric primary care office in the Southwestern United States. This project received expedited approval from the institutional review board at Arizona State University and approval from the project site to protect participants' human rights. Pre/Post-EMR Alert Survey and Retrospective Chart Audit Forms were instruments utilized to analyze eight weeks of data upon EMR alert implementation. Data analysis includes descriptive statistics and retrospective data analysis. This project found a 60% increase in spacer prescription rate following the intervention. The findings from this project indicate that EMR alerts are helpful reminders, easy to implement and use, cost-effective, and influential in prescribing practices and clinical decision making.

Keywords: asthma, pediatrics, spacers, prescribing practices, EMR alerts

Effect of Electronic Medical Record Alerts on Pediatric Asthma Providers

Asthma is one of the most common chronic diseases in pediatrics. Asthma exacerbations present an increase in children seen by their primary care doctor, urgent care, or emergency room facilities. Many researchers would argue that a significant issue with managing pediatric asthmatics is the incorrect use of inhaled medications. Lack of knowledge and understanding of asthma can also affect how well it is managed. Pediatric primary care providers play a large role in ensuring that their patients and parents can confidently care for their children with asthma.

Problem Statement

A pediatric primary care office located in the Southwestern United States has acknowledged a gap within the practice of providers inadequately prescribing spacers and masks to their asthmatic patients. Spacers are an important piece of equipment that assists in introducing inhaled medication into the child's lungs more effectively. Face masks are necessary for young children, usually aged three and under, who cannot hold a mouthpiece between their teeth and lips to aid in medication delivery (Csonka et al., 2021).

The population affected by this problem includes pediatric patients and families diagnosed with asthma. The most recent national data from the Centers for Disease Control and Prevention [CDC] (2023) includes 6.5% of children under 18 years old with an asthma diagnosis. At Arizona's state level, according to the Arizona Department of Health Services (2021), for children with asthma from infants to four years old, the average number of hospitalizations monthly was 19.87. Within the same year, the average number of hospitalizations per month for children five to nine years old was 20.87. Finally, for children 10-14 years old, the state average monthly hospitalizations of pediatric patients with asthma were 8.2, and for children 15-19 years old, the monthly state average was 4.2. Pediatric patients and families diagnosed with asthma are

affected by the inadequate prescription of spacers and masks.

According to the Global Initiative for Asthma (GINA), about 70-80% of asthmatic patients do not use their inhalers correctly (GINA, 2023). This can lead to an increased risk of asthma exacerbations and adverse effects. Spacers have been around for over sixty-five years, but patients continue to use them incorrectly. Primary care providers have a role to play in assisting with this change.

Background and Significance

Based on a review of recent literature, multiple interventions are necessary to improve pediatric asthma care and providers' prescribing practices of spacers and masks. Following pediatric asthma guidelines, utilizing electronic medical record alerts, and education on proper inhaler techniques can improve providers' adherence to prescribing masks and space chambers. Ultimately, significant improvement in provider spacer prescription, patient spacer use, and overall asthma control should be seen.

Asthma in Pediatrics

Asthma is one of the most common chronic diseases in pediatrics, which is not new but continues to rise as a global health concern. The World Health Organization [WHO] defines asthma as a significant noncommunicable disease in which the narrowing and inflammation of the small airways in the lungs cause symptoms such as cough, wheezing, chest tightness, and shortness of breath (WHO, 2023). Healthy People 2030 stated that their goal to improve respiratory health is to reduce emergency department visits for children with asthma younger than five years old (Office of Disease Prevention and Health Promotion, n.d.). It is important to keep in mind that there are many variables to consider when dealing with children with asthma. Severity and control of disease, patient and parent knowledge and understanding, adherence to

medication regimen, and incorrect use of spacers and masks are all issues associated with managing pediatric asthma (Morton et al., 2020; Root & Small, 2019; Volerman et al., 2021).

Electronic Medical Record Alerts

Incorporating electronic medical record alerts for pediatric providers when prescribing pressurized metered dose inhalers is one potential intervention to increase provider adherence to prescribing spacers and masks. Leibel and Weber (2019) implemented a quality improvement project to evaluate the effectiveness of an electronic medical record-based best practice advisory focused on asthma control that improved their response to poorly controlled asthma. In addition to educating pediatric providers about the importance of ordering spacers and masks, provider engagement in education is another priority intervention (Neininger et al., 2022; Root & Small, 2019). Educating providers about spacer use and why they are essential will increase the effectiveness of medication delivery. Video-based education is another intervention that has been considered an effective way to deliver asthma education (Frydenberg et al., 2022). Integration of electronic medical record alerts with provider engagement in education appears to be the most promising of the interventions examined to date.

Spacer and Mask Use

Currently, the GINA (2023) guidelines and the National Heart, Lung, and Blood Institute [NHLBI] (2020) recommend spacers to be ordered, taught, and utilized correctly for the effective use of inhaler devices in pediatric patients. Leibel and Weber (2019) found that 28-68% of patients do not use inhalers efficiently to benefit from the medication that is prescribed. Inhaler skills need continued practice with reinforcement; therefore, teaching and reinforcing inhaler skills and adherence are recommended at every visit (GINA, 2023; Leibel & Weber, 2019; NHLBI, 2020; Root & Small, 2019). Ensuring proper inhaler technique, although it can be

viewed as time-consuming, can also be considered as just as important as the prescribed inhaler. Chaicoming et al. (2020) found that homemade valved holding chambers are effective for metered-dose inhaler use, which are also cheap, easy to make, and disposable if commercial spacers are unavailable. To improve child asthma control, healthcare providers should prioritize appropriate inhalers and spacer use with patient and family education to alleviate the health disparity.

Provider Prescribing Practice

As a result of appropriate intervention, it is anticipated that pediatric primary care providers will prescribe spacer and mask devices more frequently to their pediatric asthmatic patients in the future. Additional benefits that should be seen with an increase in providers' prescribing practices for spacer and mask devices are an improvement in asthma control and a decrease in asthma exacerbations, hospitalizations, and emergency room visits. The goal is for every pediatric asthma patient with a metered-dose inhaler prescription to have a spacer prescription with the proper knowledge and demonstration of how to use it (Neininger et al., 2022; Root & Small, 2019). The shift of provider buy-in for pediatric spacer prescription utilization and education on proper techniques would increase the effective use of inhaler devices in pediatric patients.

Common Themes

A review of the literature revealed common findings that pediatric asthma continues to be a global health concern, although improper use of inhaler medications and teaching of inhaler skills are an unfortunate commonality. At the state level, the number of pediatric hospitalizations related to asthma is not improving. In current practice, there is little formal education from pediatric primary care providers, and this occurs simultaneously with spacer prescriptions.

Providing education from the pediatric provider to families and patients is necessary to improve medication delivery with the proper use of inhaler medications with a spacer.

Internal Data

A pediatric primary care office located in the Southwestern United States provides preventative services, including immunizations, annual wellness exams, sports physicals, chronic disease maintenance, allergies, acute and sick visits, behavioral health concerns, and newborn screenings and support. The identified gap found in this practice is that primary care providers inadequately prescribe spacers and masks to patients diagnosed with asthma. A stakeholder within the organization discovered this problem. If this problem goes unaddressed, pediatric primary care providers will continue to see improper use of inhaled medications and uncontrolled asthma, as evidenced by an increase in asthma exacerbations, missed school days, and hospitalizations.

Purpose and Rationale

Improper use of inhaled medications and inadequate prescriptions of spacers and masks for pediatric patients with asthma can lead to poorly controlled asthma, an increase in asthma exacerbations, and an increase in hospitalizations. This project aims to discover the effect of electronic medical record alerts on pediatric primary care providers' prescribing practices of spacer and mask devices for pediatric asthma patients. By improving providers' prescribing practices of spacer and mask devices, we may see an increase in asthma control, a demonstration of proper use of inhaled medications, a decrease in asthma exacerbations, and a decrease in hospitalizations.

PICO Question

A review of the literature led to the clinically relevant PICO question: In clinical practice

settings (P), how do electronic medical record alerts (I), compared to standard practice (C), affect clinical decision-making and prescribing practices (O)?

Search Strategy

A detailed appraisal of the most current evidence took place to answer the PICOT question. Three databases were extensively searched, including the following: PubMed, Cumulative Index of Nursing and Allied Health Literature (CINAHL), and PsychINFO. These databases were preferred for their significance of medical relevance, research base, and peer review process on the topics of clinical practice settings, electronic medical record alerts, and provider prescribing practices that yielded relevant and applicable articles. The search process has been described below.

Keyword Selection

The databases were searched using combinations of the key terms that addressed all aspects of the PICOT question. The keywords were thoroughly considered to address the PICOT question because key terms such as *pediatrics, children,* or *spacers* were not included, as this narrowed the search too significantly, yielding little to no relevant research studies. There is a scarcity of research that looks at the role of electronic medical record alerts in pediatric asthma control. Instead, keywords that were utilized were the following: *electronic medical record alerts, best practice alerts, prescribing practices, asthma,* and *clinical decision-making*. Mesh terms included *reminder systems, best practice alerts,* and *primary care providers,* which helped widen the search.

Initial and Final Search Yields

An initial search of *electronic medical alerts* or *best practice alerts* and *clinical decision-making* yielded a total of 293 results in PubMed, 397 in CINAHL, and 192 in PsychINFO.

