Asthma in Pediatrics: Implementation of Inhalation Therapy Through Meter Dosed Inhaler and Spacer with Video Education

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DNP Quality Improvement Project

April 24, 2023
Abstract

**Background:** Asthma is a serious disease that affects about six million children in the United States. Metered-Dose Inhalers with Spacer (MDI+S) devices and nebulizers (NEBs) are used to deliver inhalation medication. Although the MDI+S device has been recognized as a superior delivery system, about half of the patients that are prescribed these medications do not know how to use them resulting in poor asthma control. Observations from a reflective practice and an evidence-based literature review guided by the Ace Star Model, prompted a quality improvement (QI) project focused on children 5-11 years of age diagnosed with asthma, experiencing wheezing, and needing inhalation therapy.

**Method:** The QI project included implementing inhalation therapy using the MDI+S device with video education on its correct use to improve asthma symptoms. A form with QR codes linked to an educational video was provided to each patient. The Childhood Asthma Control Test (C-ACT) questionnaire designed for children 4-11 years was used to assess asthma symptoms both at pre and post intervention. A step-by-step checklist was used to evaluate MDI+S technique.

**Results:** All ten patients who completed this QI project exhibited improved C-ACT scores, had no wheezing, and demonstrated the proper technique using the MDI+S device. Limited impact on heart rate, fewer tremors, cost-effectiveness, and other benefits were also seen.

**Discussion:** Publications suggest that NEBs are effective for the treatment of pediatric asthma, however, the MDI+S device is generally considered superior for this indication. When properly used, it will lead to better asthma control and improve quality of life while being cost-effective.

**Keywords:** childhood asthma, inhaler, nebulizer, adherence, compliance, instruction, video, cost
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Asthma is a chronic inflammatory disease of the respiratory tract characterized by recurrent airway obstruction. In most cases, asthma exacerbations also known as “attacks” develop in response to environmental triggers, respiratory infections, stress, and other exposures. When this occurs the linings of the airways swell, the muscles around the airways tighten, and thick mucus is produced. These responses collectively lead to airway obstruction and the symptoms associated with asthma attacks, including wheezing, difficulty breathing, coughing, chest pain, and chest tightness. These symptoms can frequently be so severe that the patient will require hospitalization and may at times be life-threatening. Over time, recurrent asthma attacks can cause permanent damage to the lungs and airways.

In addition to its impact on quality of life, uncontrolled asthma can lead to missed work and school days as well as disruption of sleep, play, and other activities. Asthma is also associated with a heavy economic burden for patients, healthcare systems, and society as a whole. Approximately six million children in the United States ages 0-17 years suffer from asthma (CDC, 2018). More than 50% of children diagnosed with asthma had one or more attacks in 2016 alone. Furthermore, 1 in 6 children with asthma visit the emergency department (ED) and about 1 in 20 children with asthma are hospitalized for asthma each year. The cost of pediatric asthma in 2013 alone was $5.92 billion dollars; this amount increased to $6.31 billion dollars in 2018 (CDC, 2018).

Seven percent of children currently residing in Texas suffer from asthma (dshs.texas.gov, 2023). Related to this are the children who live in El Paso, which is a unique city at the United States (US)-Mexico border. The border region is defined as an area that extends 100 km
in each direction from the international boundary. On the US side, there are substantially more Hispanic communities found than elsewhere in the nation (Grineski et al., 2014). In 2014, the need for advanced care for asthma was 36% higher in this border region than among children living elsewhere in Texas (Grineski et al., 2014). The Healthy People 2030 initiative addresses these concerns and aims to reduce asthma attacks, asthma-associated deaths, and asthma-associated ED visits for children five years of age and older (health.gov, 2023). Thus, the intent of this QI project is to address asthma as it is experienced by this specific pediatric population and implement interventions aimed at providing better asthma control consistent with the aforementioned Healthy People 2030 objectives.

Asthma therapy typically includes step-up or step-down approaches based on the severity of symptoms. For example, inhalation therapy via a rescue inhaler provides quick-relief that can be complementary to medications that promote long-term control and are vital components of any asthma regimen. Short-acting beta-agonist (SABA)s bronchodilators such as albuterol can be used for quick-relief or as rescue medication. This medication is formulated for inhaler use or in ampules for NEB treatments. Long-term control (also known as maintenance) medications, including inhaled corticosteroids (ICSs) are typically taken every day, likewise via an inhaler or NEB treatment. There are also combination inhalers that contain ICS formulations with a long-acting beta-agonist (LABA). While adverse effects have been reported, these medications are comparatively safe in patients who are monitored by a healthcare provider. However, it is important to note that children may experience a sudden increase in heart rate and/or tremors when receiving nebulized albuterol treatments. This may result in even more stress for a child who is already experiencing asthma symptoms.
Correct use of these delivery devices is an essential component of the medical management of asthma. The delivery devices used to administer these medications permit the inhaled medication to be distributed evenly throughout the patient’s lungs. The metered-dose-inhaler (MDI) and the NEB are among the most frequently used of these delivery devices. A MDI is a small hand-held device that is attached to an aero chamber or a spacer. A NEB is a device that converts the medication into a fine mist that the patient breathes in while wearing a mask.

**Problem Description**

Observations from a reflective practice and an evidence-based literature review prompted an exploration of pediatric asthma and ultimately led to the execution of a QI project. Pediatric asthma was identified as a local problem with several critical concerns that emerged from the data that were extrapolated. First, many of the older pediatric asthma patients were prescribed inhalation medications to be delivered using a NEB rather than with a MDI with a spacer (MDI+S). NEB utilization may be due to provider and/or family preference, comfort, habit, and/or lack of awareness. Similarly, among the patients who were provided with inhalation medications to be administered by a MDI, many were not provided with the spacer needed for effective drug delivery into the patient’s lungs. Another problem is misunderstanding and confusion among the patients and their caregivers which frequently led to the incorrect use of medication and the device. This was evident during encounters with patients who experienced asthma attacks or at follow-up visits. Many caregivers and patients were not sure what the medications were for or, when and how they should be used. Furthermore, when assessing patient use of MDI+S, many exhibited incorrect technique. This was alarming but not surprising. Collectively, these factors can all lead to improper use of the MDI+S device. Patients may
receive incorrect drug doses that trigger asthma symptoms and lead to clinical deterioration and poor asthma control.

