Asthma Education in Pediatrics: Instituting an Electronic Health Record Alert for Discharge

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Abstract

Inconsistent asthma discharge education in pediatric emergency departments (EDs) contributes to readmissions and increases healthcare costs. Despite existing pathways, a pediatric ED within a large nonprofit health organization showed only 24% provider adherence to asthma discharge rescue plans in 2023. This quality improvement (QI) project, using the Chronic Care Model (CCM), aims to address this gap by implementing an electronic health record (EHR) alert to improve discharge practices. The goal is to enhance provider adherence to discharge orders, increase patient education, and reduce hospital readmission rates. An EHR alert was collaboratively designed with the IT department and embedded into the system. Triggered by specific ICD-10 codes and ED asthma management pathway activation, the alert prompts providers to select appropriate discharge education, thereby improving clinical decision support. A pre- and post-implementation design, using an internal data collection tool, evaluated the alert's impact on provider adherence and 30-day readmission rates. This EHR alert is hypothesized to improve order adherence, increase patient education, and decrease hospital readmissions. A two-tailed Wilcoxon signed-rank test yielded significant results ($p = .012$), indicating that standardizing asthma rescue plans in the ED leads to a clinically significant reduction in asthma-related hospital readmissions. Integrating this alert, guided by the CCM, standardized processes, improved care quality, and enhanced care transitions by optimizing asthma discharge education.

Keywords: asthma, pediatric, alert, EHR, adherence

Asthma Education in Pediatrics: Instituting a Clinical Practice Alert for Discharge

Asthma is a worldwide problem that brings millions of children to the emergency department (ED) every year. Billions of dollars are spent managing and educating these patients and families. Many hospitals have instituted a standardized treatment pathway for asthma in the ED, but access to essential, consistent discharge education for patients is lacking. Working with providers to improve asthma discharge order adherence may decrease patient readmission rates and develop long-term health benefits.

Problem Statement

Asthma is a chronic respiratory disease that affects around 300 million people worldwide and is the most burdensome chronic disease in children (Dharmage et al., 2019; Ferrante & La Grutta, 2018). According to data from the Centers for Disease Control and Prevention (CDC), approximately 18.7% of cases are in children, with 15.3% being below the poverty line (CDC, 2022). Despite increased research and standardized asthma treatment in children, asthma is still the leading cause of ED visits annually. Direct costs to the healthcare system for pediatric asthma management and treatment account for 50-80% of the total cost, which was approximately $5.92 billion in 2013 (Perry et al., 2018). In Arizona, approximately 15% of the population suffers from asthma, and if under the poverty line, the rate increases to 20.7% (Arizona Department of Health Services (AZDHS), 2022). Within the last decade, numerous resources have been implemented to improve the diagnosis, treatment, and education of patients suffering from asthma.

Asthma education has evolved but is still significantly lacking at ED discharge (Davis & Fitzmaurice, 2020). Several educational factors must be addressed, including environmental exposures, genetic susceptibility, and host factors, all correlated causes of asthma exacerbation (Dharmage et al., 2019). The concerns surrounding asthma education in the ED include time, consistency of the material, and parental/patient knowledge retention (Davis & Fitzmaurice,

2020). Having an asthma discharge plan that provides clear and detailed information to every patient is vital in decreasing readmission rates.

Background and Significance

Asthma is a chronic, non-communicable respiratory disease that disproportionately affects children (Dharmage et al., 2019; Perry et al., 2018). Asthma can lead to changes in the development of their airways and reductions in overall lung function, which can persist into adulthood (Dharmage et al., 2019). Children are also at higher risk for other comorbidities and infections, which could worsen their asthma symptoms (Dharmage et al., 2019). These factors make managing and treating asthma in the pediatric population more challenging. Education related to medication adherence, effective provider communication, and timely interventions are the most critical aspects of managing asthma long-term (Rehman et al., 2020). Improving asthma discharge education will decrease care burdens and associated costs for the patients and the healthcare system (Perry et al., 2018).

Providers and the EHR

The population of interest in implementing better adherence to asthma discharge plans is the ED providers. They are responsible for inputting orders and creating a safe environment to educate patients (Lee et al., 2020; Rehman et al., 2020). Two studies discovered the provider's role is to explore methods and interventions that ensure clear asthma education is delivered to the patient or caregiver. Variables affecting a provider’s ability to disseminate asthma education include time constraints, lack of resources, and ineffective communication (Rehman et al., 2020). To provide proper asthma management and education, the child’s circumstances, including age, financial burden, follow-up procedures, and medication adherence, should be considered (Lee et al., 2020; Rehman et al., 2020). Providing comprehensive education to families has demonstrated a decrease in readmission rates (Dilts et al., 2018; Lee et al., 2020). Provider experience and work location should also be considered.

Level of expertise can affect ordering preferences, and different clinical settings can affect resources, costs, and time (Dilts et al., 2018; Hartford et al., 2020).

The EHR is also an important tool that should be used to support providers in standardizing asthma education by using pre-programmed education materials and order sets specific to the disease process. Advancements in EHR technology now allow these materials to be readily available and easily included in the visit discharge handouts. According to Kaiser et al. (2020), the evaluation of 64 EDs showed increased asthma guideline adherence in the following areas: asthma triage severity, corticosteroid prescribing, and discharge protocols. They also found changes in adherence were unrelated to feedback, auditing, or department readiness (Kaiser et al., 2020). Focusing on EHR education and standardizing discharge education with providers can normalize processes, streamline and improve the quality of care, decrease medical errors, and reduce lengths of stay (LOS). (Banker et al., 2022; Dilts et al., 2018; Farmer et al., 2019).

Electronic Health Record Alert

Instituting an EHR alert when providers are discharging patients could mitigate missing documentation, increase provider-patient education adherence, and ensure timely completion of documentation or prevent inaction (Banker et al., 2022; Elliman et al., 2020). EHR alert implementations may differ for each organization, but collaboration with the information technology (IT) department to create these EHR-embedded alerts when specific orders are placed by providers or pertinent patient parameters are documented helps to improve asthma care (Dilts et al., 2018; Farmers et al., 2019). Many studies triggered the alert when the asthma action plan or asthma management pathway was ordered or initiated (Dilts et al., 2018; Farmers et al., 2019; Johnson et al., 2018). Collaboration is required with the IT department to integrate the alert into the EHR. The alert will need to be embedded into the system with diagnosis ICD-10 codes and active ED asthma management pathways. Nowhere in current research has this

discharge alert been instituted. This is essential in a department with an action plan but not ordering it.

Addressing the need for follow-up care in the outpatient setting during discharge is also a common finding across the literature (Banker et al., 2022; Global Initiative for Asthma (GINA), 2023; Global Asthma Network (GAN), 2022). Integrating an alert into the EHR will bring attention to the individualized asthma action plan (IAAP). Most research suggests that IAAPs include a referral to pulmonology, address the primary care provider, and coordinate initial asthma prescriptions from the ED (Banker et al., 2022; Farmers et al., 2019; Johnson et al., 2018). Newly diagnosed asthmatics must establish care outside of the ED for their long-term management. Ensuring patients have access to a primary care provider or specialist outside of the ED can improve their access to medication and adherence to prevention medication regimens.

Current Discharge Methods

Many healthcare facilities have instituted individualized asthma action plans, encouraging increased outpatient visits for improved long-term adherence (Dilts et al., 2018; Elliman et al., 2020; Farmers et al., 2019). Currently, basic educational handouts are being used with brief teaching by the nursing staff. Healthcare facilities must have an educational curriculum that is patient-focused and designed for support at home (GAN, 2022; GINA, 2023). According to GINA (2023), it is also advised and generally accepted to have a shared decision-making partnership with the patient or family to provide education at their literacy level. Increasing the level of education at discharge through individualized action plans is recommended in several studies because it is made based on the patient's current asthma status and need for medications (Farmer et al., 2019). These plans can be with different learning methods, including videos, written material, and provider-guided (GINA, 2023).

Improved Adherence

The goal of educating providers and implementing a discharge alert for patients with asthma is to improve order adherence and increase patient knowledge. Improving patient knowledge will result in enhanced home management and reliable outpatient care that can decrease repeat visits to the ED. Embedding an alert into the EHR at discharge increases the patient's access to education on medication adherence, follow-up care, and symptom recognition before discharge (GINA, 2023). The literature shows that incorporating an alert into the EHR is beneficial by improving provider adherence to order sets, decreasing the length of stay, improving patient medication prescription rates, and decreasing patient readmissions (Dilts et al., 2018; Drewek et al., 2018; Farmers et al., 2019; Hartford et al., 2020; Johnson et al., 2018).