Utilizing that same search field but adding *doctors, physicians,* or *health professionals* brought the results down to 157 results in PubMed, 58 in CINAHL, and 29 in PsychINFO. After reviewing the titles and abstracts of the articles found in these database searches, 75 relevant studies were found. Following rapid critical appraisal and exclusion of articles over five years old, 10 studies were selected for in-depth evaluation. These 10 studies included two randomized control trials, two cross-sectional analyses, two quality improvement projects, one retrospective cohort study, one quasi-experimental, one prospective experimental, and one qualitative study.

Limitations, Inclusion, and Exclusion Criteria

Omitting the ideal patient population of pediatric asthma patients and spacers was key to success in finding ample research on how electronic medical alerts affect provider prescribing practices. The inclusion criteria consisted of studies published in English from 2019 to the present. Articles greater than five years old were excluded. The criteria for inclusion consisted of adults, children, primary care, and hospital settings. Studies from multiple countries were included unless they were not published in English. Many of the studies examined were conducted in American regions. Studies that were not primary research and opinionated studies were omitted without evidential support. Inclusion and exclusion criteria were the same for all databases. The limitations prescribed were English-published articles within the last five years.

Critical Appraisal and Evidence Synthesis

Melnyk and Fineout-Overholt's (2019) rapid critical appraisal was used to evaluate the quality and strength of the 10 articles in this literature review. The evaluation process included analyzing the demographics, settings, study design, major variables, findings, bias, and implications. The final studies that were proven to have strength and the highest quality are included in the tables below (see Appendix A, Tables A1-A2). All the studies used had an

adequate sample size, or the size was not applicable for time series analysis or systematic review. Much of this literature review stays within the U.S., with only two studies from other countries, including Germany and Australia (see Appendix A, Table A3).

The sample characteristics were relatively homogeneous, as most participants were males younger than 20 years old, except for one outlier of males with a mean age of 72 years old (Ghazi et al., 2022). In addition to being outside the pediatric age range and setting, this study examined electronic alerts and their effect on heart failure patients in the outpatient setting, a problem not typical for pediatric patients. Despite being an outlier, Ghazi et al. (2022) is an important study to include for their statistically significant results and strong provider feedback, which the majority found EHR alerts helpful. Otherwise, all studies included took place in a pediatric hospital setting, either inpatient, outpatient, or emergency department.

Among these 10 studies, the major variable was the best practice alert; others used electronic health/medical record alerts, which can be used synonymously. The only outlier within these studies is McCoy et al. (2022) data analysis of their quality improvement aimed to improve quality and safety and reduce burnout through systematic alerts. Therefore, all 10 studies analyzed the use of systematic alerts in their unique way. Because of this, common findings or themes were easy to identify among the 10 studies. Common themes identified were reduction in alerts, alarm fatigue, medication adherence, and cost for implementation (Table A3).

Finally, four of the 10 articles reported their funding source, with only one study recognizing bias for including a non-best practice alert (BPA) arm of the study that coordinated with improved medication therapy. Three of the 10 articles reported using financial incentives, benefits, or gamification for study participants, which could also be considered biased. Given the topic of best practice alerts, some incentivization might be necessary to get true provider

feedback in some cases. Reliability and validity were found to be strengths for all the selected studies due to the tools and methodology used, and statistically significant findings (Appendix A, Tables A1-A3).

Influence of Evidence

Electronic medical record alerts are easy to use and evaluate, cost-effective, and influential on clinical decision-making and prescribing practices. It is important to factor in alarm fatigue as an obvious element to influence potential future studies, prescribing practices, and clinical decision-making. While this literature review emphasizes the prescribing practice of spacers for pediatric asthma patients, it is apparent that best practice alerts can be employed across all age ranges and specialties in various electronic health systems. To form a well-planned alert, with the evidence to support the need and a specific goal in mind, electronic record alerts can influence clinical practice change and support providers in their practice.

Theory Application

The Technology Acceptance Model (TAM) was chosen as the conceptual framework to guide the practice change for this project (see Appendix B, Figure B1). TAM is an information systems theory that represents how to accept and use technology (Davis, 1985). This researcher suggests that several factors influence individuals when presented with new technology. As depicted in Appendix B (Figure B1), perceived usefulness and perceived ease of use can determine the attitude toward using the new technology and, ultimately, the act or behavior toward using the new technology (Davis, 1985). This theory applies to the use of electronic medical record alerts and their relationship with clinical decision-making and prescribing practices. For example, a provider can be influenced by the perception of using the EMR alert if providers believed the alert would make their job easier in clinical decision-making and

prescribing practice. Similarly, providers will be less likely to respond to an EMR alert if it is not easy to use, the alert is too complicated, or it slows down their workflow. In conclusion, TAM has been found to have high reliability and predictive validity in providing practical evidence of the relationship between ease of use and system use when presented with new technology.

Implementation Framework

The Quality Improvement Model that was selected to guide the implementation framework of this project was the Plan-Do-Check-Act (PDCA) cycle (see Appendix B, Figure B2). The framework for the PDCA cycle was first introduced by Dr. William Edward Deming (1950) and is used to carry out ongoing processes focused on assessing, planning, acting, monitoring, evaluating, reassessing, and acting again (Anderson, 2018). This framework is often called the rapid improvement cycle, which was ideal for this project given the purpose of effecting change quickly (Anderson, 2018). The PDCA cycle has four steps that were easily implemented in this project. The first step, titled Plan, involves identifying what could be improved, deciding the root cause of the problem, and collecting data to help in the evaluation process (Anderson, 2018). Step one was completed and found in the sections leading up to the PICO question in this review of literature, including the problem statement, purpose and rationale, background and significance, and internal data. The problem of inadequate prescription of spacers and masks to asthmatic patients was identified within a pediatric primary care office located in the Southwestern United States, and a soft collection of data can be found above. After a firm collection of data within this practice was performed, step two can be attempted.

Step two of the PDCA cycle, titled Do, tests the proposed change through data simulation by mapping out and implementing a trial run (Anderson, 2018). This step was implemented after meeting with stakeholders to set up the EMR alert and trial on different test patients before

deciding to implement the final EMR alert in the next step. Step three of the PDCA cycle, titled Check, assessed the implemented change and modified the change process (Anderson, 2018). This step of the PDCA cycle was reliant on a set date range of eight weeks' worth of data from September 17th, 2024, to November 12th, 2024. This data set was compared to eight weeks of data exactly a year before the implementation of the EMR alert, which ranged from September 19th, 2023, to November 14th, 2023. These eight weeks of data analyzed the PPCPs' prescribing practices of spacers in this pediatric primary care office. The fourth and final step of the PDCA cycle, titled Act, is where the tested change is implemented to improve the process (Anderson, 2018). After gathering findings from step three, it was ultimately up to the PPCPs of this pediatric primary care office to decide if they liked the EMR alert and found it helpful to maintain it or adjust it to better suit their practice.

Setting and Stakeholders

As previously stated, the organization in which this project took place was a pediatric primary care office located in the Southwestern United States. This organization had two separate locations in which this project was implemented. This primary care practice provides several outpatient and preventative services, including annual wellness exams, immunizations, breastfeeding support, newborn screenings, sports physicals, nutritional education, allergy testing and immunotherapies, chronic disease maintenance, behavioral health concerns, community and social supports, as well as acute and sick concerns. This pediatric primary care organization strives to be understanding and available to their families, which providers are privileged to serve with high-quality care and services.

Stakeholders play a valuable role in project outcomes. A few key stakeholders apart of this organization include the project site champion, the director of operations, PPCPs, the chief

executive officer, the practice manager, and the medical assistants. The project site champion was a provider within this organization who helped identify the gap in practice and was a support person in the practice change. The director of operations played a key role in the logistics of the EMR and was instrumental in the process of the EMR alert. The PPCPs within this organization are considered stakeholders as this project will impact them, as they were the participants and vectors of change. The chief executive officer provided oversight of this project and suggestions or feedback where needed. The practice manager has been an integral part of this project from an organizational standpoint, and this role aided in the recruitment process. Finally, another important group of stakeholders was the medical assistants who were involved in identifying established pediatric asthma patients who were missing spacers from their medicine reconciliations.

Participant Recruitment

The participants of this study were PPCPs of this organization who were willing to participate. The one provider that was excluded from participation was the project site champion, as it would have been a conflict of interest. Otherwise, inclusion criteria included PPCPs who prescribe albuterol to children aged two to 18 years old, as that was the parameter set for the EMR alert. Providers could have addressed ethical concerns before participating when presented with the consent form and the first pre-EMR alert survey. The providers were recruited through a lunch-and-learn presentation at each of the practice sites. Lunch was provided while PPCPs listened to a brief presentation regarding national asthma guidelines, the importance of spacer use, proper inhaler technique, simply how to order spacers through eClinicalWorks, and an introduction to the implementation of the EMR alert. The practice manager was the recruiter for this lunch by placing a block in the PPCP schedule on each day the lunches took place. No email

or flyer was necessary for recruitment, as this organization is smaller and those would simply be overlooked or missed.