Similarly, other problems were evident among the patients who received inhalation medications via NEB devices. Many parents were dismayed by the amount of time needed to prepare and administer inhalation treatments using this method. Results from clinical practice and reports from parents and home experiences suggest that an average of 20-30 minutes are needed to prepare and complete the administration of a NEB inhalation treatment. Additional problems identified include increased heart rates and tremors experienced by patients treated with albuterol via a NEB device. The design of the NEB can also generate problems. This is because the NEB device is relatively large, requires electricity, it is difficult to transport, and inconvenient to use anywhere other than in a home environment. This is important to consider because children with asthma can experience symptoms at any time, including those that may be life-threatening. These children require immediate and easy access to inhalation therapy. If a NEB device is unavailable and/or there is no power source in the immediate vicinity, the child’s respiratory condition can deteriorate rapidly and can lead to acute respiratory distress.

Available Knowledge

The literature review highlights critical scientific evidence that can be used to address pediatric asthma and implemented in clinical practice to improve patient care and outcomes. Current clinical guidelines for the implementation of inhalation therapy in pediatric asthma include a preference for administration of quick-relief and maintenance medications with a MDI+S if the patient can use the device instead of inhalation therapy via a NEB (NAEPP, 2007; NAEPP, 2020; GINA, 2022). Children with asthma benefit significantly when provided with inhalation therapy via a MDI+S device compared to NEB treatments. The use of the MDI+S
device limits the drug-associated increase in heart rate and reduces the risk of developing
tremors. Furthermore, the results of the literature review revealed that the administration of
inhalation therapy using a MDI+S device also resulted in increased oxygen saturation and fewer
hospitalizations (Roncada et al., 2018; Snider et al., 2018; Cates, et al. 2013). Thus, inhalation
therapy administered via a MDI+S device is not only an effective method of drug delivery, it
may also reduce the incidence or prevent additional complications.

The literature review also highlighted other advantages resulting from the administration
of inhalation therapy via a MDI+S device instead of a NEB. As noted above, the NEB device
requires a power source as well as considerable time for the preparation and administration of the
inhalation therapy. By contrast, the MDI+S device is small and lightweight and thus increased
portability. The MDI+S device can thus be readily available, convenient to use, and requires only
minimal time for the preparation and administration of the inhalation therapy (Payares-
Salamanca et al., 2020).

It is always important to acknowledge and consider the financial burden presented by an
illness. The literature review highlighted the cost implications of these therapeutic strategies,
including cost differences between the two treatment options presented. Pediatric asthma is
associated with a high financial burden. Children with asthma use the healthcare system more
frequently than children without asthma, given their need for outpatient and inpatient visits,
pharmaceutical, and other specialty care (Perry et al., 2018). The Unites States Centers for
Disease Control reported the cost of pediatric asthma in 2013 was $5.92 billion dollars; these
costs increased to $6.31 billion dollars in 2018 (CDC, 2018). With respect to this QI project, it is
important to focus on the cost differences between NEB treatments and the use of a MDI+S
device. The price for an albuterol treatment with a MDI+S device was $96.68 compared to a
NEB, at an average cost of $121.41 per patient (Rodriguez-Martines et al., 2020). Safe practice principles indicate that it is always critical to do what is best and necessary for patient care. These cost differences may serve to encourage clinical practices to recommend the use of MDI+S devices as means to reduce costs in an already financially taxed healthcare system.

Findings from the literature review acknowledge that despite the clinical and economic benefits associated with the use of MDI+S devices, this method remains less than ideal specifically for pediatric asthma patients. Among the factors contributing to this problem, many patients and their caregivers are not skilled in the proper use of MDI+S devices. Clinical guidelines dictate and highlight the importance of providing detailed instructions regarding the correct use of the inhaler and the spacer both at the initiation of treatment and via regular assessments at each clinical visit. Approximately half of the asthma patients who have received prescriptions for these medications do not know how to use these devices (CDC, 2018). A systematic review of these findings identified three categories of problems that lead to improper MDI+S use: (1) patients lack appropriate technique when using the device; (2) poor patient understanding; and (3) inadequacies on the part of the healthcare provider (Plaza et al., 2018). The providers inadequacies included a lack of knowledge regarding the use of these inhalers, polypharmacy, limited time during office encounters, poor provider-patient communication, and no routine assessments of inhaler technique (Plaza et al., 2018). Collectively, these inadequacies result in poor patient education. This will lead to misunderstandings regarding asthma treatment, inappropriate administration and dosages of medication, poor compliance, and overall inadequate asthma control.

To master the correct use of a MDI+S device and generate patient adherence and thus better control of pediatric asthma, information from the literature review validated the use of
technology-based interventions, for example, interactive websites or videos with complementary verbal instructions. The findings emphasize that it will be important to begin with the fundamentals of teaching the inhaler technique. Findings from a randomized controlled study in which patients were provided with verbal instruction along with a “trainhaler” revealed that this essential approach to the training and ultimately mastery of the MDI+S device resulted in the reduction of asthma symptoms and improved quality of life (Ammari et al., 2017). Several large clinical studies revealed that the implementation of technology-based interactive websites or videos designed to help patients master the correct MDI+S technique led to improved asthma control as measured by both quantitative and qualitative questionnaires (Ramsey et al., 2019; Ozkars et al., 2019; Azak et al., 2021; Fidler et al., 2021). The incorporation of evidence-based information that supports the use of interactive websites and videos ensures the inclusion of a culture that is already captivated by technology and may lead to improved asthma control.