Internal Data

A pediatric ED within a large nonprofit health organization in the greater Phoenix area found that it was non-adherent in ordering its asthma discharge rescue plan. Provider adherence and accessibility to the discharge education rescue plan were identified as the primary concerns. Lack of staff participation and provider resistance also contribute to the problem. The associate director of the ED was internally auditing and found poor adherence to provider-ordered discharge education pathways for asthma patients. Internally, the soft data reflected increased asthma readmissions within 60 days of discharge. With an acute asthma management pathway and written discharge rescue plan education in place, readmissions can be avoided. The hard data confirmed this: the average asthma rescue discharge education use was 24% in 2023. Annual improvement from 2022 to 2023 was 3% but did not meet their benchmark standard of 50%. This data assumes that a lack of education from staff to families across all socioeconomic backgrounds results in return visits. It is currently unclear what asthma education is being provided to families.

PICO Question

A review of the literature led to the clinically relevant PICO question: Among the providers in a pediatric ED (P), how does implementing an alert for asthma discharge into the EHR (I), compared with no intervention (C), affect patient education and readmission rates in patients with asthma (O)?

Search Strategy

A vigorous review of the literature was performed to answer the PICO question. The following databases were used: PubMed, ProQuest, and Cumulative Index of Nursing and Allied Health Literature (CINAHL). These databases were selected for their relevance to the topic, rigor, and extensive compilation of trustworthy resources. They have strict criteria and contain the highest levels of evidence, including systematic reviews. This is fundamental for producing high-quality information to guide evidence-based practice.

Keyword Selection

A combination of keywords was used to search the databases to yield high-quality results specific to the PICO question. The keywords for the population included: *provider(s), emergency department (ED) provider(s), emergency department (ED), pediatric emergency department (ED), pediatric, electronic health record (EHR),* and *electronic medical record (EMR).* The keywords for the intervention included: *discharge, asthma, asthma discharge, discharge protocol, protocol, alert, clinical practice guideline (CPG), asthma clinical practice guideline (CPG), asthma education, discharge education, discharge alert,* and *clinical practice guideline (CPG) alert.* The keywords for the outcome included: *asthma education, compliance, adherence, education, admission, discharge education,* and *patient readmissions*. Medical subject headings and Boolean connectors “AND” and “OR” were used further to narrow the search for relevant, high-level data.

Initial and Final Search Yields

The initial search of PubMed yielded 956 results using the key terms: (*clinical practice guidelines), asthma,* and *education*. Additional keywords narrowed the results. The final search produced 53 results using the following terms: *pediatric, (emergency department), (clinical practice guidelines),* and *asthma*. This strategy was used for the other databases. The initial search of ProQuest yielded 266 results using the following terms: *pediatric, (emergency department), (clinical practice guidelines),* and *asthma*. The final search produced 77 results using the keywords *provider, (clinical practice guidelines), (asthma education),* and *pediatric*. The initial search of CINAHL yielded 43,611 results using (*clinical practice guidelines).* The final search generated 31 results with the following keywords: *(asthma education)* and *(emergency department).* The CINAHL database required a broadened search with fewer keywords because there were zero results with multiple keywords or phrases.

Full-text copies of these final yield studies were obtained and reviewed for relevance and appropriateness. A gray literature database search (Google Scholar) was also performed, but these resources were not chosen for the final yield because of their low level of evidence or inability to find full peer-reviewed articles. The final yield studies were further evaluated using the Rapid Critical Appraisal Checklist to limit to the 10 most pertinent and high-quality studies. These included one prospective study, two retrospective studies, two observational studies, one systematic review, one meta-analysis/systematic review, one randomized pilot study, and two randomized control studies.

Limitations, Inclusion, and Exclusion Criteria

Inclusion, limitations, and exclusion criteria were consistent across all databases. The inclusion and limitation criteria included: English language, human species, full text, clinical trial, quality improvement, randomized control trial, and peer-reviewed. Exclusion criteria included no relation to asthma diagnosis and any studies with a publication date beyond the last five years.

Landmark studies were included irrespective of the publication date. The most vigorous and relevant data was collected using these criteria.

Critical Appraisal and Synthesis of Evidence

Rapid critical appraisal tools by Melnyk and Fineout-Overholt (2023) were used to evaluate each study's quality, rigor, and strength of evidence. Only quantitative studies were included (see Appendix A, Table A1). Qualitative studies were not evaluated in this setting and population and thus were omitted. The results of the studies support that improving asthma education in the pediatric ED has an overwhelming impact on the patient, provider, and healthcare system. The strength and quality of the research were validated by numerous studies using the highest levels of evidence, as shown in the synthesis table (see Appendix A, Table A2). The findings reflect the value of pediatric ED discharge asthma education in improving patient outcomes while decreasing the burden on the healthcare system.

There were some gaps in the research surrounding this topic since no studies were found that evaluated a discharge alert for asthma education in the pediatric ED setting. Broader searches were completed to establish the efficacy of asthma education in the ED and the use of alerts in the EHR to support providers with order-set adherence. The evidence was strong, with studies at levels three or above, to support the implementation of an alert intervention for asthma education.

The evidence synthesis was primarily in a pediatric ED setting, with two studies comparing ED care to the inpatient/ICU settings. The subjects were typically between the ages of 2 and 17, with one study evaluating the providers. The children were primarily male and Hispanic, and all of the children had an asthma diagnosis or used the asthma pathway while in the ED. Most of the studies were completed in the United States, with one randomized control trial (RCT) and data from both meta-analyses/systematic reviews being international.

Across the studies, no specific framework was used, but the central theme addressed quality improvement in the pediatric ED setting. The major independent variables included instituting a clinical practice alert in the ED, implementing a written asthma action plan at discharge, and evaluating providers' asthma order-set adherence. The primary dependent variables included decreased ED visits, improved controller medication prescribing, and enhanced provider ordering adherence. These variables were collectively homogeneous. The findings demonstrated decreased ED visits or readmissions, improved prescribing of controller medications, and improved provider ordering adherence for patients with asthma.

The overall strengths of these studies include minimal to no bias, quality improvement studies with positive results of CPGs in the ED setting, and improved patient and provider outcomes. Several weaknesses were noted, including single-location studies, poor long-term tracking of intervention effectiveness, and provider variability. This can be partly attributed to several studies being driven by internal quality improvement processes and provider preference or practice techniques not being recorded. It is important to note that reliability and validity were not shared in these studies. Across the studies, most denied bias except for two that reported possible recall bias. The systematic reviews also mentioned possible publication bias but did not elaborate.

Discussion

Current literature confirms asthma education in the pediatric ED setting is lacking. To address this problem directly, research has proven that EHR alerts are effective at notifying providers to use the correct education plan and that individualized asthma education at discharge improves patient outcomes. Therefore, instituting an EHR alert in the ED setting will promote the use of current asthma discharge orders, thus increasing provider adherence and improving asthma education for families.

Purpose and Rationale

Asthma is not only a burden to the patient and their families but to the healthcare system. The costs associated with asthma are billions annually. Education is lacking once a child is discharged, which leads to readmissions and worsening symptoms. Treatment protocols have been implemented successfully over the past decade, but post-discharge home education needs improvement. Education must cover several things, including environmental exposures and personal factors that take time and lifestyle changes. Ensuring staff have the correct protocol, time, and consistency is vital in reducing patient returns. This paper aims to develop an electronic health record (EHR) alert at discharge to ensure providers activate the correct education plan for children with asthma. This should improve asthma education adherence, decrease ED visits, and reduce the cost burdens to families and the healthcare system.

Theory/Theoretical Framework Application

The evidence-based practice model implemented for this research is the Chronic Care Model (CCM) by Edward Wagner (Wagner, 1998). This model assumes that providers are the main point of care with assistance from the support staff (Wagner, 1998). According to Wagner (1998), self-management support and community resources are needed in conjunction with a healthcare organization using decision support, delivery system design, and clinical information systems to interact and create informed patients and skilled teams for care (see Appendix B, Figure B1). This model applies to this project because asthma is a chronic condition that burdens the healthcare system. By using CCM, correcting a discrepancy found in the pediatric ED could improve the organization’s adherence to providing asthma education to all patients and improve patient/caregiver understanding of the disease process. This can also decrease the burden of chronic disease on the healthcare system. The goal is to improve this disparity by measuring the rate of order sets used and patient readmission rates and then deduce if the implementation was successful in reaching these goals.

Implementation Framework

The PDSA Model, developed by W. Edwards Deming, is a systematic process for quality improvement commonly used in healthcare (The Deming Institute, 2021). It is a four-part framework used to develop, test, and implement change following the steps of proposing an idea, implementing change, analyzing the results, and adopting that change or repeating the cycle (see Appendix B, Figure B2). The PDSA framework perfectly applies to the implementation of this project by using a systematic approach to analyze and review performance. A review of the current literature produced evidence to support a plan to implement an asthma alert in the EHR. The alert will be integrated into the EHR and triggered for patients who meet the criteria upon discharge. ED providers will receive education before this alert integration. Data will be collected over six months following implementation and analyzed for effectiveness. Based on the results, the site will adopt the new alert or identify further areas for improvement and repeat the PDSA cycle to improve asthma discharge compliance.