Ethical Considerations

Three ethical principles guided this project: respect for persons, beneficence, and justice. Respect for persons is defined as individuals who must be treated with autonomy or the ability to make responsible decisions based on their values, beliefs, and preferences (NIEHS, 2023). The project adhered to this principle by ensuring participants understand their right to participate voluntarily, their ability to withdraw without fear of penalty, and decline participation if they choose (Cheraghi et al., 2023). For this project, participants made an informed decision, clearly declaring all risks, benefits, and likelihood of success in prescribing spacers for their pediatric patients. Participants were given written consent to allow for an informed decision of participation at the formal lunch and learn presentation. The project also adhered to beneficence, which intends to do good and avoid harm to the practitioners involved (Cheraghi et al., 2023). The project adhered to this principle by analyzing potential risks and benefits for research participants (NIEHS, 2023). Possible risks participants could face include time constraints, alarm fatigue, or any unforeseen side effects. Possible benefits include increased understanding of the importance of spacers, improvement in the process of ordering spacers, and increased satisfaction with ordering spacers through EMR.

Justice was the final principle utilized and is defined as following the right to fair treatment and the right to privacy (Cheraghi et al., 2023). The project adhered to this principle by fair distribution of resources, rights, and potential conflicts. For example, all providers participated in one formal presentation before the EMR alert was established. There was no coercion or rewards for participation. This project received expedited approval from the

institutional review board at Arizona State University and approval from the project site in August 2024, which reviewed the project methodology and ensured that the ethical principles would be followed and that participants' human rights would be protected.

Project Description

This project aims to understand the prescribing practices of spacers for PPCPs following an educational session complemented by an EMR alert. The evaluation question to consider is as follows: after the implementation of an EMR alert at a pediatric primary care office, is there a measurable difference in prescribing spacers, and how do providers feel about the EMR alert? The prescribing practice of PPCPs for spacers will be the measurement of change to evaluate before and after the implementation of the EMR alert.

Intervention and Timeline

The project design followed the PDCA cycle, a quality improvement model, to guide the implementation framework of this project. The first step to this cycle, the *plan*, was completed from May 2023 through May 2024. This step consisted of a thorough literature review, extensive data collection, and identification of the gap in practice to form the purpose of this project, utilizing TAM as the conceptual framework to guide the practice change into action. The plan affected PPCPs who prescribe spacer devices to pediatric patients with an asthma diagnosis or prescription of Albuterol from ages two to 18 years old. Once those parameters were met, the PPCP received an alert that pops up stating, **"SPACER NEEDED?** This patient has a diagnosis of Asthma. Does this patient have a spacer?"

Following IRB approval, this EMR alert, step *do*, was implemented on September 17th, 2024. This EMR alert was initiated the week following the lunch-and-learn presentation at each practice site. The educational session was a brief 15-minute presentation with clear objectives

identified, covering the GINA 2024 guidelines, demonstration of proper inhaler technique, and various examples of how to order spacers for pediatric asthma patients. The presentation occurred before the EMR alert was initiated to ensure PPCPs received the disclosure of information regarding the project and what it entails. This allowed the providers to make a competent and unbiased decision on participation that was completely voluntary. Once the PPCPs agreed to participate in this project, provider readiness was assessed through the five-point Likert scale pre-EMR alert survey immediately before the educational session.

After the EMR alert was initiated, it continued for eight weeks before the next step of the PDCA cycle occurred. After eight weeks had passed, utilizing the EMR alert, a thorough manual chart audit occurred for analysis of the PPCPs' prescription rate of spacer devices, along with the delivery of the five-point Likert scale post-EMR alert survey to assess PPCP thoughts and feelings of the EMR alert, as well as their understanding of GINA 2024 guidelines, proper inhaler technique, and management of pediatric asthma. This step occurred on November 19th, 2024. Data collected over the eight weeks was compared to one year ago before the EMR alert to account for the same seasonal comparison. Finally, after collecting all the data as stated above, the final step of the PDCA cycle, *act,* occurred by disseminating the findings with the PPCPs, and the EMR alert will continue as planned following their improved prescription rates and satisfaction with the EMR alert. The PPCPs assisted in the decision-making process of maintaining the EMR alert. Potential barriers for implementation of this project included alarm fatigue, heightened provider stress, perceptions of usefulness among providers, and perceived time constraints.

Data Tools and Collection

Data collection was performed to evaluate the outcomes of EMR alerts on PPCPs'

prescribing practice of spacers for pediatric asthma patients. The primary outcome measured was the PPCPs' prescription rate of spacer devices. This data was collected through retrospective data collection utilizing a manual chart audit form, detailed in Appendix C (see Table C1). Manual chart reviews are commonly employed in research, care assessments, and quality improvement projects, even without substantial data on their reliability and validity (Siems et al., 2020). Because of the absence of reliability and validity, these researchers aimed to establish a chart review system to prove strength and dependability and identify potential therapeutic advances. Validity and reliability were found after a structured chart review conducted by experienced primary reviewers, supplemented by a brief secondary review, examining 327 randomly selected cases (Siems et al., 2020). Therefore, manual chart audits constitute a credible approach for data collection for this DNP project.

Another essential instrument for measuring observable change in this project was pre- and post-EMR alert surveys. These surveys were created based on the literature, featuring a five-point Likert scale for participants to fill out, as outlined in Appendix C (see Tables C2 and C3). The survey will evaluate their familiarity with the Global Initiative for Asthma (2024) national guidelines, familiarity with proper inhaler technique, familiarity with ordering spacer devices through the EMR, the frequency of ordering spacer devices through EMR and a medical equipment supplier, and feelings toward an EMR alert. To ensure face validity, experts in the field, including the project site champion and other pediatric specialists in a similar setting, thoroughly reviewed the surveys.

Additionally, demographics were collected from the PPCPs with the pre-EMR alert survey, including the subject's age, years of experience, gender, and ethnicity/race. In addition to the provider demographics, the patient demographics were collected with the manual chart audit,

to include age and insurance status. The provider and patient demographics were protected through a de-identification process by generating a unique subject ID for everyone.

Outcome Measurements

This project sought to investigate the prescribing practices of PPCPs of spacers for pediatric asthma patients after an educational session paired with an EMR alert. Descriptive statistics were utilized to analyze the data and describe the sample and outcome variables. Specific outcomes to be measured are the prescribing practice of PPCPs for spacers for pediatric asthma patients, the management of pediatric asthma, and the prescribers' thoughts and feelings toward the EMR alert. These outcomes are tied to the theoretical framework of the Technology Acceptance Model. The outcomes suggest that PPCPs' prescribing practices may be shaped by their perceptions of using the EMR alert. These perceptions, in turn, can impact how PPCPs manage pediatric patients with asthma and ensure that all such patients have access to spacers.

Budget

The budget for this DNP project was $2,650 (Appendix D, Table D1). This project site has two locations, and the budget cost was split between these two clinic locations. This budget supports many studies that found medication adherence is associated with cost savings. Enhancing adherence to inhaled medications through EMR alerts for providers ordering spacer devices could lead to substantial cost savings with minimal investment. In the United States healthcare system, there exists an extensive economic burden of asthma in the pediatric population. According to Perry et al. (2019), the total direct cost of asthma within pediatrics in 2013 was 5.92 billion dollars. A system of cost savings via continuous improvement is an essential sustainability asset that drove this DNP project.

Results

After data collection, data analysis was performed to determine the effect of EMR alerts on PPCPs' prescribing practice of spacers for pediatric asthma patients. A password-protected statistical software, Intellectus Statistics, was used to store, manage, and analyze the data (Intellectus Statistics, 2023).

Demographics

A total of five Pediatric Primary Care Providers (n=5) completed this project. The majority of the ages of this sample were between 31-35, 2 (40%), and the remaining categories were 26-30, 46-50, 56-60, 3 (60%). The majority of the sample was female, 3 (60%), and the remainder were male, 2 (40%). The majority of this sample was White or Asian, with two each for a total of 4 (80%), with the remaining Hispanic or Latino of 1 (20%).

Table 1

Frequency Table for Demographic Variables

Variable	*n*	*%*
Age		
26-30	1	20.00
31-35	2	40.00
46-50	1	20.00
56-60	1	20.00
Gender		
Male	2	40.00
Female	3	60.00
Race		
White	2	40.00
Asian	2	40.00
Hispanic or Latino	1	20.00
Years As Provider		
< 16 years	2	40.00
> or = 16 years	3	60.00

Descriptive Statistics

Frequencies and percentages were calculated for each variable or question for both the pre- and post-EMR alert surveys. The frequencies and percentages are presented in Table 2, found below. Although a few frequencies stood out, they are worth mentioning. The most frequently observed categories of Pre_GINA_Guidelines were Sometimes and Often, each with an observed frequency of 2 (40.00%). The most frequently observed category of Post_GINA_Guidelines was Often (n = 4, 80.00%). This indicated PPCPs were more frequently following the 2024 GINA guidelines post-intervention. The most frequently observed category of Pre_Order_Spacers was Sometimes (n = 3, 60.00%). The most frequently observed category of Post_Order_Spacers was Often (n = 3, 60.00%). PPCPs were more frequently sending orders for spacers post-intervention. The most frequently observed category of Pre_Check_Inhaler_Technique was Rarely (n = 3, 60.00%). Post_Check_Inhaler_Technique's most frequently observed category was Sometimes (n = 3, 60.00%). Indicating PPCPs were checking the patient's inhaler technique more often post-intervention. Please find all eight pre- and post-EMR alert survey variables with frequencies and percentages presented in Table 2.