**Rationale**

The outcomes of the literature review support the main premise of this QI project which focuses on the implementation of inhalation therapy aimed to improve asthma symptoms experienced by pediatric asthma patients 5-11 years of age using MDI+S devices with video education. Medications used include bronchodilators, ICSs, or combination therapy. Although inhalation treatment using NEBs is effective, recent clinical evidence supports the use of MDI+S devices for pediatric asthma, provided that the patient can use the device (NAEPP, 2007; NAEPP, 2020; GINA, 2022; Roncada et al., 2018; Payares-Salamanca et al., 2020). Inhalation therapy administered via MDI+S devices may provide numerous benefits with respect to the management and outcomes of pediatric asthma. While most practitioners provide verbal instruction and possibly a demonstration of the use of the MDI+S device at the initiation of
therapy as well as assessments at follow-up visits, many factors can contribute to failure. Among these problems are device difficulties, poor understanding of the use of MDI+S devices by patients and their caregivers; and some practitioners not fully familiar with the correct use of MDI+S devices. Collectively, these factors can contribute to poor asthma management. Thus, it will be critical to identify a better method that might be used to teach the correct MID+S technique to pediatric asthma patients and their caregivers. Fortunately, technology-based interventions including interactive websites or videos based on evidence from the medical literature have been developed to address the acquisition of correct MDI+S technique and consequently improve asthma management (Fidler et al., 2021; Poursamad et al., 2022).

Specific Aims

The QI project described in this report was conducted for several reasons. The first goal was to determine whether implementation of inhalation therapy using a MDI+S device and viewing video education on the correct technique would lead to reductions in asthma symptoms by having no wheezing as well as the ability to demonstrate appropriate use of the MDI+S device, as suggested by results from the literature review. Another purpose was to address the other benefits associated with the use of the MDI+S device compared to NEB. While nebulized albuterol is clearly an effective therapy for the management of pediatric asthma, another goal was to determine whether specific adverse effects experienced by patients using this deliver method might be alleviated with the appropriate use of the MDI+S device. Similarly, reports published in the literature highlight reductions in the time and effort needed to prepare and administer inhalation therapy and thus the increased convenience associated with the use of MDI+S device. The results of this QI project revealed that mastery of the MDI+S device after
video-based training led to reductions in asthma symptoms, elimination of associated systemic effects, increased medication adherence, and cost containment.

Methods

Context

This QI project was conducted at Children’s Pediatric Practice. This clinic is located in the west side of El Paso, Texas and serves patients from El Paso, Southern New Mexico, and Juarez, Chihuahua, Mexico. This office provides pediatric primary care services for newborns to young adults up to 21 years of age. Pediatric care includes preventive medicine with wellness exams and physicals, acute medicine, and management of chronic conditions including asthma, diabetes, and obesity. The medical team includes one pediatrician, three pediatric nurse practitioners (PNP’s), twelve medical assistants (MA’s), and the ancillary department. The clinic provides care for 175 to more than 200 patients nearly every day. Primary health insurance programs accepted at the clinic include Texas and New Mexico Medicaid, private insurance, and Tricare. Self-pay patients are also seen in this clinic. Observations from the reflective practice highlighted the diagnosis of recurrent Asthma detecting a recurrent pattern of prescribing inhalation medications to be administered by a NEB. Similarly, improper technique was noted among patients provided with a MDI+S device as part of their care program. The review exposed misunderstandings on the part of patients and their caregivers as contributing to the confusion. Thus, the improper administration of inhalation medication and incorrect dosing led to poor compliance and poor asthma control.

Interventions

The Ace Star Model of Knowledge Transformation by Dr. Kathleen Stevens was essential for the development of this QI project. This model is organized into five points, each
with a different stage of knowledge transformation from evidence-based practice. The model progresses from one point of the star to the next, with having an impact on health-care outcomes as the ultimate goal (Stevens, 2013). As indicated in this model, it is imperative to consider all five stages of knowledge transformation to apply the results of evidence-based research to direct patient care initiatives in order to produce the outcomes intended by the individual study findings as shown in (Figure 1).

The Discovery Research of Stage 1 requires one to identify the transformation that knowledge needs to undergo in order to support informed clinical decisions (Stevens, 2013). This stage is aligned with the aforementioned 10-day reflective practice in which asthma was identified as a frequent diagnosis associated with the recurrent use of inhalation therapy via a NEB in clinical practice. The original research indicated by the first point of the star focuses on prescriptions for inhalation medication used to control asthma symptoms. Stage 2, which is the Evidence Summary, mandates an evaluation and summary of the evidence. Numerous quantitative research projects are identified, grouped, extrapolated, and summarized to provide the information needed to progress to the next stage (Stevens, 2013). In Stage 3, (Translation to Guidelines), the evidence generated in Stage 2 is paired with clinician experience to identify missing gaps, research, and evidence needed (Stevens, 2013). Clinical guidelines are developed as the output of this process.

**Figure 1**

*Stevens Star Model of Knowledge Transformation*
For this QI project, the literature review was conducted using electronic databases including CINAHL, MEDLINE, PubMed, EMBASE, and COCHRANE with a focus on the evaluation of asthma guidelines aligned with Stages 1, 2 and 3 of the Ace Star Model. Evidence retrieved from this review revealed deficits in pediatric asthma care including those addressing the method of delivery of inhalation therapy, and the use of delivery devices together with gaps in patient education that collectively result in suboptimal patient outcomes. This discovery promoted a PICOT question that became the focus of this QI project.