Implications for Practice Change

The evidence from this synthesis (see Appendix A, Table A2) guides the implementation to alter the asthma discharge process for pediatric patients in the ED. This intervention will be addressed in a single, urban pediatric ED within a large healthcare organization. Specific steps for plan initiation include three key stakeholders: the associate director of the ED, the asthma educator, and the providers within the ED implementing the changes. These stakeholders will be able to implement and sustain the changes to ensure long-term success.

The proposed intervention is implementing an EHR alert when a child with asthma is discharged to guarantee proper asthma education and resources are being delivered to the families. This alert will notify the provider to place orders for individualized asthma education. This will trickle down the department, from provider to staff, then to the patients and families.

The goal is to have more providers consistently ordering the asthma rescue discharge plan, which will also improve patient education. With the help of IT, the alert will be embedded into the EHR and activate when trigger terms are entered. The trigger terms include asthma, reactive airway disease, and/or exacerbation. This plan is cost-effective for the organization, and the audit process will not change to evaluate the intervention's strength. Education will be provided to the ED staff via on-site educational sessions, and infographics will be posted to update them on the process change.

Implementing an EHR alert at discharge for asthma patients in the pediatric ED will benefit the organization by streamlining the workflow and significantly improve the chronic care of asthma patients in Arizona. This can easily be implemented in other ED settings worldwide with a discharge asthma action plan already in place. This alert would reduce the direct costs to organizations that have repeat visits for asthma exacerbations and the community by improving access to medication, follow-up care, and symptom management.

Ethical Considerations

Informed consent is not required for this project because the population being evaluated is the providers. Implied consent will be obtained through completing the education session. This project does not require patient consent, as protected health information (PHI) will not be violated. The project site Research Determination Committee approved this quality improvement project on September 12, 2024. The Institutional Review Board (IRB) at Arizona State University reviewed the project methodology to ensure that ethical principles are followed and participants' human rights are protected. IRB approval exempt status was given on November 8, 2024.

Setting

This quality improvement project is set in a large, urban pediatric ED in the Southwestern United States. The pediatric ED sees over 50,000 infants, children, and adolescents each year for various urgent and emergency needs, including asthma

exacerbations. It is a nonprofit organization that aids underserved populations and gives back to the community. This organization uses the Cerner EHR system, which is already familiar with EHR alerts for high-risk medications and contraindications. Adding an alert into the EHR for asthma rescue discharge education should improve outcomes.

Participants

The participants of this study include pediatric ED providers who ordered the asthma discharge rescue plan. This consists of all of the current medical doctors (MD/DO), nurse practitioners (NP), and physician assistants (PA) who work full-time, part-time, or as needed in the department. No providers will be excluded from this study to reduce bias. Recruitment will be via mandatory one-on-one education sessions. The ED leadership will send an email inviting participants to participate and give an overview of the project. Education will be completed via an in-person education session. Accounting for each provider will be confirmed by comparing providers who attended the education sessions with a list of providers who care for the project population. Flyers of the alert will also be placed on the unit to provide information related to the process change. This method was chosen to give the providers direct contact and new education on the alert process to improve the understanding of “who, what, why.” This method also allows the providers to ask real-time questions and participate in the implementation process.

Pediatric patients with asthma will also be participants in measuring secondary outcomes. To meet inclusion criteria, participants must be diagnosed with asthma and be under 18 years old. There is no differentiation between cases that arrive via personal vehicle, ambulance or transfer from an outside facility. Exclusion criteria include critical condition (ESI 1/Red) and hospital admission.

Intervention

SmartZone Alert

The alert will trigger for all asthma-related ICD-10 codes (see Appendix D) and when the asthma treatment pathway is ordered in the ED for active asthma exacerbation management. This will ensure all asthma patients are receiving the alert. The prompt will state [Select “BH Asthma Child with ED Rescue Plan” Patient Education. Click for Information.] A SmartZone alert will appear on the side of the screen in a blue box with medium urgency. The alert only applies to children 18 and younger who are receiving care in the ED, and the alert will be dismissed if education is already selected. The hyperlink for more information assists ED providers in navigating to the correct education tab and selecting it as a favorite. The following steps are: 1. Navigate to the Discharge/Admit tab in Provider View 2. Add Acute Asthma Exacerbation to the problem list 3. Choose BH ASTHMA Child with ED Rescue Plan, which will be the first suggested patient education for “Acute asthma exacerbation” 4. Click the star to make it a favorite for easy access in the future.

Alert Integration

Alert integration will answer the following evaluation question: After project implementation, was there an increase in asthma rescue discharge plan adherence by the providers and a decrease in patient hospital readmission rates? An SBAR report (situation, background, assessment, and recommendations) presentation was given to the Emergency Medicine (EM) CHaRGe Committee to receive organizational support. The board had to approve the alert design for the ED, and the meetings were held bimonthly. The presentation was based on the following SBAR: S—current poor discharge rescue plan adherence and the concerns that asthma burdens the healthcare system. B—Internal evidence showed that correct education use was only approximately 24% in 2023. Annual improvement from 2022 to 2023 was 3%, but not meeting their benchmark standard of 50%. A—evidence synthesis of the literature (see Appendix A, Tables A1 and A2): 10 high-level studies evaluating providers and children with asthma in the pediatric ED setting receiving asthma education instituting an EHR

alert in the ED, implementing a written asthma action plan at discharge, evaluating asthma order-set adherence by providers showed improved ordering adherence by providers, decreased ED visits, and enhanced controller medication prescribing. The main takeaway is all studies found the alert to be a significant support tool in the ED. R— Integrate an alert into the EHR for providers to order asthma education. IT specialists would be contacted quickly after committee approval to complete the alert design and integrate it into the Cerner EHR. After approval, IT will have full authority over the timeframe of alert integration completion for project implementation. This will affect the duration of data collection.

Data Collection

Data will be collected using Tableau and Power BI, the organization's current analytics tools. Licenses were obtained for Tableau and Power BI, neither of which require validity or reliability. The outcomes to be measured include provider adherence rates to the asthma discharge rescue plan and asthma hospital readmission rates. These outcomes were chosen to model the CCM by creating an informed patient and a prepared, proactive healthcare team. They also represent CCM by promoting the provider-patient partnership. The outcomes will be compared before and after alert integration. Data will be selected before implementation based on the same months from the previous year to ensure a similar seasonal effect.

Monthly data will be collected for the 30-day readmission rate (pediatric asthma-pediatric inpatient) and the asthma rescue plan discharge instructions utilization rate (pediatric asthma-pediatric ED) measures recorded by the asthma educator and documented on the paper data collection form. This data will be gathered from Tableau Clinical Reporting and Analytics and Power BI. Pre-alert data will be collected from December 1, 2023, through February 29, 2024, to compare with post-implementation data collection from December 1, 2024, through February 28, 2025, at monthly intervals. This will assess the effectiveness of the alert on providers regarding ordering the "BH Asthma Child ED Rescue Plan" education for patients with asthma upon

discharge. All chart audit information will be de-identified, ensuring no PHI will be collected. Data will be stored on a locked computer in an encrypted file. This information will be retained for approximately one year after project completion for organizational or publication needs.

Data Analysis Plan

Data analysis for the quality improvement project will occur after receiving all data. The Intellectus data analytics tool and descriptive statistics will be used to analyze the data. The asthma educator will provide the data for the 30-day readmission rates and asthma rescue plan discharge instructions utilization rates for all pre-and post-implementation dates from December 1, 2023, to February 29, 2024, and December 1, 2024, to February 28, 2025.

Budget

There is no budget for this quality improvement project. The project site provided all funding (see Appendix C, Figure 1).

Results

This project examined the impact of an alert intervention on ED asthma rescue plan use at discharge and 30-day hospital readmission rates. Pre-intervention data from patients in December 2023, January 2024, and February 2024 were compared with post-intervention data from December 2024, January 2025, and February 2025. Descriptive statistics were used to summarize the data. A two-tailed Wilcoxon signed-rank test was conducted to determine whether the observed differences between ED asthma rescue plan use at discharge and 30-day hospital readmission rates from pre- to post-intervention were statistically significant. This non-parametric test is suitable for comparing two related samples without assuming a normal distribution (Conover & Iman, 1981).

Descriptive Statistics

Summary statistics for patients who received the asthma rescue plan at discharge and those readmitted with asthma within 30 days were calculated for the pre-intervention period.

The average number of patients who received the asthma rescue plan was 25 (SD = 7.09), ranging from 19 to 33. The average number of patients readmitted with asthma within 30 days was 3 (SD = 1), ranging from 2 to 4. Results are summarized in Appendix C, Figure 2 (see Table 1).