Table 2

Frequency Table for Survey Variables

Variable	*n*	*%*
Pre_GINA_Guidelines		
Sometimes	2	40.00
Often	2	40.00
Always	1	20.00
Post_GINA_Guidelines		
Often	4	80.00
Always	1	20.00
Pre_Order_Spacers		
Sometimes	3	60.00
Often	2	40.00
Post_Order_Spacers		
Sometimes	1	20.00

Often	3	60.00
Always	1	20.00
Pre_Medical_Equipment_Supplier		
Never	1	20.00
Rarely	1	20.00
Sometimes	2	40.00
Often	1	20.00
Post_Medical_Equipment_Supplier		
Never	1	20.00
Rarely	1	20.00
Often	2	40.00
Always	1	20.00
Pre_Send_Spacer_Rx_to_Pharmacy		
Never	1	20.00
Sometimes	2	40.00
Often	2	40.00
Post_Send_Spacer_Rx_to_Pharmacy		
Never	1	20.00
Sometimes	1	20.00
Often	2	40.00
Always	1	20.00
Pre_Check_Inhaler_Technique		
Rarely	3	60.00
Sometimes	2	40.00
Post_Check_Inhaler_Technique		
Rarely	1	20.00
Sometimes	3	60.00
Often	1	20.00
Pre_Nebulizer_Over_Spacer		
Rarely	1	20.00
Often	4	80.00
Post_Nebulizer_Over_Spacer		
Sometimes	2	40.00
Often	2	40.00
Always	1	20.00
Pre_Teach_Inhaler_Technique		
Rarely	2	40.00
Sometimes	3	60.00
Post_Teach_Inhaler_Technique		
Sometimes	2	40.00

Often	2	40.00
Always	1	20.00
Pre_Educate_Rinse_Mouth		
Rarely	1	20.00
Sometimes	1	20.00
Often	1	20.00
Always	2	40.00
Post_Educate_Rinse_Mouth		
Rarely	1	20.00
Often	2	40.00
Always	2	40.00

Next, frequencies and percentages were calculated to compare pre- and post-intervention on how often providers teach proper inhaler technique compared to years as a provider. The most frequently observed category of Pre_Teach_Inhaler_Technique within the 0-5 category of Years_As_Provider was Sometimes (n = 2, 100.00%). The most frequently observed category of Pre_Teach_Inhaler_Technique within the 16-20 category of Years_As_Provider was Rarely (n = 1, 100.00%). The most frequently observed categories of Pre_Teach_Inhaler_Technique within the >20 category of Years_As_Provider were Rarely and Sometimes (n = 1, 50.00%). The most frequently observed categories of Post_Teach_Inhaler_Technique within the 0-5 category of Years_As_Provider were Sometimes and Always (n = 1, 50.00%). The most frequently observed category of Post_Teach_Inhaler_Technique within the 16-20 category of Years_As_Provider was Often (n = 1, 100.00%). The most frequently observed categories of Post_Teach_Inhaler_Technique within the >20 category of Years_As_Provider were Sometimes and Often (n = 1, 50.00%). Frequencies and percentages are presented in Table 3.

Table 3

Frequency Table for Proper Inhaler Technique and Years Practiced

	Years_As_Provider		
Variable	0-5	16-20	>20
Pre_Teach_Inhaler_Technique			
Rarely	0 (0.00%)	1 (100.00%)	1 (50.00%)

Sometimes	2 (100.00%)	0 (0.00%)	1 (50.00%)
Total	2 (100.00%)	1 (100.00%)	2 (100.00%)
Post_Teach_Inhaler_Technique			
Sometimes	1 (50.00%)	0 (0.00%)	1 (50.00%)
Often	0 (0.00%)	1 (100.00%)	1 (50.00%)
Always	1 (50.00%)	0 (0.00%)	0 (0.00%)
Total	2 (100.00%)	1 (100.00%)	2 (100.00%)

Finally, providers were asked to describe how the EMR alert was helpful to them. One provider reported it was "A great reminder!" Another provider reported, "Reminds me to always send the spacer along with the inhaler." All five of the PPCPs found this EMR alert to be helpful. "It was helpful to get the message/reminder across." This was something another provider reported on how the EMR alert was helpful. Another PPCP wrote, "Reminds to make sure they have a spacer." Finally, another provider wrote, "It brought the spacer to mind every time I Rx inhaler." Overall, the provider feedback was positive, with three of the five PPCPs reporting they would not change anything about the EMR alert or that it is working fine. The other two PPCPs suggested to "Link to spacer Rx," or "Directly send into Rx site what type of spacer covered by insurance."

Retrospective Chart Audit

As stated previously, the primary outcome measured for this project was the PPCPs' prescription rate of spacer devices. For pre-EMR alert, the number of spacer prescriptions ordered was four out of 118 Albuterol prescriptions. Therefore, the pre-EMR alert spacer prescription rate was found at 3%. Compared to the post-EMR alert, the number of spacer prescriptions ordered was 66 out of 243 Albuterol prescriptions. The post-EMR alert prescription rate was found to be 27%. Of these five PPCPs, this project found a 60% increase in spacer prescription rate following the intervention of the EMR alert paired with the brief educational

session upon implementation.

Project Impact

Implementation of a well-designed EMR alert, with proper education to the PPCPs on the utilization and purpose of EMR alert to support the correct use of inhaled medications by properly prescribing spacers and teaching the proper technique to patients and their families. Applying this evidence to a pediatric primary care office located in the Southwestern United States led to a practice change in prescribing spacers at the individual provider level. In addition, the patient level should see an improvement in correct use of inhaled medication through improved spacer use and impact overall asthma control. Therefore, this practice and system should see fewer ER visits, school absences, and hospitalizations for pediatric asthma patients over time.

Sustainability

The practice of building, refining, and improving a project or initiative is necessary to achieve sustainability when implementing a quality improvement project. This DNP project aimed to investigate the effect of EMR alerts on PPCP's prescribing practices of spacers. The project site champion at this organization was one of the PPCPs within this practice who helped identify this gap in the practice of inadequate prescriptions of spacers for pediatric asthma patients. The project site champion will continue to act as a resource, advocate, and leader in guiding colleagues on ordering spacers, while monitoring and assessing the effectiveness of the EMR alert through manual chart audits following implementation. Eventually, sustainability will be reached with the long-term goal in mind of PPCPs adapting to ordering spacers for their pediatric patients with asthma without an EMR alert, which can be seen in the logic model in Appendix F (see Figure F1).

The framework that guided this quality improvement project was the Plan-Do-Check-Act (PDCA) cycle, which provides a natural iterative developmental process that will be continued upon project completion until the PPCPs are satisfied with the result of 100% of pediatric asthma patients obtaining spacers with their inhalers. Upon project completion, the PPCPs have found the EMR alert beneficial to their practice and would like to continue the alert. The PPCPs have also been left with a quick, saved template to be inserted into their notes to provide patient spacer care and instructions. Along with the note template, the PPCPs were provided with a spacer care instruction handout to give to the patients and their families with their spacers.

The sustainability of this quality improvement project will be ensured through the establishment of a dedicated site champion, an effective EMR alert, a note template, a care instruction handout, and ongoing evaluation and adaptation. PPCPs play a large role in educating families on how to confidently care for their children with asthma, which will evolve through this sustainable project plan. This approach will foster a culture of continuous improvement in pediatric asthma management, ultimately enhancing the quality of care provided to pediatric patients with asthma.

Discussion

Strengths and Limitations

Upon implementing an effective EMR alert paired with an educational session for the PPCPs on the utilization and purpose of EMR alerts at a pediatric primary care office located in the Southwestern United States, a 60% increase in the spacer prescription rate was observed. This intervention was cost-effective, received strong support from the project site, and positively impacted the PPCPs. This relates back to the initial literature review findings that EMR alerts are easy to use and implement, cost-effective, and influential on clinical decision making. All

participating PPCPs for this project want to keep the EMR alert as a reminder always to send the spacer and inhaler.

While this project has several strengths, there are limitations and barriers that must be acknowledged. Since this project is unique in its kind, no standardized tool was utilized, as such a tool does not exist. Also, this project timeline was implemented before the respiratory season in the pediatric setting. The timeline followed was what best suited the project site for implementation. Finally, there was a lack of support from the medical equipment supplier supporting this practice. The medical equipment supplier generates more revenue from nebulizers sent through them than from spacers, which were found to have an influence on the amount of equipment supplied within each practice location. One challenge was that the medical equipment supplier was reluctant share their data, which could have provided additional information within this project.

Recommendations

Future study recommendations include implementation during the respiratory season within the pediatric setting. Another future recommendation would be to implement this EMR alert across various pediatric primary care offices. This should take careful care and consideration of alarm fatigue when implementing across various practices. Finally, create an EMR alert to have the ability to link directly to the order set, smart enough to factor in what spacer would be accepted per each patient's insurance, making this a seamless and simple transition for the PPCPs.

Conclusion

Ultimately, asthma in pediatrics remains among the most common chronic diseases. PPCPs are responsible for bridging the gap of inadequate prescription of spacer devices for

children with asthma and empowering families with knowledge on how to care for their child with asthma confidently. This quality improvement project acknowledged the positive effect of an EMR alert complemented with an educational session and the PPCP prescribing practice of spacer devices for children with asthma. Upon conclusion of this project, PPCPs are expected to be more likely to order spacers over nebulizers for pediatric patients with asthma, and more likely to teach proper inhaler technique. While alarm fatigue and provider perceptions must be acknowledged as potential barriers to this project, EMR alerts can be easy to use and evaluate, cost-effective, and influential on clinical decision-making and prescribing practice in various specialties and electronic health systems.