PICOT Question was as follows:

P: Children 5-11 years of age diagnosed with asthma who can use inhalers with spacer

I: Use of inhalation therapy through MDI+S with video education on correct technique

C: Albuterol neb, Budesonide neb, ICS inhaler, ICS+LABA inhaler, SABA inhaler. Quick explanation and demonstration of use of inhaler with demo inhaler during office visits.

O: Demonstration of correct use of inhaled medications with spacer and improvement of symptoms by having no wheezing.

T: Follow up in two weeks.

A review of the literature with the highest quality of available evidence indicated that the use of a MDI+S device to administer inhalation therapy in children with asthma is superior to NEB. Furthermore, technology interventions such as websites or videos used to provide instruction on the correct technique for their use can lead to reductions in asthma symptoms. Based on these findings a QI project was planned and a proposal was formulated. The proposal
was presented to the Supervising Physician with detailed explanations. The medical team was then notified. The practice change was ultimately accepted and approved with full support.

Stage 4 of the Ace model is Practice Integration. The goal at this point is to evaluate the quality of the evidence collected and identify recommendations that have been validated as effective in clinical practice. During this stage, the clinician needs to consider these recommendations and how they might be implemented into practice (Stevens, 2013). In this case, the highest quality scientific evidence was amplified by the clinical guidelines recommendations that validated the implementation of the MDI+S device for inhalation therapy with the integration of video education designed to help patients master the MDI+S technique and reduce asthma symptoms. Conversion of these findings into practice change required a full review of numerous relevant videos produced in both English and Spanish that explain and teach the correct MDI+S technique. This process was crucial because careful consideration was required to ensure that an effective technique was presented with directions that were simple, easy to understand, and of short duration. It was important to distinguish between video instructions based on whether the patient was wearing a mask or a mouthpiece. Four QR codes were created that were linked to appropriate videos. These were placed on an educational form that was also available in both English and Spanish that also included written instructions on the MDI+S technique. Creation of the educational form was also part of the preparation process along with a step-by-step checklist on the correct use of this device (Appendices A, B, and E).

The new intervention was implemented in clinical practice for two weeks for patients who met appropriate diagnostic and treatment criteria. The Childhood Asthma Control Test (C-ACT) questionnaire was used as a pretest to measure asthma symptoms. Patients were also provided with a brief set of verbal instructions and a demonstration of the use of the MDI+S
device during the initial visit. Patients were provided with the educational form during this initial visit and encouraged to review the corresponding video that was over a minute in duration at home as they initiated treatment with the MDI+S device. At follow-up on weeks 3 and 4, the C-ACT questionnaire for evaluation of asthma symptoms was administered. Patients were also evaluated on the use of the MDI+S devices following a step-by-step checklist using either their own equipment or the office MDI+S demo device.

The final point of the star represents Stage 5, or Process Outcome Evaluation. Data collection and evaluation of the project were conducted two weeks later. Outcomes were generated and compiled based on evaluations of patient Electronic Medical Records (EMRs) along with the pre and post C-ACT questionnaires scores and the step-by-step checklist of MDI+S. The final observations were discussed with the Supervising Physician, the two PNPs, and eventually with the other members of the medical team. The practice changes for the delivery of inhalation therapy using MDI+S devices augmented by the benefits of video education secured the implementation of this QI in the clinical setting.

**Study of the Interventions**

The QI project included patients 5-11 years of age diagnosed with asthma, who were wheezing, and were capable of receiving inhalation therapy delivered by a MDI+S device. Prescribed inhalation therapy included medications providing quick-relief and maintenance therapy that were administered via the MDI+S device. These interventions were implemented based on the evidence from clinical trials and guidelines that highlighted the efficacy of inhalation medication delivery via the MDI+S device in association with improved tolerability, ease and convenience of its use, and fewer cost implications (NAEPP, 2007; NAEPP, 2020; GINA, 2022; Roncada et al., 2018; Payares-Salamanca et al., 2022; Rodriguez-Martines et al.,
Caregivers were provided with an education form with QR codes linked to video education on the correct technique for using the MDI+S devices. Technology-based interventions, including interactive websites or videos with verbal instructions, were used to address mastery of the MDI+S device and to improve asthma outcomes as shown in several clinical studies (Ammari et al., 2017; Ramsey et al., 2021; Ozkars et al., 2019; Azak et al., 2021; Poursamad et al., 2022). A systematic review added to the significance of technology-based interventions by highlighting improvements in asthma control, quality of life, decreased healthcare utilization, improved lung function, and reduced number of missed school and work days (Ramsey et al., 2021). The C-ACT questionnaire was used to assess pre and post practice change. A step-by-step checklist was used at the follow-up to evaluate the MDI+S technique. Based on these interventions, patients demonstrated the correct technique when using the MDI+S device and presented with reduced asthma symptoms, specifically reductions in wheezing.

**Measures**

The C-ACT questionnaire designed for use in children 4-11 years of age was used to evaluate asthma symptoms both pre and post intervention (Appendices C and D). Questions 1-4 were answered by the child with assistance from caregivers as needed. These sections were based on the experienced of general asthma symptoms, specific problems when engaging in exercise or sports, cough, and disruption of sleep. Responses to each of these questions ranged from 0 to 3, with a score of 0 indicating severe symptoms and a score of 3 indicating no asthma symptoms. The caregivers were asked to respond to questions 5-7. In these sections, the frequency of asthma symptoms, wheezing, and sleep disruption was also addressed. Responses to these questions ranged from a score of 5 indicating no symptoms to a score of 0 representing symptoms occurring every day. The points assigned to each question were added to create a final
score. Nineteen points or fewer indicated that asthma may not be well-controlled. Twelve points or fewer may indicate poor asthma control. Current asthma guidelines emphasize the validity and reliability of the C-ACT assessment tool and promote its use (NAEPP, 2007; NAEPP, 2020; GINA, 2022). Here, the C-ACT questionnaire was useful for the evaluation of asthma symptoms before executing the new initiative and setting a baseline for this QI project. Brief verbal instructions and a demonstration with a demo inhaler were provided at the initial encounter. At the same time, a language-specific educational form with QR codes providing a link to an instructional video on the correct technique to be used when administering medication via a MDI+S with a mask or mouthpiece were provided (CDC, 2022, a; CDC, 2022, b; CDC, 2022, c; Azak et al., 2021; Johns Hopkins Medicine, 2013). Follow-up appointments were set for two weeks later. The C-ACT questionnaire was administered at the follow-up encounter to assess asthma symptoms after implementing the QI intervention. Because of the abbreviated timeline of this project, the C-ACT questionnaire directed at caregivers was modified to include asthma symptoms experienced by the child during the two weeks post intervention. A step-by-step checklist was used to assess proficiency when using the MDI+S device while wearing a mask or with a mouthpiece. All information was collected and analyzed.