For the post-intervention period, summary statistics were calculated for patients receiving the asthma rescue plan at discharge and those readmitted with asthma within 30 days. The average number of patients who received the asthma rescue plan significantly increased to 62 (SD = 27.06), ranging from 34 to 88. Simultaneously, the average number of patients readmitted with asthma within 30 days decreased to 0.67 (SD = 0.58), ranging from 0 to 1. Results are summarized in Appendix C, Figure 2 (see Table 2).

Two-Tailed Wilcoxon Signed Rank Test

The two-tailed Wilcoxon signed-rank test results were significant at an alpha value of .05, V = 36, z = -2.52, p = .012. This indicates that the differences between the number of patients receiving an asthma rescue plan at discharge and those readmitted with asthma within 30 days are unlikely due to random variation. The median number of patients receiving the asthma rescue plan at discharge (Mdn = 49) was significantly larger than that for patients readmitted within 30 days (Mdn = 2). These findings suggest that standardizing asthma rescue plans in the ED results in a clinically significant reduction in asthma-related hospital readmissions. Boxplots illustrating the relationship between asthma rescue plan use at discharge and 30-day readmission rates are shown in Appendix C, Figure 3.

Implementing the SmartZone alert had significant effects on the healthcare system. It improved patient self-management, increased the use of written asthma action plans, and significantly reduced asthma-related readmissions within 30 days, leading to better health outcomes and quality of life. Providers saw improved patient adherence and more effective asthma management, facilitating earlier interventions and decreasing acute care visits. The alert

reduced hospital readmissions and associated costs, easing the burden on healthcare resources and improving system efficiency. These findings support new policy initiatives that promote standardized asthma discharge planning and education, aligning with quality improvement and readmission reduction goals.

Several key strategies must be implemented to maintain the alert's sustainability. Continuous engagement with essential stakeholders is vital for ongoing support and adherence to proper standardized asthma discharge education. Areas for improvement should be identified when analyzing asthma education and readmission data to assess the alert's effectiveness. Collaborating with other healthcare organizations to create a standardized asthma discharge care network could facilitate broader implementation and integration of sustainability. Incorporating the EHR alert into standard operating procedures and emphasizing its role in reducing readmission rates could enhance long-term success. These strategies may secure the project's ongoing benefits, leading to consistent, high-quality asthma care and better patient outcomes.

Discussion

This project has several limitations. One significant limitation is that no prior studies have focused on evaluating a discharge alert tailored for asthma education in pediatric EDs. Although existing literature supports asthma education in the ED and the implementation of EHR alerts to enhance provider adherence, no research has explicitly addressed the effects of a discharge alert in this context. Consequently, conclusions must be drawn from studies with slightly different aims, which may limit the direct relevance of their findings. Furthermore, pediatric ED return visits were not closely tracked, making it challenging to establish a direct link between the intervention and ED return rates. The alert's start date was delayed to December 18, 2024, potentially skewing early post-intervention results from December 1 to the 17th. The organization also transitioned from Tableau to Power BI for internal data analytics, which could

introduce inconsistencies in data evaluation. The alert has a limited scope, relying on provider-driven order entry rather than patient comprehension or guarantee of education delivery.

The findings align with existing literature emphasizing the importance of asthma education at ED discharge (Davis & Fitzmaurice, 2020). The literature review supports that improving asthma education in the pediatric ED has an overwhelming impact on the patient, provider, and healthcare system. The studies included in the review validate the value of standardizing asthma education at discharge, which improves patient outcomes while decreasing the burden on the healthcare system. Addressing the need for follow-up care in the outpatient setting during discharge is also a common theme in the literature (Banker et al., 2022; GAN, 2022; GINA, 2023). Studies also show that providing comprehensive education to families has decreased return visit rates (Dilts et al., 2018; Lee et al., 2020).

Future research should evaluate the impact of implementing a discharge alert for asthma education in the pediatric ED setting. Studies could explore the effectiveness of different alert designs and implementation strategies and their impact on provider behavior and patient outcomes. Research should investigate strategies to address barriers such as time constraints, lack of resources, and ineffective communication, which were identified as factors affecting providers' ability to disseminate the correct asthma education (Rehman et al., 2020). Exploring the role of interprofessional collaboration and shared decision-making in improving asthma education and adherence to discharge plans would also be beneficial.

In conclusion, while existing research supports the importance of asthma education and the use of EHR alerts, there is a gap in the literature regarding the specific application of discharge alerts in the pediatric ED setting. This project demonstrated that an EHR alert can improve provider adherence to asthma discharge education, enhance patient understanding of the disease, and reduce readmission rates. However, further research is needed to address the identified limitations and challenges while optimizing the alert design and integration. By

addressing these gaps and challenges, healthcare providers can strive to enhance the quality of care for children with asthma while alleviating the burden of this chronic disease on patients, families, and the healthcare system.

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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
Farmer et al., (2020). Inhaled corticosteroids prescriptions increased in the ED for recurrent asthma exacerbations by automated electronic reminders in the ED. **Country**: USA **Funding**: None noted **Bias**: Provider financial incentive with >75% ordering rate	Lewin's Model of Change	**Design:** Prospective study **Purpose:** Evaluate the impact of the electronic alert on the Rx rate of ICS by ED providers for poorly controlled persistent asthmatic children	**N=** 125 children **Demographics:** • Mean age 7 • Male • Hispanic • Medicaid insurance • Not Admitted • Not using ICS **Setting:** Pediatric ED, Arizona **Exclusion:** Comorbid conditions: DD, BPD, CF, SCD, ILD **Attrition:** None noted	**IV1:** Clinical decision electronic alert in the ED **DV1:** Prescribed ICS **DV2:** Rate of ICS Rx **DV3:** ED asthma visits	**Tools:** • SAS software (Version 9.4) • The R program (R Core Team (2018) **Validity/ Reliability:** • All statistical tests were 2-sided with significance evaluated at the 5% level. (*p*-value of < 0.05 was considered statistically significant).	**Statistical Tests Used:** • The Fisher exact • The Fisher–Freedman–Halton test • The Kruskal–Wallis test	**DV1:** N=48. Estimated at 77% **DV2:** 0.77 **DV3:** N=62; P<0.0001	**Level of Evidence**: Level II, primary study **Strengths**: • Effective electronic alert • Increased prescribing of ICS • Decreased readmissions **Weakness**: • Unable to track Rx fill rates • Frequent provider rotations • Incentive only for attending providers • Non-ICS Rx reasons missing **Conclusion**: Electronic alert for ICS Rx is effective *More studies needed currently
Drewek et al., (2018). Asthma treatment and outcomes for children in the	Supply chain integration model	**Design:** Retrospective study **Purpose:**	**N=** 287 children **ED** N= 106 **ICU** N= 47 **Unit** N= 134	**IV1:** Compare ICS management across areas **DV1:** Previous ED visit	**Tools:** • SAS software (Version 9.4) **Validity/**	**Statistical Tests Used:** • Fisher exact test	**DV1:** ED = 88% ICU = 68% Unit = 60% P = <0.0001	**Level of Evidence**: Level III, primary study **Strengths**:

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emergency department and hospital. **Country**: USA **Funding**: None noted **Bias**: None noted		To compare asthma treatment across units (ED, ICU, unit).	**Demographics:** • Mean age 8.4 • Male • Hispanic • Medicaid insurance **Setting:** Pediatric Hospital, Arizona—ED, ICU, Unit **Exclusion:** Comorbid conditions: DD, BPD, CF, SCD, ILD. Age <5. **Attrition:** None noted	**DV2:** Previous Pulmonology consult **DV3:** ICS initiation Or step-up **DV4:** Readmission	**Reliability:** • All statistical tests were 2-sided with significance evaluated at the 5% level (*p*-value of < 0.05 was considered statistically significant).	• The Kruskal–Wallis test	**DV2:** ED = 30% ICU = 15% Unit = 19% P = 0.05 **DV3:** ED = 1.9% ICU = 72% Unit = 54% P = <0.0001 **DV4:** ED = 77% ICU = 40% Unit = 42% P = <0.0001	• Compares multiple locations and treatments **Weakness**: • Severity and acuity of asthma onset in ED • Addressing outpatient needs • Pulmonology referral/follow-up concerns **Conclusion:** Preventative care and education start in the ED during visits. Initiate ICS treatment
Johnson et al., (2018). Implementation and improvement of pediatric asthma guideline improves hospital-based care. **Country**: USA **Funding**: None noted **Bias**: Ms. O'Kelley has provided paid expert	Lewin's Model of Change Plan-Do-Study-Act model	**Design:** Observational study **Purpose:** Implement a pediatric asthma CPG to improve ED, inpatient care, and ICU outcomes.	**N=** 7116 **Pre** = 3650 **Post** = 3466 **Demographics:** • Children >2 years old • Asthma diagnosis **Setting:** Pediatric Hospital >51k ED visits, 16k hospitalizations annually **Exclusion:** • Chronic, comorbid conditions • Initial wheezing episode	**IV1:** Asthma CPG **DV1:** Dexamethasone adherence/ ordering **DV2:** LOS **DV3:** Admission **DV4:** Cost	**Tools:** • AAIRS • QI Chart software • Internal dashboard pseudo real-time for all asthma discharges • Delayed merging of internal data with PHIS database. **Validity/ Reliability:** AAIRS validated via their institution	**Statistical Tests Used:** • X-bar charts • S charts • P-charts • G charts • Special cause variation • Statistical process control charts	**DV1:** Pre = Rare Rx Post = 85% of patients received 1 dose **DV2:** • ED reduced from 3.9 to 3.3 hours, sustained over 15 months • ICU/unit reduced from 1.52 to 1.33 days, sustained over 2 years	**Level of Evidence**: Level III, primary study **Strengths**: • Effective CPG • Increased prescribing of dexamethasone • Decreased admissions • Decreased overall costs and resources • Sustained results >1 year **Weakness**: • ED "treat and release" patients saw $182 increased cost • No order set compliance validation