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Appendix A

Evaluation and Synthesis Tables

Table A1

Evaluation Table for Quantitative Studies

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
Ghazi et al., (2022), Electronic alerts to improve heart failure therapy in outpatient practice: a cluster randomized trial. **Country**: USA, New Haven, Connecticut. **Funding**: AstraZeneca funded and several author disclosures listed **Bias**: non-BPA arm of study coordinated with	Theories of persuasion and motivation	**Design:** cluster RCT **Purpose:** EHR alerts recommending medical treatment in eligible patients with heart failure with reduced ejection fraction to improve prescription rates of therapies compared to usual care	**N=** 1,310 **n=** 685 (alert) **n=** 625 (no alert) **Demographics:** Mean Age of 72 Female 30.7% Black 18.1% White 71.7% Asian 1.5% Hispanic 9.5% Medicaid 85.3% **Setting:** Yale-New Haven Health System **Exclusion:** PTs on hospice care (n= 7)	**IV:** PROMPT-HF clinical trial; EHR embedded BPA **DV1:** addition of GDMT prescription at 30 days **DV2:** Increase in Dose or Addition of GDMT Class at 30 Days	**Tools:** - O'Brien and Fleming stopping rule - binomial distribution - log link intention-to-treat principle **Validity/ Reliability:** - comparing two treatments - only one outcome in each trial - non-negative and well-behaved predictions - unbiased comparison	**Statistical Tests Used:** chi-square test Wilcoxon rank sum test	**DV1:** p=0.03 Absolute increase=10% 2-sided alpha= 0.05 intraclass correlation coefficient=0.05 **DV2:** p=0.01	**LOE**: I **Strengths**: statistically significant results, strong provider feedback, majority found helpful **Weakness**: single health system examined increase in medication start rather than dosing; tested in one EHR **Feasibility**: cost-effective, targeted, individualized, and scalable **Application**: apply outside of single health system, variety of EHR

Key: **AUA** American Urological Association, **ABX** Antibiotics, **BBD** Bowel Bladder Dysfunction, **BP** Blood Pressure, **BPA** Best Practice Alert, **CDS** Computerized/Clinical Decision Support, **CI** Confidence Interval, **DV** Dependent Variable, **ECG** Electrocardiogram, **ED** Emergency Department, **EHR** Electronic Health Record, **EMR** Electronic Medical Record, **GDMT** Guideline Directed Medical Therapy, **ICS** Inhaled Corticosteroids, **IV** Independent Variable**, LOE** Level of Evidence, **LVC** Low Value Care, **NAEPP** National Asthma Education and Prevention Program, **OR** Odds Ratio, **PT** Patient**, PCP** Primary Care Provider, **PROMPT-HF** PRagmatic trial Of Messaging to Providers about outpatient Treatment of Heart Failure, **RCT** Randomized Control Trial, **UA** Urine Analysis, **VUR** Vesicoureteral Reflux

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
improved medication therapy			**Attrition:** not mentioned					
Wengryn et al., (2022), Use of electronic health record best practice alerts to improve adherence to American urological association vesicoureteral reflux guidelines. **Country**: Aurora, Colorado, USA **Funding**: American Urological Association data grant **Bias**: none nor conflicts of interest	technology acceptance model theory	**Design:** Retrospective cohort study **Purpose:** evaluate the effect of BPA in the EHR on adherence to AUA VUR guidelines	**N=** 123 (pre- 68) (post- 55) **Demographics:** Mean Age= 3.7 Female= 65.9% Male= 34.1% White= 61.8% Other Race= 32.5% Reflux Grade: 1-2= 37, 3= 41, 4-5= 39 History of BBD: Yes- 32, No- 91 Family History Reflux: Yes- 12, No- 110 **Setting:** Children's Hospital Colorado outpatient tertiary referral center **Exclusion:** missing 5 data points **Attrition:** not applicable, retrospective	**IV:** BPA implementation **DV1:** provider guideline adherence at initial visit **DV2:** provider guideline adherence at follow-up visit	**Tools:** - Statistical Analysis System - open-source programming language **Validity/ Reliability:** - consistent data overtime - enhance security and transparency	**Statistical Tests Used:** Chi-square test Wilcoxon rank sum test	No significant findings- **DV1: P values** height- <0.001 BP- 0.72 UA- 0.11 ABX- 0.34 **DV2: P values** height- 0.88 BP- 0.79 UA- 0.25 Follow up 47.2%	**LOE**: II **Strengths**: height recorded for patients significantly increased, customize EHR to enhance clinical practice **Weakness**: AUA 2010 guidelines, formatting alert, alert fatigue, time constraints in clinic, lack of workflow, limited by study design, possible clinic staff change over course of study, outpatient setting, lack for survey for providers feedback **Feasibility**: inexpensive, can be repeated with room for improvement **Application**: BPA must fit into workflow of

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Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
								clinic or inpatient settings
Leibel et al., (2019), Utilizing a physician notification system in the EPIC electronic medical record to improve pediatric asthma control: A quality improvement project **Country:** San Diego, California, USA **Funding:** none **Bias:** internal peer-approved "pay-for-performance initiative"	Model for improvement	**Design:** quality improvement **Method:** clinical informaticist with EMR system created BPA, observe over 3 months **Purpose:** evaluate EMR- based BPA centered on asthma control	**N=** 439 encounters with asthma, 207 completed questionnaire **Demographics:** not disclosed **Setting:** Division of Allergy, Immunology, and Rheumatology at Rady Children's Hospital **Exclusion:** none listed **Attrition:** 47% completion rate	**IV:** BPA implementation **DV1:** medication changes **DV2:** inhaler technique review **DV3:** further evaluation **DV4:** no action necessary	**Tools:** Asthma Therapy Assessment Questionnaire **Validity/ Reliability:** Cronbach α of .75	**Statistical Tests Used:** Slicer Dicer Component of EMR	99% documented action taken **DV1:** 55% **DV2:** 65% **DV3:** 56% **DV4:** 11%	**LOE**: I **Strengths**: easy to use, improve clinician compliance, increase prescription for controller medications, follow asthma care plans, improved pulmonary function tests **Weakness**: no before/after comparison, small sample size, short duration, alarm fatigue, increase in provider stress **Feasibility**: cost effective, targeted, individualized, and scalable **Application**: apply outside of single health

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Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
								system/office, variety of EHR
Lawrence et al., (2024), Retrospective analysis of the impact of electronic medical record alerts on low value care in a pediatric hospital **Country**: Melbourne, Australia. **Funding**: Digital Health Fellowship **Bias**: none	technology acceptance model theory	**Design:** time series analysis, quasi-experimental method **Method:** evaluate EMR data over 76-months **Purpose:** evaluate EMR alerts and effectiveness at reducing pediatric LVC towards hospital cost	**N=** four different LVC practices **Demographics:** not specified **Setting:** Royal Children's Hospital in Melbourne, Australia **Exclusion:** timing in the workflow, wording, action required **Attrition:** not stated	**IV:** EMR alerts **DV1:** full iron studies for iron deficiency anemia **DV2:** bronchodilators in bronchiolitis **DV3:** full thyroid function tests **DV4:** ECG sleeping bradycardia	**Tools:** -STATA statistical software version 16 (Texas, USA) -Akaike information criterion -Bayesian information criterion -Bradford-Hill criteria **Validity/ Reliability:** - numerical accuracy tests - Lower= better, measuring variation - lower= better, likely function - nine criterion for causation deduced	**Statistical Tests Used:** Descriptive statistics Poisson regression analysis Sensitivity analysis	**DV1:** p <.001 Pre: 56.7% Post: 31.0% **DV2:** p <.001 Pre: 6.9% Post: 3.2% **DV3:** p <.001 Pre: 25.1% Post: 9.9% **DV4:** p .305 Pre: 28.8% Post: 28.1%	**LOE**: II **Strengths**: cost reducing, improvement in LVC ordering practice, consistent, **Weakness**: introduced in sequential order not as intentionally designed, efficacy of alerts vary, method detects association not causation, large EMR data sets **Feasibility**: cost effective, targeted, individualized, and scalable **Application**: apply outside of single health system/office, variety of EHR
Farmer et al., (2020), Inhaled corticosteroids	technology acceptance model theory	**Design:** prospective cohort study	**N=** 125 **Demographics:** Mean Age= 7.4 Female= 45% (36)	**IV:** electronic alert	**Tools:** Fisher exact	**Statistical Tests Used:**	**DV1:** p-value <0.0001 **DV2:** 95% CI	**LOE**: II **Strengths**: specific prompts for physicians