Analysis

Quantitative and qualitative methods were used to analyze the data collected in this QI project. The C-ACT questionnaire for children 4-11 years of age was used for the quantitative evaluation of asthma symptoms both before and after the intervention. The scores from each initial encounter were calculated and compared to scores collected at follow-up visits. Auscultation of lungs pre and post intervention was crucial to detect wheezing and represented another variable used to quantify the impact of the intervention. A step-by-step checklist was
used during the follow-up visit to assess patient technique when using the MDI+S device. Qualitative measures used for patient and caregiver assessments both pre and post intervention included a history of symptoms, disruption of quality of life, treatment plan, and financial implications.

**Ethical Considerations**

This QI project was approved by the Supervising Physician at Children’s Pediatric Practice. The IRB from the University of Texas at El Paso (UTEP) approved this QI project while emphasizing that it was not a research project. Confidentiality as required by the Health Insurance Portability and Accountability Act (HIPAA) was used to protect patient information including data collected from encounters and EMRs. Only patients that met the inclusion criteria were included in this QI project. Patients and their caregivers were provided with education focused on the symptoms leading to a medical diagnosis of asthma, treatment implications including medications, adverse effects, and financial implications such as insurance coverage. This QI project posed no risk and patients were not coerced to accept this treatment plan. All identifiable data were removed from the patients’ forms. As per the HIPAA regulations and employment policies, only approved members of the medical personnel have access to patient information, including EMRs.

**Results**

This QI project included 24 patients diagnosed with asthma who were 5-11 years of age, wheezing, and capable of using MDI+S devices. All patients were prescribed inhalation therapy that included a SABA, ICS, or combination therapy to be administered with a MDI+S device together with an educational form with QR codes that linked them to online video education with instructions on the correct technique to use to administer drugs using a MDI+S device. Patients
and caregivers viewed a brief video during the initial visit and were instructed to review it at home. Patients and caregivers also received brief verbal instructions and an in-office demonstration that either introduced or reviewed the appropriate MDI+S technique using a demo device. The C-ACT questionnaire was used to evaluate asthma symptoms pre and post interventions. At follow-up, a step-by-step checklist was used to evaluate the MDI+S technique used by the patient.

Fourteen of the original twenty-four patients completed this QI project. Parents of two of the patients voiced their preference for NEB treatments at scheduled follow-up encounters and stopped using the MDI+S delivery method. One mother reported that she felt that her child was too young and was unable to use the MDI+S device. The mother of another child expressed similar concerns. Data from these patients were not included in the final analysis. Furthermore, two other patients reported no improvements in their symptoms and required follow-up within days of starting new treatment protocol. This prompted a different course of treatment. Chest radiography revealed evidence of pneumonia in both patients. Due to the strict timeline and inclusion criteria, these two patients were eliminated from the QI project.

During the two weeks that this project required for data collection and analysis, three more patients were identified that had followed up but were seen by the other two providers. Unfortunately, the post intervention evaluation process was not completed as mandated by this project. Data from these three patients were also eliminated from further evaluation. Furthermore, during the final data collection and analysis phase, seven patients were identified who did not follow-up and thus did not complete this QI project.

Of the original twenty-four patients selected for evaluation, ten patients consisting of six males and four females ultimately completed the QI project. At the initial visit, four of these
patients presented with C-ACT scores less than 12. The remaining six patients received scores between 13 and 19. After the treatment plan was explained to parents and patients, a verbal understanding of treatment plan and returned demonstration of MDI+S with demo were obtained.

At the two-weeks follow-up appointments, qualitative findings were collected via routine questions that address overall patient well-being and updates of medical regimens. All ten patients and caregivers reported an overall improvement in asthma symptoms and general acceptance of the MDI+S delivery method. All ten patients noted that they viewed the instructional video again at home. Patients and caregivers reported satisfaction with the video content and noted that it was brief, informative, and included easy-to-follow step-by-step directions. All ten patients confirmed that the educational form with QR codes that provided links to video education was crucial to learning or reviewing the MDI+S device technique and that they plan to keep this available for future reference. All ten patients expressed their preference for the MDI+S device because of its accessibility, quick medication administration, and portability. Of note, four of these patients had previously used the NEB method and were introduced to the MDI+S system through this QI project. These patients also expressed a preference for the MDI+S method. Equally important, all ten patients reported that they experienced no increase of heart rate or tremors in response to albuterol that was administered using the MDI+S device.