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testimony on an asthma case. Corticosteroid use, and order compliance were unvalidated in the study (bias toward null). **Ethical**: Approved by Vanderbilt University IRB			**Attrition:** None noted				**DV3:** • Admission rates decreased 23.53% to 18.77%, sustained for 13 months • ICU requirement decreased from 23.03% to 13.24%, sustained for 18 months • 72-hour ED return not SS **DV4:** Decreased cost from $4457 to $3652 per visit, sustained for 2 years.	• Did not track corticosteroid Rx for discharged patients • Transferred patients and previous treatment unknown **Conclusion**: CPG is effective for improving asthma patient outcomes
Dilts et al., (2018). Effect of an asthma guideline in 2 pediatric emergency departments	Lewin's Model of Change	**Design:** Observational study **Purpose:** Evaluate ordering of albuterol via	**N=** 18,831 children between all 3 sites **ED (U)** N= 3774 **ED (SU)** N= 2650 **UCC** N= 1553	**IV1:** Asthma CPG in the ED **DV1:** Prescribed albuterol (MDI-	**Tools:** • Time-series analytic techniques • Stata software **Validity/**	**Statistical Tests Used:** • Linear regression model	**DV1:** • Increase from 33.95% (P < 0.0001) to 69.91%	**Level of Evidence**: Level III, primary study **Strengths**: • Effective electronic alert

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and an urgent care center. **Country**: USA **Funding**: None noted **Bias**: None noted		metered-dose inhaler with spacer, LOS, and 72-hour return rates before and after publication of an internally developed pediatric asthma CPG.	**Demographics:** • Mean age 6.9 • Male • White • English speaking • Medicaid insurance **Setting:** 2 EDs (U teaching hospital and SU pediatric community hospital), community-based UCC. **Exclusion:** • <2 or >17 years of age • Transfer from OSH • Admitted • Classified as critical, emergent (ESI scoring) **Attrition:** None noted	spacer only) not nebulized **DV2:** LOS (compared to with nebulized treatment) **DV3:** ED return rates within 72 hours	**Reliability:** • All statistical tests were 2-sided with significance evaluated at the 5% level. (*p*-value of < 0.05 was considered statistically significant).	• Dubin-Watson statistic • Levene robust test statistic • A 2-sample t test	• Long term (33 months): Not SS decline −0.17%; (P = 0.116) **DV2:** <u>Median</u> • MDI-spacer only: 117.4 min (P < 0.0001) • Nebulizer included: 162.6 min <u>Comparison</u> • Pre-CPG, 135.3 min • Post-CPG, 117.4 minutes (P < 0.001) **DV3:** Not SS	• Increased ordering by providers • Large study group **Weakness**: • LOS influenced by multiple factors • Only 3 locations used in one region • Provider ordering variability • Severity of asthma not documented **Conclusion**: CPG is overall effective in the ED setting for increasing inhaler use, decreasing LOS, and improving provider education and ordering behavior
Hartford et al., (2020). Improving patient outcomes by addressing provider variation in emergency department asthma care.	Plan-Do-Study-Act model	**Design:** Retrospective cohort study **Purpose:** Evaluate patient outcomes based on provider guideline adherence	**N=** 742 **Providers =** 31 **Demographics:** • Interns, junior residents • Senior residents • Fellows • Attendings • Patients: on asthma pathway—Initially with a high	**IV1:** Improve provider adherence to asthma pathway **DV1:** Provider adherence hour 2 **DV2:** Admissions	**Tools:** • QI Charts 2.0 add-on for Microsoft Excel **Validity/ Reliability:** • Centerline and upper and lower control limits, generally 2 SDs	• Mann–Whitney U test • Fisher's exact test • Statistical process control charts (SPC)	**DV1:** Baseline: 15/31 adherent After: adherence improved from 64% to 77% **<u>Patients seen by less</u>**	**Level of Evidence**: Level III, primary study **Strengths**: • 2 years of data • Randomized assignments • Equal exposure to patients • Familiar with clinical pathways

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Country: USA **Funding**: None noted **Bias**: None noted **Ethical**: Quality improvement			respiratory score (≥6) and a moderate respiratory score (5–8) after 1 hour of therapy. **Setting:** Free-standing academic pediatric ED (50k annual visits **Exclusion:** None; they evaluated all asthma pathway cases between July 1, 2013-August 30, 2015 **Attrition:** None noted; only 25/31(80.6%) providers completed anonymous survey	**DV3:** LOS **DV4:** Cost **DV5:** ED return within 72 hours/ICU	above and below the mean. • Standard rules to identify special cause variation		**adherent providers:** **DV2:** More likely to be admitted (65.1% versus 50.8%, *P* < 0.001) **DV3:** Longer ED LOS before discharge (4.7 versus 4.2 h, range 2.1–8 versus 2–7h, P = 0.007) **DV4:** Higher median ED-related costs ($1,896.20 versus $1,728.50, P < 0.001) **DV5:** Not SS	**Weakness**: • Patient-specific limitations (severity, history, etc) • Pathway designation and scoring differences per person • Providers misclassified related to minimal asthma cases **Conclusion**: Provider adherence to asthma pathways has better patient outcomes
Muhammad et al., (2023). Written asthma action plan improves asthma control and the quality of fife	Model for Change to Evidence-based Practice	**Design:** Single-blind parallel randomized control trial **Purpose:** Assess and demonstrate	**N=** 129 **WAAP** = 61 **C** = 59 **Demographics:** • Partially controlled asthma • Uncontrolled asthma • 6-12 years old	**IV1:** WAAP **DV1:** Asthma control **DV2:** Quality of life	**Tools:** • Asthma education flip chart • WAAP • ACQ • PAQLQ • PEFR	**Statistical Tests Used:** • Descriptive statistics • One-way analysis of variance (ANOVA)	**DV1:** • Baseline 1.9 (95% CI) • 3M =1.0 (95% CI) Degrees of freedom 5.0(1, 116), P = 0.027	**Level of Evidence**: Level II, primary study **Strengths**: • Randomized groups with follow up • Evaluated with validated tools

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among pediatric asthma patients in Malaysia: A randomized control trial **Country**: Malaysia **Funding**: None noted **Bias**: Possible recall bias from interviews **Ethical**: 2 Ethical Committees approved. Consent was obtained from all participants.		the efficacy of WAAP in improving asthma control in younger children with partly controlled and uncontrolled bronchial asthma	• Male • Malay • Family with asthma • Rhinitis • Government insurance **Setting:** Pediatric Clinic, Hospital Kuala Terengganu, Malaysia **Exclusion:** None noted **Attrition:** 9 children due to lack of follow-up		**Validity/ Reliability:** • ACQ validated in ages 7-17 • PAQLQ validated for 7-17 years of age, Cronbach's α of 0.87	• Repeated-measures ANOVA (RM ANO-VA) as statistical analysis	**DV2:** **Baseline** • Activity limitation P=0.341 • Symptoms P=0.998 • Emotional function P=0.315 • Total P=0.94 **3M** • Activity limitation P=0.006 • Symptoms P=0.007 • Emotional function P<0.001 • Total P=0.001	**Weakness**: • Recall bias • Second-hand smoke exposure greater in control group • Long-term effects not analyzed • **Conclusion**: Better asthma control increases quality of life. WAAP is successful for asthma patients
Davis & Fitzmaurice (2020). Improving patient outcomes by addressing provider variation in emergency department asthma care. **Country**: USA	Model for Change to Evidence-based Practice	**Design:** Prospective, randomized pilot study **Purpose:** Determine if creating an individualized WAAP during an ED visit led to fewer asthma-related unplanned	**N=** 91 children **WAAP** = 45 **C** = 46 **Demographics:** • Age 2-17 • Asthma exacerbation • Asthma diagnosis • 2 prior episodes of wheezing treated with inhaled bronchodilator **Setting:**	**IV1:** WAAP in pediatric ED **DV1:** Return ED visits **DV2:** Controller med Rx **DV3:** Scheduled follow up rates	**Tools:** • REDCap electronic data capture tools • SPSS 13.0 (SPSS Inc, Chicago, IL) • PACT **Validity/ Reliability:** PACT is verified and reliable tool	**Statistical Tests Used:** • Student's T-test • Chi-squared test	**DV1:** 7/39 P = 0.038 **DV2:** 29/45 P=0.002 **DV3:** 23/39 P = 0.083 **DV4:**	**Level of Evidence**: Level II, primary study **Strengths**: • Randomized groups with follow up • Evaluated with validated tools • Decreased ED visits • Increased controller Rx **Weakness**: • Possible recall bias • Small sample size