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Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
prescriptions increased in the ED for recurrent asthma exacerbations by automated electronic reminders in the ED **Country:** Phoenix, Arizona, USA **Funding:** none **Bias:** financial incentive offered to physicians ordering ICS		**Purpose:** evaluate impact of electronic alert on prescription rate of ICS by ED providers	Male= 80% (64) Hispanic=78%(62) White= 24% (19) Black= 14% (11) Native= 8% (6) Other= 1% (1) Medicaid= 100% (80) Non-Medicaid= 18% (18) Self-pay= 7%(7) No Prior ICS= 86% (69) Yes Prior ICS=39% (31) **Setting:** Phoenix Children's Hospital ED **Exclusion:** comorbidities- developmental delay, broncho- pulmonary dysplasia, cystic fibrosis, sickle cell disease, interstitial lung disease **Attrition:** not applicable	**DV1:** ED asthma visits **DV2:** ICS prescribed	Fisher–Freedman–Halton test Kruskal–Wallis test **Validity/ Reliability:** based on 10000 random samples	Confidence interval Fisher exact test Kruskal-Wallis test Fisher-Freeman-Halton test Binomial Clopper-Pearson exact calculation		to order ICS; improved rate in ICS prescription **Weakness**: unknown sustainability/affect sustained, not able to track prescription fill rates; unable to assess reasoning for not prescribing ICS **Feasibility**: cost effective, targeted, individualized, and scalable **Application**: apply outside of single health system/office, variety of EHR
Fierro et al., (2023), A pilot study to improve provider adherence to	Model for improvement	**Design:** serial cross-sectional analysis **Purpose:** improve provider adherence	**N=** (6606) **2014**, (6945) **2018** **Demographics: 2014** Male=3745 (56.7) Female 2861 (43.3)	**IV:** CDS embedded into EMR **DV1:** Asthma control test	**Tools:** Asthma control test Cerner EMR	**Statistical Tests Used:** General Linear	**DV1:** OR =14.95, 95% CI 12.67, 17.65, p <.001	**LOE**: III **Strengths**: statistically significant findings; adherence to NAEPP guidelines improved;

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Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
NAEPP guidelines **Country:** Orange County, California, USA **Funding:** none. **Bias:** none nor conflicts of interest		to NAEPP guidelines in EMR	0–4 years: 2396(36.3) 5–11 years: 2828(42.8) ≥12 years: 1382(20.9) Hispanic 5099 (77.2) Caucasian 740 (11.2) **2018** Male=3977 (57.3) Female= 2968 (42.7) 0–4 years: 1399(20.1) 5–11 years: 3223 (46.4) ≥12 years: 2323(33.4) Hispanic 5089 (73.3) Caucasian 888 (12.3) **Setting:** Children's Hospital of Orange County **Exclusion:** > 21 years old, asthma diagnosis after 2015; Cerner Standard 2017 Pediatric Asthma Registry Requirements **Attrition:** not applicable	**DV2:** Asthma action plan **DV3:** inhaled corticosteroids **DV4:** spacers	HealtheIntent database **Validity/ Reliability:** Reliability= 0.77	Mixed Models Chi Square test	**DV2:** OR =12.70, 95% CI 11.10, 14.54, p <.001 **DV3:** OR =1.85, 95% CI 8.52, 14.54, p <.001 **DV4:** OR = 1.45, 95% CI 1.31, 1.6, p < .001	easy access to NAEPP guidelines **Weakness**: diagnostic coding changed in 2015; difficult determination of patients benefitting from ICS; limited Medi-Cal patients only; reduced generalizability of one site; 4 year study questions internal validity; provider years of practice effect guideline implementation **Feasibility**: cost effective, targeted, individualized, and scalable **Application**: health policy decision making; direct impact to patient care
Stephens et al., (2021), Effect of electronic health record reminders for routine	Social contract theory	**Design:** randomized cluster cross over trial **Method:** EHR-based immunization	**N=** 15,343 **Demographics:** Male= 50.0 % Female= 49.5% Hispanic/Latino= 28%, Other=	**IV:** EHR reminder **DV1:** captured opportunities	**Tools:** Regional IIS CDS Allscripts Sunrise Clinical Manager	**Statistical Tests Used:** Chi Square test	**DV1:** 54.0 vs. 50.3% p=0.0001; difference 3.7%; 95% CI: [1.8–5.6%]	**LOE**: I **Strengths**: compared across four different sites, improved captured opportunities,

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Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
immunizations and immunizations needed for chronic medical conditions. **Country:** New York, USA **Funding:** Agency for Healthcare Research and Quality grant **Bias:** none stated, no conflicts of interest disclosed		reminder using open-source resource **Purpose:** assess impact of EHR reminders for immunizations	66.8%, White= 10.4%, Other= 83.6% Public Insurance= 94.7%, Language: English= 41.1% Spanish= 52.7% **Setting:** four community pediatric health clinics in New York, low-income, urban population **Exclusion:** none listed **Attrition:** not available	**DV2:** under-immunization **Definitions:** Captured opportunities- medical visit which PT was eligible and received an immunization Under-immunization percent overdue for CDC recommended immunization	Synchronized Immunization Notifications Survey **Validity/ Reliability:** Accuracy-verified extensively with test patients Usability- test trial conducted with small group of physicians 61% survey respondence rate, 95% somewhat satisfied with alert		**DV2:** 89.1 vs. 88.3% p= 0.16; difference= 0.8%; 95% CI: [0.3 to 1.8%]	maybe useful in settings without routine check of immunizations **Weakness**: overly complex study, low survey respondence rate, questioned accuracy of alert, not all data is depicted, experienced ceiling effect with little room for improvement, no impact on condition specific immunizations **Feasibility**: difficult to replicate **Application**: not generalizable in other settings

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Table A2

Evaluation Table for Qualitative Studies

Citation	Theory/ Conceptual Framework	Design/ Method/ Sampling	Sample/ Setting	Major Themes Studied/ Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Themes	Level/ Quality of Evidence; Decision for/ Application to practice; Generalization
Chaparro et al., (2022), Clinical decision support stewardship: best practices and techniques to monitor and improve interruptive alerts **Country:** Stuttgart, Germany **Funding:** none **Bias:** none	Alert evaluation framework Donabedian model Medical Research Council's Framework	**Method:** systematic review and cross-sectional analysis **Purpose:** preserve value of BPA via EHR, physiologic monitor, or mobile device	**Sample:** not applicable **Demographics:** not disclosed **Setting:** academic pediatric health systems **Attrition:** not applicable	(1) assess interruptive alert burden (2) reduce excessive firings (3) optimize alert effectiveness (4) establish quality governance	**Data Collection:** 1) two patient-focused denominators a. alerts/ inpatient-day b. alerts/ encounter 2) two clinician-focused denominators a. alerts/ 100 orders b. alerts/ clinician day 3)Proximal measures 4) Distal measures	No current standard metrics exist for comparison of BPA burden on EHR users or effectiveness at improving outcomes	(1) require multiple metrics for burden reduction strategies (2) alert address target quality/safety problem, examine process adherence plan-do-study-act cycles (3) identify malfunctioning alerts, gather user feedback, and human factors (4) 1-overall model approval, maintenance/review needs established 2- ensure alerts justified, establish standards 3- alert design maximize effectiveness	**LOE:** I **Strengths:** well-designed with framework depicted, identifies need for standard metrics for BPA burden on EHR users, provides holistic view, review questions knowledge check **Weakness:** no current standard metrics, no negative consequences **Feasibility:** low-cost **Application:** standardize across EHR
Souganidis et al., (2022), Physician-	Theory of acceptance	**Design:** qualitative analysis	**Sample:** (n=22) **Demographics:**	(1) BPA utilization	**Data Collection:** semi structured interviews	constant comparison analysis	(1) 32% reliance on PT characteristics:	**LOE:** V

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Citation	Theory/ Conceptual Framework	Design/ Method/ Sampling	Sample/ Setting	Major Themes Studied/ Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Themes	Level/ Quality of Evidence; Decision for/ Application to practice; Generalization
specific utilization of an electronic best practice alert for pediatric sepsis in the emergency department **Country:** USA **Funding:** not applicable **Bias:** none and declare no conflict of interest		**Method:** collected data through semi structured interviews, analyzed through iterative coding process **Purpose:** identify common reasons for acceptance/rejection of a sepsis BPA in ED & how BPA affects physician management of suspected sepsis	Male=8 Female=14 Years since completing residency: <5: 11 5–10: 1 10–15: 4 15–20: 4 >20: 2 Work at institution before protocol initiation Yes 9 No 7 **Setting:** quaternary-care children's hospital ED **Attrition:** not applicable	(2) BPA rejection (3) Management of shock protocol PT (4) Functionality of BPA **Definitions:** Sepsis- body's overwhelming response to infection with subsequent organ dysfunction	triangulation with 2 coders κ statistic for interrater reliability between the investigators and the EHR **Data Dependability:** κ statistic= 0.97		(a) preexisting conditions (b) developmental status (c) BPA strongly influenced physician decision Non-PT characteristics: (a) ED-specific factors (b) provider- specific utilization (c) BPA-specific characteristics (2) PT characteristics: (a) medical history (b) clinical presentations Non-PT characteristics: (a) work environment (b) BPA timing (3) fluid resuscitation, empiric antibiotics, illness severity, & medical history (4) incomplete understanding of	**Strengths:** thematic saturation achieved; BPA strong influence on decision making; first study of its kind to understand provider-specific practice patterns **Weakness:** physician limited understanding of BPA; 1 institution by volunteer sampling over 1 year; not all attitudes collected in sample size; may not generalize in other settings; no anonymity; no triage nurses involved **Feasibility:** low-cost **Application:** specific to this 1 institution