Persistent wheezing was among the main outcomes evaluated in this QI project. All ten patients reported that the use of the MDI+S resulted in relief from wheezing. Clear breath sounds were detected in all ten patients at follow-up, which contributed to a key quantitative parameter measured by this QI project. To strengthen these results, the C-ACT questionnaire that was
modified to address asthma symptoms experienced during the two weeks immediately post intervention supported findings that the use of MDI+S led to improved asthma control. The differences in the C-ACT questionnaires used both pre and post intervention are highlighted in Figure 2. Eight patients scored 20 points or higher on this questionnaire, indicating that their asthma was currently well-controlled asthma. Two patients reported a persistent cough that worsened during the night despite the observation that the wheezing had been relieved. These two patients had among the lowest C-ACT scores of all patients before the intervention. Therefore, a step-up approach to combination therapy administered via the MDI+S device was necessary. Interestingly, although these two patients did exhibit some improvement in their C-ACT scores in response to the intervention, another two patients that with comparatively low pre intervention C-ACT scores increased their C-ACT scores to 20 points., suggesting good asthma control. Furthermore, all ten patients demonstrated the correct technique when using the MDI+S device and by following the step-by-step checklist. Financial costs were controlled because the patients remained in outpatient care and had no need for advanced care in the ED or hospitalization. Thus, the establishment of inhalation therapy using the MDI+S device with video education in clinical practice clearly resulted in better asthma outcomes.

**Figure 2**
The Plan-Do-Study-Act (PDSA) model guided the implementation of this QI project (Figure 3). This model serves as a road map for improvement by facilitating rapid testing of the new intervention, learning from the observations, making beneficial changes, and re-testing as appropriate (ihs.org, 2021). The planning stage included months of reflecting on clinical practice, investigating the literature, and collaborating with the Supervising Physician, the medical team, and the DNP project chair, which ultimately led to the implementation of the findings from this QI project into clinical practice. All information collected during the study process was evaluated and findings were shared with the Supervising Physician which led to the development of recommendations for practice change. These recommendations were applied and the acceptance and ongoing implementation of the results of this QI project were achieved.

Figure 3

The Plan-Do-Study-Act (PDSA) Model for Improvement
Discussion

Summary

This QI project enrolled pediatric asthma patients 5-11 years of age who were wheezing and thus required inhalation therapy. The ten patients evaluated in this project were prescribed inhalation therapy to be administered via MDI+S device and provided with an educational form with QR codes linked to an instructional video that demonstrated the correct technique for using the MDI+S device. The primary and best indicator of improved asthma control resulting from this QI project was that none of the ten patients exhibited persistent wheezing on auscultation at follow-up and all demonstrated the correct technique for using the MDI+S device post intervention. The findings from this QI project are consistent with those reported previously in a large meta-analysis (Roncada et al., 2018). Results from the C-ACT questionnaire also revealed improvement in scores, thereby further augmenting the value of this QI project and its implementation in clinical practice. Qualitative measures including reports of no increase in heart rate and no tremors by all ten patients, represented added benefits associated with the use of the MDI+S device to deliver inhalation therapy and were consistent with outcomes reported in the literature (Iramain et al., 2019). Results from two other meta-analyses demonstrated similar outcomes, thereby strengthening the findings that specifically address inhalation therapy with albuterol using the MDI+S device (Roncada et al, 2018; Payares-Salamanca et al., 2020). All ten patients viewed an educational video and demonstrated the correct MDI+S technique using a step-by-step checklist. These findings are consistent with high quality evidence supporting the use of technology-based interventions for improving asthma outcomes (Ramsey et al., 2019; Fidler et al, 2021). Finally, financial costs associated with this diagnosis were minimized, as
patients only required outpatient care. None of the ten patients included in this QI project needed advanced care in the ED or hospitalization. The reduced treatment costs associated with these interventions were similar to those identified in large studies that directly assessed the financial burden of asthma (Castro-Rodrigues et al., 2020; Perry et al, 2018).

**Interpretation**

The evidence presented in this paper indicates that the implementation of inhalation therapy via a MDI+S delivery device accompanied by video instructions on the correct technique for its use is both effective and valuable in clinical practice. This implementation of these improvements was guided by the highest quality of evidence available for asthma (NAEPP, 2007; NAEPP; 2020; GINA, 2022). Colleagues have recognized the overall success of this intervention and have implemented these changes for asthma patients in their respective practices. These colleagues have noted specifically their appreciation of the highly effective and easy-to-use educational form with QR codes linked to critical instructional videos that are available in English and Spanish. Given the ever-increasing demands on healthcare personnel and the relatively short duration of patient office visits, providers may not be capable of providing complete and fully effective instructions on the use of the MDI+S device for their asthma patients. This may create confusion and distress among providers, patients, and caregivers, thereby negatively affecting asthma management and its outcomes. For example, one systematic review reported that ineffective use of inhalers by patients could be attributed to errors in provider instruction due to lack of knowledge, polypharmacy, insufficient time during office visits, poor communication, and no assessments of inhaler technique (Plaza et al., 2018). Providers with a poor understanding of the proper use of these devices cannot effectively instruct their patients and will be unable to evaluate correct inhalation techniques (Plaza et al., 2018).
Thus, the distribution of an easy-to-use form with links to an evidence-based educational video will provide the critical assistance needed to educate patients on the correct method of using the MDI+S device and will thus be effective at promoting better asthma control.

It is also important to understand the impact of this QI project on the financial costs associated with pediatric asthma. All patients enrolled in this study had private or state Medicaid insurance which covered their care. A treatment step-up approach was needed by two patients who presented with a persistent cough, even though the main outcome of no wheezing was achieved. The ICS treatment was discontinued, and combination therapy was initiated in these patients (NAEPP, 2007; NAEPP, 2020; GINA, 2022). Even with a step-up approach with these two patients, none of the ten patients enrolled in this QI project required advanced care in the ED or hospitalization. In a Cochrane review, Cates et al. (2013) reported that children with asthma spent an average of 103 minutes in the ED when given inhalation treatments via a NEB compared to only 33 minutes for those treated with a MDI+S device. Apart from the inconvenience, the longer duration of stay required for inhalation treatment via a NEB will lead to significantly higher overall costs than would be generated during the shorter duration required for the MDI+S treatment. These findings are consistent with those of a meta-analysis that revealed that the use of a bronchodilator administered via a MDI+S device in children presenting to the ED with severe asthmatic attacks, reduced the rate of hospitalization by greater than 50% compared to that resulting from treatment with a NEB (Castro-Rodriguez, 2004). While these findings have a significant impact with respect to the overall economic burden of asthma, they do not even begin to consider the additional savings resulting from decreased missed work and school days and the improved quality of life.
Limitations