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Funding: IRB approved (#1290276). Funding was provided by the Children's Mercy Hospital Residual Fund Grant Program **Bias**: Intervention and recall bias are possible **Ethical**: Written consent obtained. Assent was obtained over age 7.		return visits up to three months after the ED visit.	Single, academic, pediatric ED **Exclusion:** • Required admission • Comorbid cardiac or pulmonary illness • Parent not fluent in English • Child already had a WAAP **Attrition:** 8 children, lost to follow up (survey)	**DV4:** Caregiver confidence (4 questions)			• 4.34; P=0.043 • 4.17; P=0.259 • 3.97; P=0.111 • 4.54; P=0.203 Confidence measures: 1 = not confident at all 5 = extremely confident	• Large number of eligible participants not enrolled—ED provider ensure provision of WAAP during visit • Single hospital study • WAAP not controlled outside ED **Conclusion**: WAAP is successful in the ED by decreasing readmissions and improving controller medication Rx.
Liu et al., (2022). Effect of asthma education on health outcomes in children: A systematic review. **Country**: USA, China **Funding**: None noted **Bias**:	Model for Change to Evidence-based Practice System Theory Model	**Design:** Meta-Analysis and Systematic Review *Cohort, case-control, longitudinal **Purpose:** To study the effect of asthma education on children's hospitalization, ED, and clinic visits.	**N=** 15 studies **Demographics:** • Children only • Asthma diagnosis **Exclusion:** • Incomplete data • Study design • Participants in asthma education were not only children **Attrition:**	**IV1:** Asthma education in children **DV1:** Hospitalizations (13 studies) **DV2:** ED visits (13 studies) **DV3:** Clinic visits (6 studies)	**Tools**: Independent assessment by 2 reviewers, utilizing criteria on the basis of the standard principles of quality assessment *Instruments not specified **Validity/ Reliability:** Not reported	**Statistical Tests Used:** • Stata V.16.0 SE • Risk ratio (RR) with 95% CI • I2 statistic *Values of 50% or more represent substantial heterogeneity	***Reported as RR (95% CI)** **DV1:** N =2122 0.46 (0.32-0.66) 54% lower risk **DV2:** N=2040 0.69 (0.59-0.81) 31% lower risk **DV3:** N=438	**Level of Evidence**: Level I **Strengths**: • First attempt to synthesize asthma education data • Dual parent/child education—decreased hospitalizations 0.38 (0.24 to 0.59) and ED visits 0.69 (0.57 to 0.83). • Evidence quality is moderate **Weakness**:

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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
Publication bias Hospitalizations P=0.023 ED visits P=0.005 Clinic visits P=0.004			426 screened studies, 343 studies assessed for eligibility, 15 total studies				0.80 (0.67-0.97) Lower risk	• Publication bias • Did not break down education type/tools **Conclusion**: Asthma was better controlled and decreased hospitalizations/ED visits after an educational intervention
Patterson et al., (2019). Scope and influence of electronic health record–integrated clinical decision support in the emergency department: A systematic review **Country**: USA (studies worldwide) **Funding**: Agency for Healthcare Research and Quality (AHRQ), grants R01HS022086 (PC), K08HS024558 (BP), and K08HS024342 (MSP). Clinical	Model for Change to Evidence-based Practice System Theory Model	**Design:** Systematic Review **Purpose:** To examine the scope and influence of EHR–integrated CDS technologies implemented in the ED.	**N=** 42 studies **Demographics:** • Peer reviewed • Published in English • CDS defined Intervention • Implementation of CDS intervention • ED setting only **Exclusion:** • Emergency Severity Index triaging • The tools did not integrate into existing workflow • Assessed “firing” rate instead of intervention • Studies older than 2005 **Attrition:** 296 screened studies, 143 studies assessed for eligibility, 42 total studies	**IV1:** CDS alert in the ED **DV1:** Decreased ED visits **DV2:** Overall positive outcomes using CDS **DV3**: Evaluation of CDS (provider adherence and practice) **Definitions:** CDS: software aid designed for decision-making to generate patient-specific assessments or recommendations that are then presented to	**Tools**: 2 paired authors reviewed full-text articles, 2 independent providers reviewed, and if no consensus was reached, the whole group discussed inclusion *Instruments not specified **Validity/ Reliability:** Not reported	**Statistical Tests Used:** *Tests used not specified	***Reported as RR (95% CI)** **DV1:** 5/9 (56%) • ED revisits • ED LOS • Admission • Mortality rates **DV2:** 35/42 (83%) • Workflow • Medication • Imaging **DV3:** 7/42 (17%) • CDS acceptance • Feedback	**Level of Evidence**: Level I **Strengths**: • Focused on computerized EHR integration • ED specific • Positive outcomes overall **Weakness**: • Inclusion/exclusion criteria influence sample i.e. pilot studies • Lack of patient-specific outcomes detailed in studies **Conclusion**: CDS is beneficial to use in the ED setting. More studies (RCTs) should be done to confirm.

Key: **AAIRS** Acute Asthma Intensity Research Score, **ACQ** Asthma Control Questionnaire, **BPD** Bronchopulmonary dysplasia, **C** Control, **CDS** Clinical Decision Support, **CF** Cystic Fibrosis, **CPG** Clinical Practice Guideline, **DD** Developmental Delay, **DV** Dependent Variable, **ED** Emergency Department, **ICS** Inhaled corticosteroids, **ICU** Intensive Care Unit, **ILD** Interstitial Lung Disease, **IRB** Institutional Review Board, **IV** Independent Variable, **LOS** Length of Stay, **N** Number, **NIH** National Institutes of Health, **PAQLQ** Pediatric Asthma Quality of Life Questionnaire, **PEFR** peak expiratory flow rate, **PHIS** Pediatric Health Information Systems, **SCD** Sickle Cell Disease **SS** Statistically Significant, **SU** Suburban, **U** Urban, **UCC** Urgent Care Center **WAAP** Written Asthma Action Plan

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
and Translational Science Award program through the NIH National Center for Advancing Translational Sciences, grant UL1TR000427. **Bias**: All studies were assessed for bias				clinicians for consideration				
Samady et al., (2022). Interactive inpatient asthma education: A randomized controlled trial. **Country**: USA **Funding**: Internal grants from Ann and Robert H. Lurie Children's Hospital of Chicago. NIH K23HL118151 funded Dr. Press and is currently supported by NIH	Model for Change to Evidence-based Practice	**Design:** Prospective investigator-blinded, randomized controlled trial **Purpose:** To compare the impact of the 2 inpatient asthma education models (interactive versus didactic) on subsequent asthma-related ED visits and hospitalization in children.	**N=** 148 **Interactive** = 75 **C** = 73 **Demographics:** • Age 2-16 • Asthma diagnosis • Admission for asthma exacerbation • Male • African American or Hispanic **Setting:** Urban children's hospital between October 2016 and June 2017 **Exclusion:** • Comorbid diseases	**IV1:** Interactive asthma education protocol **DV1:** ED visits (6 months) **DV2:** Hospitalizations **DV3:** Inhaler technique (Initial and 12 month follow-up)	**Tools:** • Stratified block randomization by asthma severity • Blinded biostatistician • REDCap electronic data capture tools • Brief Health Literacy Screen questionnaire • NAKQ • PAMSE • PROMIS **Validity/ Reliability:** Not reported	**Statistical Tests Used:** • X2 tests • Fisher's exact tests • Sensitivity analysis • Wilcoxon rank sum test • 2-sample paired t test	**DV1:** 20.3% (P=0.50) **DV2:** 10.1% (P=0.048) **DV3:** **Initial**: Asthma checklist score increased (n = 55; mean change of 4.07 [95% CI: 3.21–4.94]) **12m**: 1-point increase from baseline (P = .03)	**Level of Evidence**: Level II, primary study **Strengths**: • Randomized groups with follow up • Decreased ED visits • Improved PROMIS (patient reported outcome) scores (P<0.01) at 12 month follow up • Improved asthma symptoms and quality of life • Education time 6.33 minutes longer for interactive group **Weakness**: • Follow-up survey rate only 46%

Key: **AAIRS** Acute Asthma Intensity Research Score, **ACQ** Asthma Control Questionnaire, **BPD** Bronchopulmonary dysplasia, **C** Control, **CDS** Clinical Decision Support, **CF** Cystic Fibrosis, **CPG** Clinical Practice Guideline, **DD** Developmental Delay, **DV** Dependent Variable, **ED** Emergency Department, **ICS** Inhaled corticosteroids, **ICU** Intensive Care Unit, **ILD** Interstitial Lung Disease, **IRB** Institutional Review Board, **IV** Independent Variable, **LOS** Length of Stay, **N** Number, **NIH** National Institutes of Health, **PAQLQ** Pediatric Asthma Quality of Life Questionnaire, **PEFR** peak expiratory flow rate, **PHIS** Pediatric Health Information Systems, **SCD** Sickle Cell Disease **SS** Statistically Significant, **SU** Suburban, **U** Urban, **UCC** Urgent Care Center **WAAP** Written Asthma Action Plan

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
R03HL144883 and funded by NIH. **Bias**: Possible recall bias from interviews **Ethical**: IRB approved. Consent was obtained from all participants.			• Consenting caregiver not available (bedside or phone) • Did not speak English **Attrition:** 6 interactive and 2 C. Parent not present or patient discharged before education					• ED visits between groups were not SS at 6 months **Conclusion**: WAAP is successful in the ED by decreasing readmissions and improving controller medication Rx.