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Citation	Theory/ Conceptual Framework	Design/ Method/ Sampling	Sample/ Setting	Major Themes Studied/ Definitions	Measurement/ Instrumentation	Data Analysis	Findings/ Themes	Level/ Quality of Evidence; Decision for/ Application to practice; Generalization
							BPA & BPA design barriers	
McCoy et al., (2022), Clinician collaboration to improve clinical decision support: The Clickbusters initiative **Country:** Nashville, Tennessee, USA **Funding:** funding for prizes not listed **Bias:** gamification process to incentivize participants, winning Amazon gift cards 1st- $250 2nd- $150 3rd- $100	Plan-Do-Study-Act Model	**Design:** descriptive analysis **Method:** x2, three-month rounds of ten step Clickbusters program **Purpose:** improve safety & quality & reduce burnout through CDS alerts	**Sample:** n=24 Round 1 (n=8) Round 2 (n=20) **Demographics:** Not applicable **Setting:** Vanderbilt University Medical Center **Attrition:** not stated	(1) individuals or committees reviewing EHR (2) sentiment analysis of comments entered by clinicians when overriding alerts (3) anomaly detection	**Data Collection:** Atlassian Jira Epic EHR Tableau Dashboard health information technology analyst	Descriptive analysis	(1) very effective, requires high effort (2) lower barrier with build/personnel effort but limited by alerts that clinicians see/respond (3) identify alerts that no longer functioning as designed, machine learning approach	**LOE:** VI **Strengths:** ten-step process with clear instructions, found reduction in unnecessary alerts **Weakness:** requires active Physician Builder program or group of people dedicated to program **Feasibility:** easy to follow plan, must evaluated for safety & efficiency to justify cost **Application:** readily replicable, can be applied to other assets of EHR

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Table A3

Synthesis Table

Study (Author, year)	Chaparro et al., (2022)	Farmer et al., (2020)	Fierro et al., (2023)	Ghazi et al., (2022)	Lawrence et al., (2024)	Leibel et al., (2019)	McCoy et al., (2022)	Souganidis et al., (2022)	Stephens et al., (2021)	Wengryn et al., (2022)
Design	SR/CSA	Cohort Study	CSA	Cluster RCT	TSA/QEM	QI	DA	QA	RCCOT	Cohort Study
LOE	I	II	III	I	II	I	VI	V	I	II
Demographics										
Sample size	n/a	125	6606/6945	1,310	n/a	439	24	22	15,343	123
M-Age/Age range	n/a	7.4	0-20	72	n/a	n/a	n/a	0-20	0-17	3.7
% Male	n/a	80.0 %	56.7%/57.3%	69.0 %	n/a	n/a	n/a	36.36 %	50.0 %	34.1%
Setting										
USA		X	X	X		X	X	X	X	X
Hospital			X	X	X	X	X			
ED		X						X		
Outpatient/Academic	X								X	X
Interventions										
Best Practice Alert	X			X		X		X		X
EMR Alert		X	X		X				X	
Quality Improvement							X			
Common Theories										
model for improvement			X			X				
technology acceptance model theory		X			X					X
Outcomes/ Themes										
Reduction in alerts	X						X			
Alarm fatigue	↓	?					↓		↑	↑
Medication adherence		↑	↑	↑		↑				
Cost for implementation	↓	↓	↓	↓	↓	↓	↑	↓	?	↓

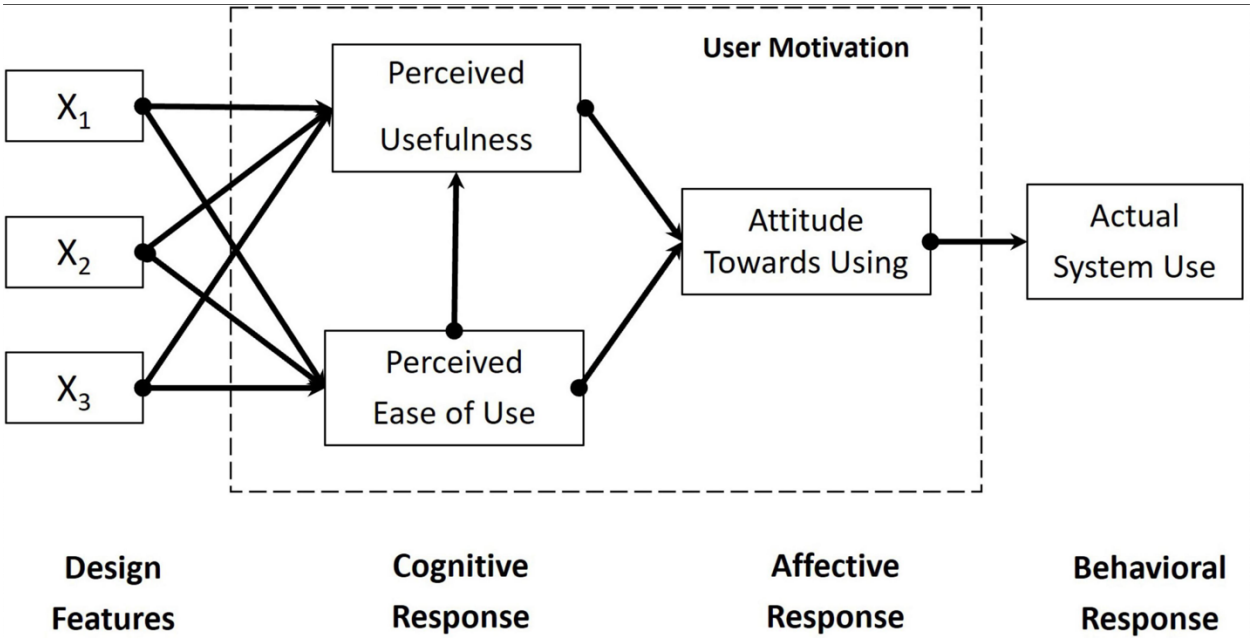
Key: **CSA** Cross-Sectional Analysis, **DA** descriptive analysis, **ED** Emergency Department, **LOE** Level of Evidence, **M-Age** Mean Age, **QA** Qualitative Analysis, **QEM** Quasi-Experimental Method, **QI** Quality Improvement, **RCCOT** Randomized Cluster Cross Over Trial **RCT** Randomized Control Trial, **SR** Systematic Review, **TSA** Time Series Analysis, **USA** United States of America, ↑ increased, ↓ decreased, ? unknown

Appendix B

Models and Frameworks

Figure B1

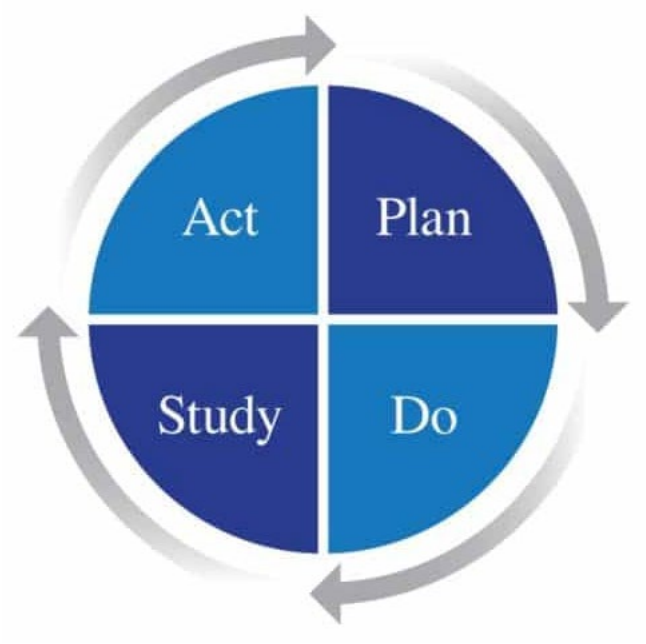
Technology Acceptance Model



(Davis, 1985)

Figure B2

The Plan-Do-Check-Act (PDCA) Cycle



(Deming, 1950)

Appendix C

Data Tools and Collection

Table C1

Chart Audit Form

Subject ID	**Age (years)**	**Groups** Pre Post	**Insurance Status:** Private Insurance AHCCCS No Insurance	**Inhaled Medication Ordered:** Yes/No	**Spacer Ordered in EMR:** Yes/No	**Spacer Ordered through medical equipment supplier:** Yes/No/UK
100						
101						
102						
103						
104						
105						

Table C2

Pre-EMR Alert Survey

Choose one of the following options for the questions below by placing a ***checkmark*** or ***"X"*** in the box that most applies.					
	Never	Rarely	Sometimes	Often	Always
How often do you follow GINA 2024 guidelines?					
How often do you order spacer devices for children ages 2-18?					
How often do you utilize a medical equipment supplier to distribute spacer devices from the office?					
How often do you send a prescription for a spacer to the pharmacy?					
How often do you check your patient's inhaler technique?					
How likely are you to order a nebulizing machine over a spacer for children under 5?					
How often do you teach proper inhaler techniques?					
How often do you educate your patients to rinse their mouths after inhalation of corticosteroids?					

Table C3

Post-EMR Alert Survey

Choose one of the following options for the questions below by placing a ***checkmark*** or ***"X"*** in the box that most applies.					
	Never	Rarely	Sometimes	Often	Always
How often do you follow GINA 2024 guidelines?					
How often do you order spacer devices for children ages 2-18?					
How often do you utilize a medical equipment supplier to distribute spacer devices from the office?					
How often do you send a prescription for a spacer to the pharmacy?					
How often do you check your patient's inhaler technique?					
How likely are you to order a nebulizing machine over a spacer for children under 5?					
How often do you teach proper inhaler techniques?					
How often do you educate your patients to rinse their mouths after inhalation of corticosteroids?					