There were several limitations to this QI project. This QI project was implemented in children with asthma who were 5-11 years of age. Results from the literature review suggest that implementing inhalation therapy with MDI+S as early as one year of age and continuing into adulthood may be associated with similar overall benefits (NAEPP, 2007; NAEPP, 2020; GINA, 2022). The potential benefits of expanding the implementation of this QI project might lead to improved asthma management while establishing cost containment. Another limitation of this QI project was patients were included at only one location. It would be beneficial to implement this QI project in a variety of clinical settings with a larger representation that might be found in our unique region of the country to determine whether other substantial outcomes might be observed. Time constraint was another factor that hampered this QI project. Although the C-ACT questionnaire was adjusted for use in evaluating symptoms at two weeks post intervention, it was originally intended to be used after four weeks. In this project, long term effects could only be estimated. Another significant limitation of this QI project was the lack of a Spanish-language version of the video required for instructions on the use of the MDI+S device with a mask. Spanish-speaking caregivers who needed instruction on this topic were provided with verbal guidance and demonstration in Spanish at the initial visit, but they were ultimately directed to the English-language video for visual instruction. Other technology-based strategies might also have been helpful in these situations. Results from a recent meta-analysis discussed the efficacy of mobile applications and smart-phone reminders for improving asthma management would have been helpful to implement. In a meta-analysis, mobile applications and smart phone reminders also improved asthma management (Fidler et al., 2021). These observations can be used as measures that might be used when implementing this QI project sometime in the future.
Conclusion

Asthma is a chronic inflammatory disease of the respiratory tract with a profound impact on quality of life and presents a high financial burden to patients, their families, healthcare systems, and society as a whole. Approximately six million children in the United States ages 0-17 years suffer from asthma (CDC, 2018). Although there is currently no cure for this disease, in most cases it can be effectively controlled with inhalation therapy delivered via a NEB or a MDI+S device. Clinical guidelines indicate a preference for delivering inhalation medications via a MDI+S device provided that the patient is capable of using it (NAEPP, 2007; NAEPP, 2020; GINA, 2022). Secondary outcomes when using a MDI+S device specifically to deliver albuterol to the respiratory tract include fewer risk of increased heart rate and/or development of tremors (Iramain et al., 2019). However, many patients that are prescribed these medications do not know how to use the MDI+S device correctly. Technology-based interventions with video education can help patients master the correct MDI+S technique (Fidler et al., 2021; Ramsey et al., 2021). The results of this QI project highlight the efficacy of inhalation therapy through a MDI+S device when supported by video education that provides instructions on its appropriate use to improve asthma control. The sustainability of this QI project will depend on whether providers choose to use the educational form with QR codes linked to video training when prescribing inhalation therapy using a MDI+S device. In summary, findings from this QI project suggest that the use of the MDI+S device, when supported by appropriate educational tools, will lead to better asthma control, improved quality of life, and overall cost-effectiveness.

Funding

This QI project was funded by the Paso Del Norte Health Foundation Graduate Fellows Program.
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https://doi.org/10.3912/ojin.vol18no02man04


Appendix A: Educational Form with QR Codes (English)

Know How to Use Your Asthma Inhaler
Using a metered dose inhaler with a spacer

1. Take the cap off the inhaler and make sure the mouthpiece and spray hole are clean.

2. Shake the inhaler 10-15 times.

3. Put the inhaler mouthpiece into the end of the spacer.

4. Inhale a deep breath and breathe out all the way.

5. Hold the inhaler and spacer between your index finger and thumb.

6. Put the mouthpiece of the spacer in your mouth and above your tongue.

7. Close your lips around the spacer.

8. Tilt your head back slightly toward the ceiling. Press the top of the inhaler to spray one dose of medicine. Slowly breathe in all the air you can and hold for 5-10 seconds.

9. Open your mouth...

10. ...and breathe out slowly.

Follow up with Erika

DATE:
Cómo usar un inhalador de dosis fija con espaciador

1. Quite la tapa del inhalador para asegurarse de que la boquilla y el orificio del aerosol estén limpios.

2. Agite el inhalador entre 10 y 15 veces.

3. Coloque la boquilla del inhalador en el extremo del espaciador.

4. Inhale profundamente y exhale completamente.

5. Sostenga el inhalador y el espaciador entre sus dedos índice y pulgar.

6. Póngase la boquilla del espaciador en la boca y por encima de la lengua.

7. Cubra bien el espaciador con los labios.

8. Incline un poco la cabeza hacia atrás. Oprima el inhalador una vez e inhale despacio y profundamente. Inhale la mayor cantidad de aire que pueda y sostenga la respiración durante 5 a 10 segundos.

9. Abra la boca...

10. ...y exhale despacio.

Cita con Erika
FECHA:
Appendix C The Childhood Asthma Control Test (English)

Patient's Name: ____________________________

Today's Date: ____________________________

Childhood Asthma Control Test for children 4 to 11 years

Know your score.

**Parent or Guardian:** The Childhood Asthma Control Test* is a way to help your child's healthcare provider determine if your child's asthma symptoms are well controlled. Take this test with your child (ages 4 to 11). Share the results with your child's healthcare provider.

**Step 1:** Have your child answer the first four questions (1 to 4). If your child needs help, you may help, but let your child choose the answer.

**Step 2:** Answer the last three questions (5 to 7) on your own. Don't let your child's answers influence yours. There are no right or wrong answers.

**Step 3:** Write the number of each answer in the score box to the right.

**Step 4:** Add up each score box for the total.

**Step 5:** Take the COMPLETED test to your child's healthcare provider to talk about your child's total score.

Have your child complete these questions.