Key: **AAIRS** Acute Asthma Intensity Research Score, **ACQ** Asthma Control Questionnaire, **BPD** Bronchopulmonary dysplasia, **C** Control, **CDS** Clinical Decision Support, **CF** Cystic Fibrosis, **CPG** Clinical Practice Guideline, **DD** Developmental Delay, **DV** Dependent Variable, **ED** Emergency Department, **ICS** Inhaled corticosteroids, **ICU** Intensive Care Unit, **ILD** Interstitial Lung Disease, **IRB** Institutional Review Board, **IV** Independent Variable, **LOS** Length of Stay, **N** Number, **NIH** National Institutes of Health, **PAQLQ** Pediatric Asthma Quality of Life Questionnaire, **PEFR** peak expiratory flow rate, **PHIS** Pediatric Health Information Systems, **SCD** Sickle Cell Disease **SS** Statistically Significant, **SU** Suburban, **U** Urban, **UCC** Urgent Care Center **WAAP** Written Asthma Action Plan

Table A2

Synthesis Table

Study (Author, year)	Farmer et al., (2020)	Drewek et al., (2018)	Johnson et al., (2018)	Dilts et al., (2018)	Hartford et al., (2020)	Muhammad et al., (2023)	Davis & Fitzmaurice, (2020)	Liu et al., (2022)	Patterson et al., (2019)	Samady et al., (2022)
Level of Evidence	II	III	III	III	III	II	II	I	I	II
Design	PRO	RET	OBS	OBS	RET	RCT	PRO Pilot	MA/SR	SR	RCT
Sample										
N subjects	125	287	7116	18,831	742	129	91	15 (S)	42 (S)	148
Children (2-17)	X	X	X	X	X	X	X			X
Providers					X					
Setting										
ED	X	X	X	X	X	X	X		X	X
ICU/Inpatient		X	X							
UCC				X						
USA	X	X	X	X	X		X	X	X	X
International						X		X	X	
Interventions										
WAAP						X	X			
CPG/CDS	X		X	X	X				X	
Provider Education					X					
Asthma Education				X	X	X	X	X		X
ICS management	X	X								
Outcomes/ Themes										
Decreased LOS			X	X						
Decreased Cost			X							
Decreased ED Visits	X	X	X				X	X	X	X
Decreased hospitalizations								X		X
Increased controller medication Rx	X	X	X	X			X			
Increased follow-up (PCP, specialist)		X				X	X	X		
Improved Asthma Control						X				X
Improved Quality of Life						X				

Key: **CDS** Clinical Decision Support, **CPG** Clinical Practice Guideline, **ED** Emergency Department, **ICS** Inhaled Corticosteroids, **ICU** Intensive Care Unit, **LOS** Length of Stay, **MA** Meta-Analysis, **OBS** Observational, **PCP** Primary Care Provider, **PRO** Prospective, **RCT** Randomized Controlled Trial, **RET** retrospective, **S** Studies, **SR** Systematic Review **UCC** Urgent Care Center **WAAP** Written Asthma Action Plan

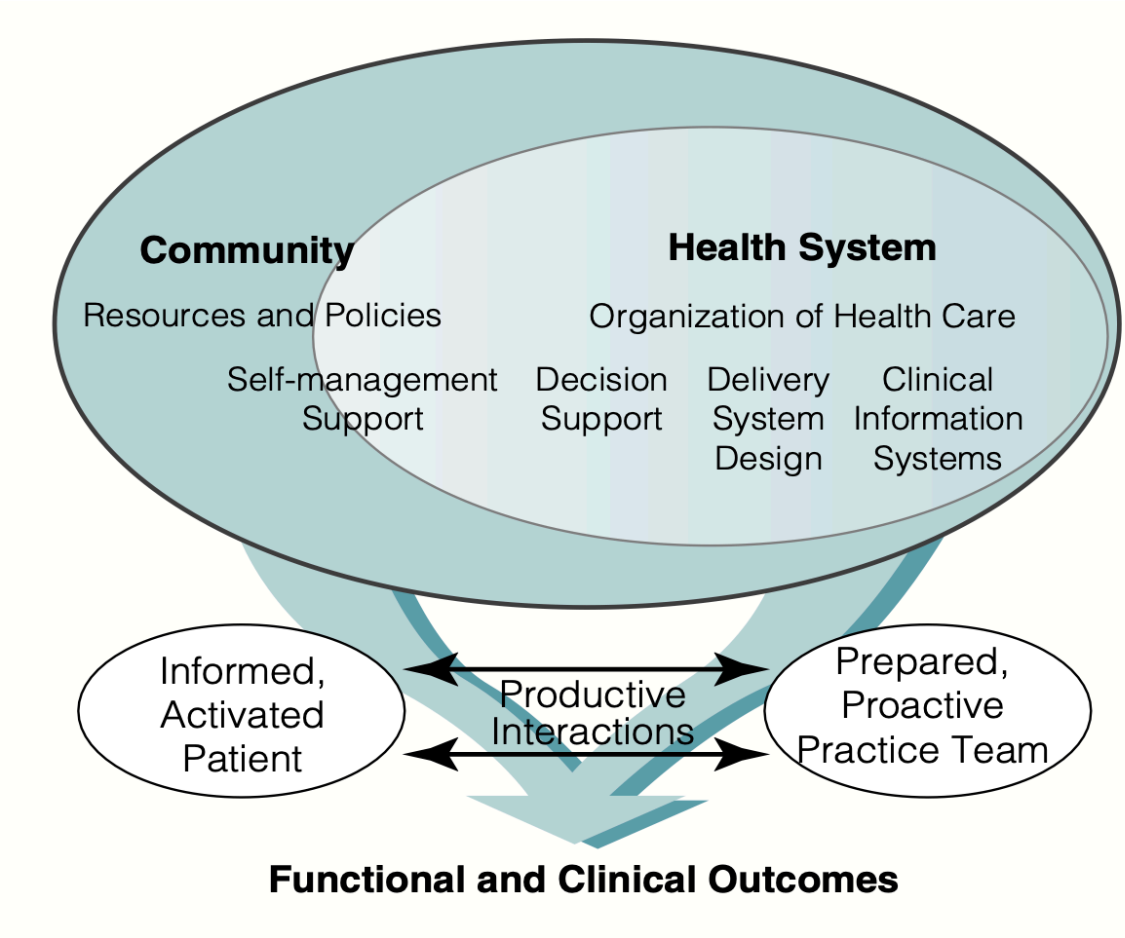
Study (Author, year)	Farmer et al., (2020)	Drewek et al., (2018)	Johnson et al., (2018)	Dilts et al., (2018)	Hartford et al., (2020)	Muhammad et al., (2023)	Davis & Fitzmaurice, (2020)	Liu et al., (2022)	Patterson et al., (2019)	Samady et al., (2022)
Improved Provider Adherence and/or Education	X	X			X				X	
Caregiver Confidence							X			

Key: **CDS** Clinical Decision Support, **CPG** Clinical Practice Guideline, **ED** Emergency Department, **ICS** Inhaled Corticosteroids, **ICU** Intensive Care Unit, **LOS** Length of Stay, **MA** Meta-Analysis, **OBS** Observational, **PCP** Primary Care Provider, **PRO** Prospective, **RCT** Randomized Controlled Trial, **RET** retrospective, **S** Studies, **SR** Systematic Review **UCC** Urgent Care Center **WAAP** Written Asthma Action Plan

Appendix B

Models and Frameworks

Figure B1
The Chronic Care Model



(Wagner, 1998)