Please describe how the EMR alert was helpful to you.

If you could change anything about the EMR alert, what would you change?

Appendix D

Budget to Improve Provider Prescribing Practices

Table D1

Direct Cost			
Item/Service	**Cost**	**Subtotal**	**Total**
Design, print, and distribute promotional materials to potential providers	$100		
Create PowerPoint for provider presentation	$200		
Design, and develop EMR Alert in eClinicalWorks	$50		
Lunch for providers and personnel at each presentation (x2)	$200		
Design and print evaluation surveys (10 of each)	$100		
Design and print spacer care handout (50)	$100		
Spacer Devices provided by medical equipment supplier	$10 per spacer	$500	$1,250
Indirect Cost			
Personnel/Service	**Cost**	**Subtotal**	**Total**
Utilize time from Director of Operations to help design and implement EMR alert in eClinicalWorks	$200		
Project site champion	$300		
Use of eClinicalWorks, already established EMR	$500		
eClinicalWorks IT Support team	$400		$1,400
Total Cost			**$2,650**

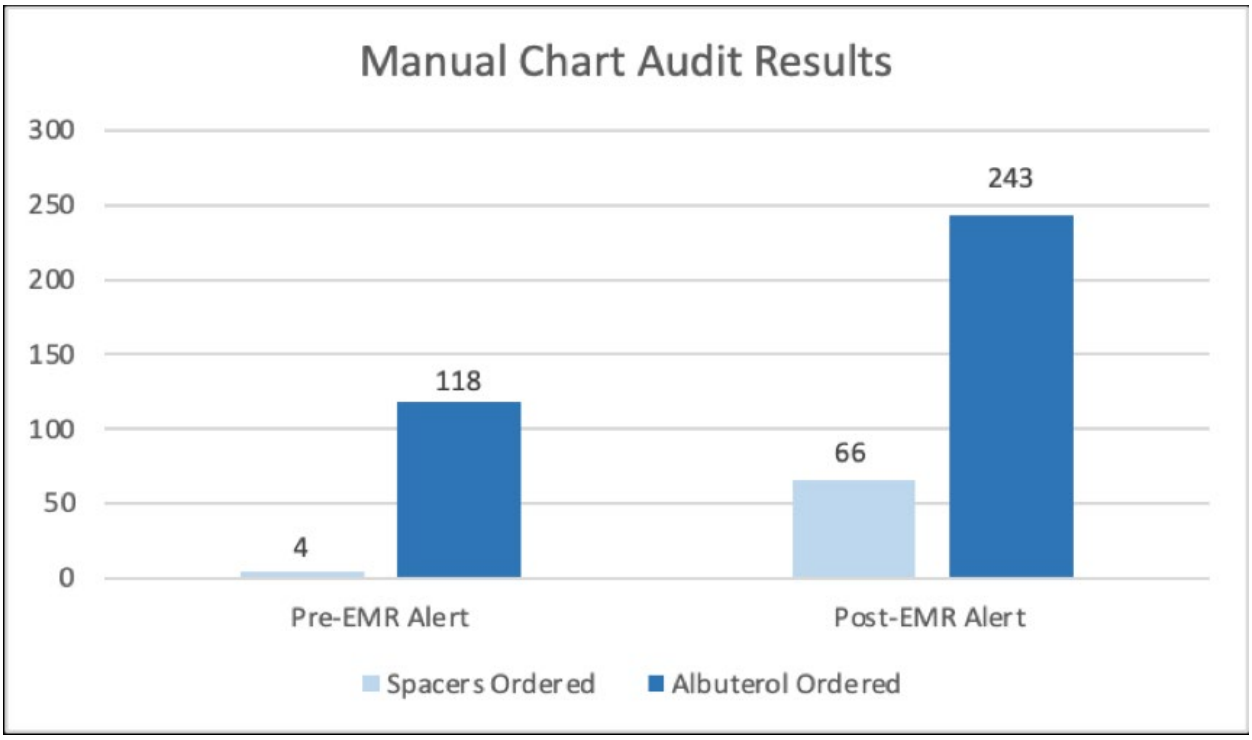
Funding Sources: The project site and the DNP student will fund this quality improvement project.

Budget Justification: Asthma in pediatrics imposes an extensive economic burden on the United States healthcare system. It has been estimated that in 2013, the total direct cost of pediatric asthma was $5.92 billion (Perry et al., 2019). Many studies have found medication adherence to be associated with cost savings. Improving inhaled medication adherence rates using an EMR alert to providers ordering spacer devices, this practice could save thousands of dollars at minimal cost, as displayed above.

Appendix E

Retrospective Chart Audit Results

Graph E1

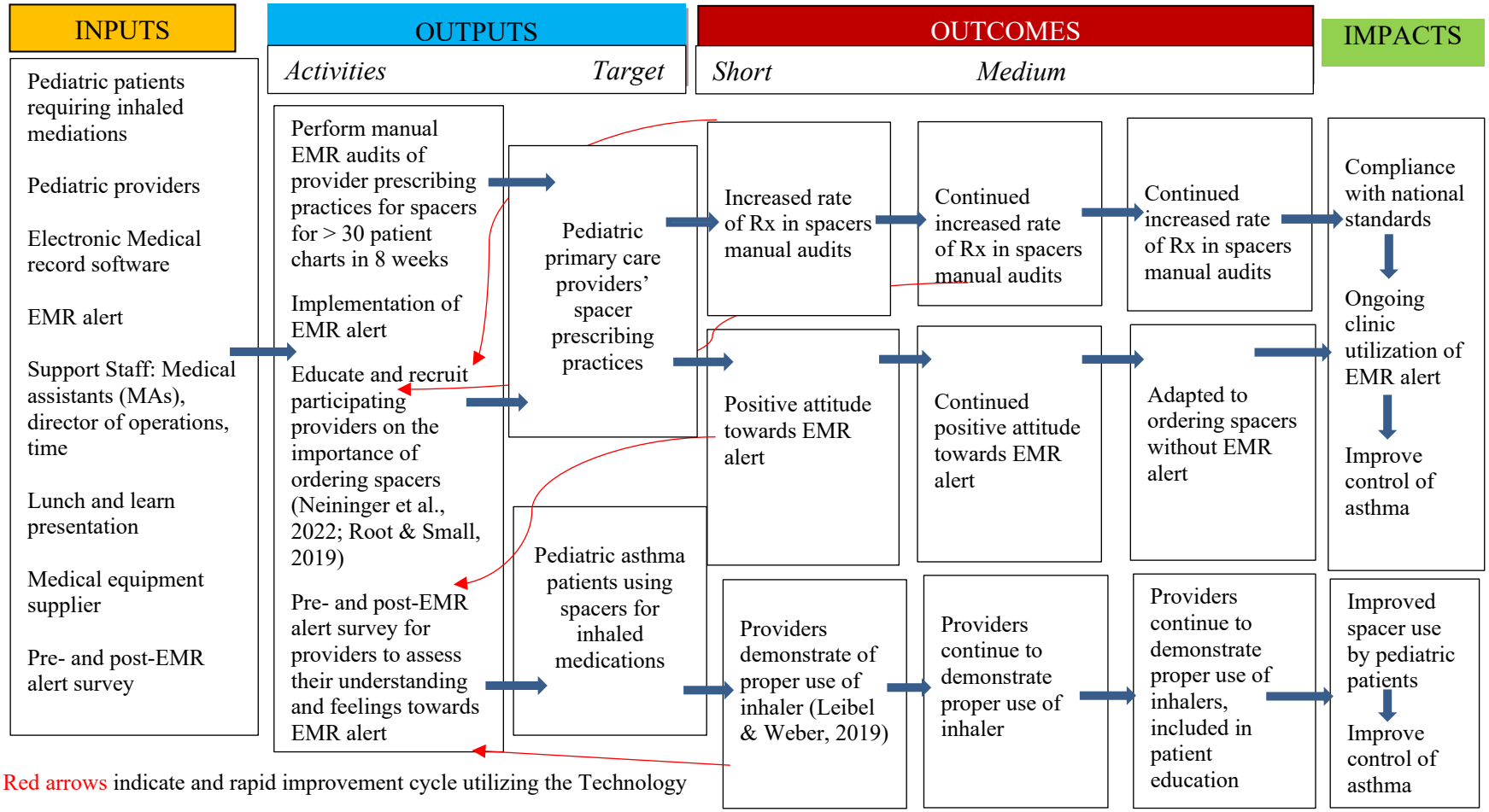


Appendix F

Logic Model: Effect of Electronic Medical Record Alerts on Pediatric Asthma Providers

Figure F1

Goals: The purpose of this evidence-based project is to investigate the effect of electronic medical record (EMR) alerts on pediatric primary care providers' prescribing practices of spacers to pediatric patients with asthma.



Red arrows indicate and rapid improvement cycle utilizing the Technology Acceptance Model Framework (Anderson, 2018; Davis, 1985).

Assumptions: Pediatric providers are receptive to the EMR alert. Pediatric providers understand and agree on the importance of spacer use for patients with asthma. The EMR alert will function appropriately and benefit providers. Pediatric providers will adapt to the EMR alert and follow recommended guidelines.