1. How is your asthma today?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very bad</td>
<td>Bad</td>
<td>Good</td>
<td>Very good</td>
</tr>
</tbody>
</table>

2. How much of a problem is your asthma when you run, exercise or play sports?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>It's a big problem, I can't do what I want to do.</td>
<td>It's a problem and I don't like it.</td>
<td>It's a little problem but it's okay.</td>
<td>It's not a problem.</td>
</tr>
</tbody>
</table>

3. Do you cough because of your asthma?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, all of the time.</td>
<td>Yes, most of the time.</td>
<td>Yes, some of the time.</td>
<td>No, none of the time.</td>
</tr>
</tbody>
</table>

4. Do you wake up during the night because of your asthma?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, all of the time.</td>
<td>Yes, most of the time.</td>
<td>Yes, some of the time.</td>
<td>No, none of the time.</td>
</tr>
</tbody>
</table>

Please complete the following questions on your own.

5. During the last 4 weeks, how many days did your child have any daytime asthma symptoms?

<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>1-3 days</td>
<td>4-10 days</td>
<td>11-18 days</td>
<td>19-24 days</td>
<td>Everyday</td>
</tr>
</tbody>
</table>

6. During the last 4 weeks, how many days did your child wheeze during the day because of asthma?

<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>1-3 days</td>
<td>4-10 days</td>
<td>11-18 days</td>
<td>19-24 days</td>
<td>Everyday</td>
</tr>
</tbody>
</table>

7. During the last 4 weeks, how many days did your child wake up during the night because of the asthma?

<table>
<thead>
<tr>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>1-3 days</td>
<td>4-10 days</td>
<td>11-18 days</td>
<td>19-24 days</td>
<td>Everyday</td>
</tr>
</tbody>
</table>

*The Childhood Asthma Control Test was developed by GSK.

This material was developed by GSK.

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Appendix D The Childhood Asthma Control Test (Spanish)

Nombre y apellido del paciente: ___________________ fecha de hoy: ______________

**Prueba de control del asma de la infancia para niños/as de 4 a 11 años**

Esta prueba le dará un puntoaje que puede ayudar a mi médico a evaluar si el tratamiento para el asma de su niño/a está funcionando o si puede ser el momento adecuado para cambiarlo.

**Cómo contestar la prueba de control del asma de la infancia**

**Pasos**

1. Deje que su niño/a conteste los primeros cuatro preguntas (de la 1 a la 4). Si su niño/a necesita ayuda para leer o entender alguna pregunta, usted puede ayudar pero deje que 1/ella sea quien elija la respuesta. Conteste usted las tres preguntas restantes (de la 5 a la 7) y no permita que las respuestas de su niño/a afecten sus respuestas. No hay respuestas correctas o incorrectas.

2. Escribe el número de cada respuesta en el cuadrado de puntuaje que se encuentra a la derecha de cada pregunta.

3. Suma cada uno de los puntajes de los cuadros para obtener el total.

4. Lea a su niño/a el total de su puntaje para hablar sobre el puntaje total de su niño/a.

Deje que su niño/a conteste estas preguntas.

1. ¿Cómo estás hoy?

   0 = Muy mala  1 = Mala  2 = Buena  3 = Muy buena

2. ¿Qué tiene problema al asma cuando corre, hace ejercicio o practicas algún deporte?

   0 = Es un problema grande, no puedo hacer lo que quiero hacer.
   1 = Es un problema, no me siento bien.
   2 = Es un problema pequeño pero estoy bien.
   3 = No es un problema.

3. ¿Has tenido asma durante el último año?

   0 = Sí, siempre.
   1 = Sí, la mayor parte del tiempo.
   2 = Sí, algo del tiempo.
   3 = No, nunca.

4. ¿Has despistado durante la noche debido al asma?

   0 = Sí, siempre.
   1 = Sí, la mayor parte del tiempo.
   2 = Sí, algo del tiempo.
   3 = No, nunca.

**Por favor conteste usted las siguientes preguntas.**

5. Durante las __últimas 4 semanas__, ¿cuántas veces tuvo su niño/a síntomas de asma durante el día?

   0 = Nunca  1 = De 1 a 3 días  2 = De 4 a 10 días  3 = De 11 a 18 días  4 = De 19 a 24 días  5 = Todos los días

6. Durante las __últimas 4 semanas__, ¿cuántas veces tuvo su niño/a respiración roncando (o silbido en el pecho) durante el día debido al asma?

   0 = Nunca  1 = De 1 a 3 días  2 = De 4 a 10 días  3 = De 11 a 18 días  4 = De 19 a 24 días  5 = Todos los días

7. Durante las __últimas 4 semanas__, ¿cuántas veces se despertó su niño/a durante la noche debido al asma?

   0 = Nunca  1 = De 1 a 3 días  2 = De 4 a 10 días  3 = De 11 a 18 días  4 = De 19 a 24 días  5 = Todos los días

**PUNTaje**

**TOTAL**
Appendix E Step-by-Step Checklist for Using the MDI+S with a Mask

<table>
<thead>
<tr>
<th>MDI+S with Mask Checklist</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Make sure counter is not at 0</td>
</tr>
<tr>
<td>2. Shake inhaler</td>
</tr>
<tr>
<td>3. Remove the cap</td>
</tr>
<tr>
<td>4. Insert the inhaler into the back of the spacer</td>
</tr>
<tr>
<td>5. Hold the mask over the child’s nose and mouth to create a seal</td>
</tr>
<tr>
<td>6. Press down on the inhaler to release one puff only</td>
</tr>
<tr>
<td>7. Keep holding the mask over your child’s face for 5 to 10 breaths</td>
</tr>
<tr>
<td>8. Repeat for every puff recommended by your child’s doctor</td>
</tr>
</tbody>
</table>