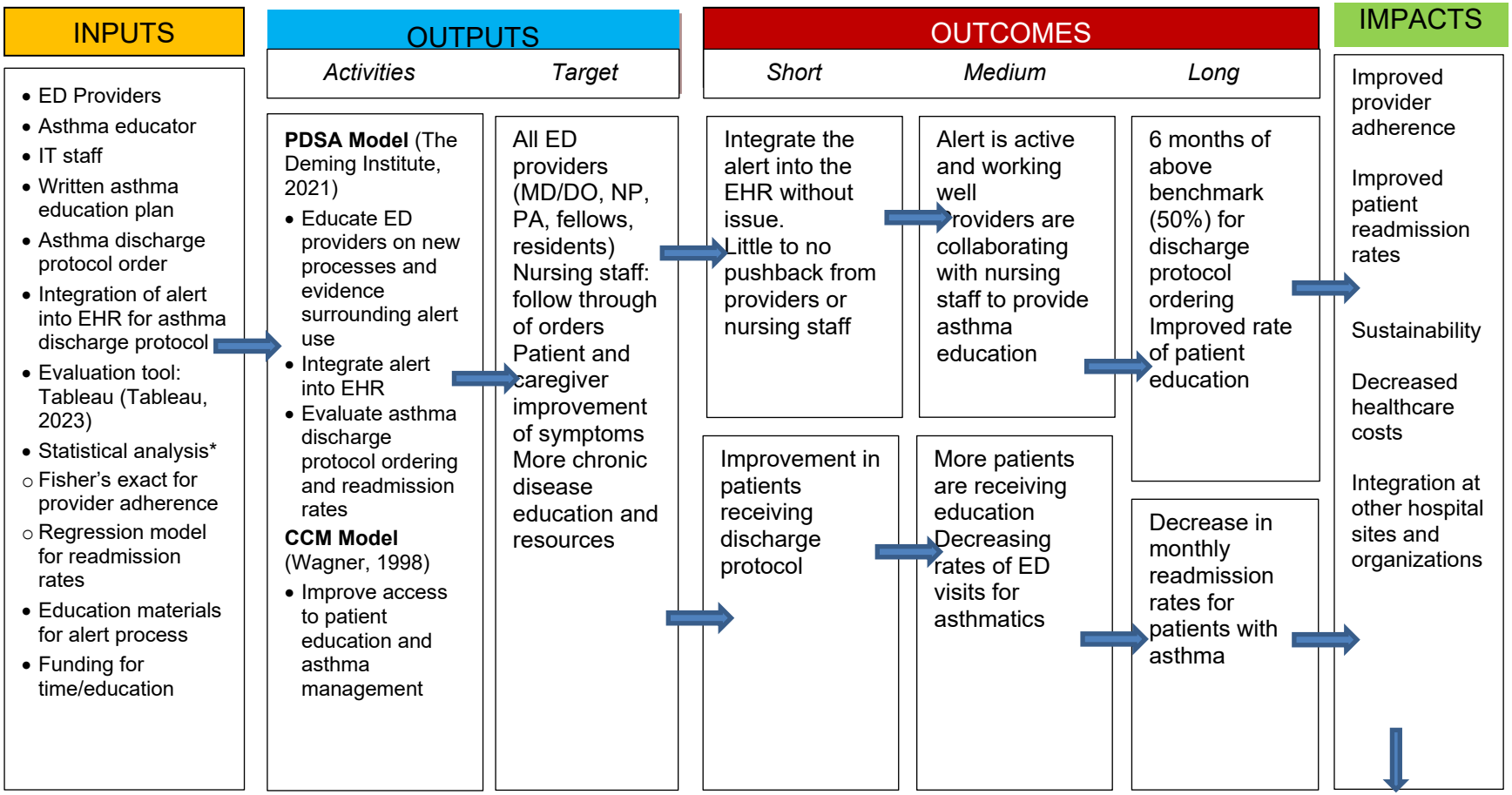
Figure B2
The Plan-Do-Study-Act Model

(The Deming Institute, 2021)

Figure B3

Clinical Practice Guideline Alert for Pediatric Asthma Discharge Protocol

Goals: To improve provider ordering adherence to the pediatric asthma discharge protocol in the emergency department (ED) using an electronic health record (EHR) alert. The goal is to exceed the monthly benchmark (>50%).



Assumptions: The providers will order the discharge asthma protocol more and become early adopters of change (Farmer et al., 2020; Johnson et al., 2018). Patients will have improved access to education with written asthma action plans upon discharge (Davis & Fitzmaurice, 2020; Muhammad et al., 2023, Samady et al., 2022). This project will have sustainability and stakeholder value (Dilts et al., 2018).

Appendix C

Tables

Figure 1
Budget and ROI Tables

Phase	Activities	Cost	Total
Resources	Site Champion time IC	$60/hour	$600
	Asthma Educator time IC	$46/hour	$184
	Printing materials DC	$20	$20
Education (15-30 minutes)	MD/DO (15 providers) IC	$448-900	$448
	NP (4 providers) IC	$56-112	$56
	PA (6 providers) IC	$114-228	$114
Alert Integration	IT support IC	$47/hour	$470
Evaluation	Tableau (free license)	$0	$0
	Intellectus (free license)	$0	$0
		Grand Total	**-$1892**

ROI	Patient education estimated savings (per visit)	$40	$2000 (50 visits*)
	Decreased burden to the healthcare system • Decreased patient visits • Less labor costs • Less drug costs • Less worry of hospital supply shortages • Improved provider ordering • Less burnout across department	• $433/visit • $34-56+/hour staff wages • Drug costs vary, albuterol MDI average cost $16 • Improved staff mentality	• $21,650 • $1,700-2,800* • $800 • Less turnover, happier staff
		Grand Total	**+$2000-$26,150***
	Net Savings	**+$108-24258***	

Budget Justification:

1. Operations:

A. Materials and Supplies:

a. Tableau and Intellectus software are necessary for the collection and data analysis processes. The latest versions are available for free to graduate students. License obtained for both.

b. Printing materials for an image of the new alert and integration process to be posted across the unit (size 8x11 pages, max 20 copies).

Funding options: Grant options via CDC sources. Have discussed this briefly with site champion. Would require a Grants.gov application (Centers for Disease Control and Prevention, 2021). The organization currently funds the project's fees to see the overall ROI improvement.

*Note: Calculations are based on this assignment's $34/hour staff wages, with room for increased savings for higher wages.

Figure 2
Descriptive Statistics

Table 1

Pre-Intervention Summary Statistics

Variable	*M*	*SD*	*n*	Min	Max
Patients Receiving Asthma Rescue Plan at Discharge	25.33	7.09	3	19.00	33.00
Patients Readmitted with Asthma within 30 Days	3.00	1.00	3	2.00	4.00

Note. M = Mean; SD = Standard Deviation; Min = Minimum; Max = Maximum

Table 2

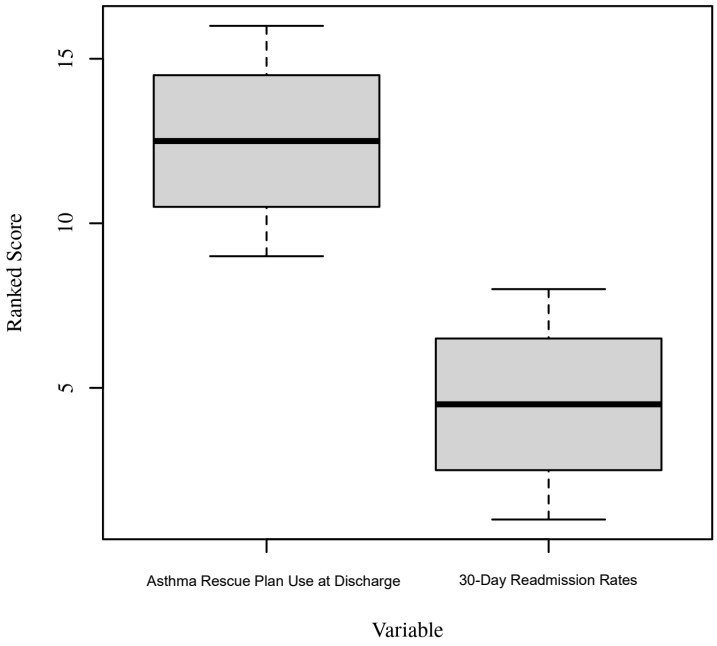
Post-Intervention Summary Statistics

Variable	*M*	*SD*	*n*	Min	Max
Patients Receiving Asthma Rescue Plan at Discharge	62.00	27.06	3	34.00	88.00
Patients Readmitted with Asthma within 30 Days	0.67	0.58	3	0.00	1.00

Note. M = Mean; SD = Standard Deviation; Min = Minimum; Max = Maximum

Figure 3

Boxplot of Ranked Values of Asthma Education at Discharge and 30-Day Readmission Rates



Appendix D

Coding

Figure 1
ICD-10 Codes