Breath of Relief: Upholding Inhaler Administration Adherence in Schools

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I have no known conflict of interest to disclose.

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Abstract

Background: Asthma management in the school setting has become a joint initiative in the early stages to improve children's health. Regulations exist to guide the use of inhalers and the administration of medications within educational institutions.

Objective: This quality improvement (QI) project aims to address and reduce the incidence of improper inhaler administration in schools.

Methods: A comprehensive literature review was conducted to establish the effectiveness of interactive education and personalized feedback systems in reducing medication errors. A six-month chart review (July 2023 – December 2023) of medication administration logs from Maricopa County schools was undertaken. The logs were analyzed for compliance with established protocols; no personal identifiers were recorded, rendering the study exempt from Internal Review Board (IRB) oversight. School staff accessed an interactive educational module on medication dosing and administration as part of their annual training. Biweekly audits of documentation logs were performed, and direct feedback was provided via email or phone to staff who had submitted logs with potential errors.

Results: The intervention resulted in a 90% adherence rate with medication administration protocols. The Intellectus Statistics platform and Friedman Rank Sum test were utilized to analyze variable relationships suggesting a higher probability of accurate dosing following the educational intervention.

Conclusion: The study highlights the need to support school nurses and uphold low medication error rates in schools. The findings advocate for the integration of specialized education and ongoing feedback mechanisms to ensure adherence to asthma medication administration guidelines.

Keywords: asthma, school surveillance programs, medication errors, school asthma

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To improve asthma care in schools, a practical and innovative approach has been developed that maintains a stock of rescue inhalers for students experiencing respiratory distress. Several local, state, and national initiatives have driven the creation of the stock program. With medication administration comes responsibility and liability to prevent medical errors and inadequate treatment.

Background and Significance

Medical emergencies such as asthma attacks can occur anywhere and at any time, particularly at any point in the school day for children. The program, referred to an emergency school medication program was first evaluated and implemented in Pima County, Arizona, in 2017 to address asthma treatment in the school setting (Lowe et al., 2020). The program aimed to reduce emergency calls and return students to class. According to the latest data available, over 20,000 children under fifteen visited the emergency department for asthma-related concerns in a year (Kemp et al., 2019; Arizona EPHT Explorer, 2020). As part of the Healthy People 2020 Initiative and National Asthma Control Program, the goal is to decrease asthma-related deaths, decrease hospital visits, and improve missed school and work (AZDHS, 2019; CDC, 2020). In the early stages of the program, specific data entry software was not developed to document asthma events and inhaler usage. The pilot study provided paper documentation logs to the school health offices (Lowe et al., 2020). When the program launched in Maricopa County, the search for an electronic tracking system ensued. A previously created online surveillance program that was used to document disease tracking has also transitioned to writing asthma events. The data comparison on this new initiative is limited, primarily due to the lack of standard or accurate documentation.

Purpose and Rationale

Documentation of the patient's condition creates a clear picture of the patient as they are represented, the change in condition, treatment received, and outcomes of those treatments. Over 60% of documented albuterol users in one year exhibited an inappropriate number of puffs administered to students (Lowe et al., 2022). Despite being recorded, the documented uses do not correspond to the written protocols, suggesting improper administration and medication errors. The protocol outlines levels of respiratory distress with the associated number of puffs to administer; however, the documentation does not provide a guide. This can lead to medication errors, falsely represented medication errors, inadequate data collection, and serve as a threat to the validity. This project aims to use existing evidence that supports the use of education along with a feedback system to improve documented medication errors and influence future emergency programs.

Background and Significance

The responsibility of dispending medications falls on nurses, including those appointed in schools. In the absence of school nurses, individuals who are not licensed are provided with the necessary training to carry out medication administration. School nurses face the disadvantage of their care outside of clinical settings with minimum resources. Consequently, initiatives like the emergency medication administration programs have been created to facilitate the management of acute symptoms. However, the programs are still in the remodeling and refinement phases to ensure a complete and comprehensive guidance in appropriate documentation and correct medication administration.

Asthma episodes, while potentially life-threatening, can be effectively managed by a school nurse. Approximately 75% of children of school age may have undiagnosed with asthma,

and those who are diagnosed may not have access to their inhalers (Kim, 2020). To address the acute concern, some states have passed legislation allowing the administration of emergency medications such as Albuterol in the school setting (Lowe et al., 2021). Only 14 states have regulations enabling schools to keep an emergency stock of albuterol. Nine of those states require documentation of each inhaler administered, but only three states, including Arizona, have mandated documentation retention. The mandate in Arizona does not specify whether or not the documentation is to be done electronically and for how long those records will be retained. However, the county and state agencies that help fund such programs require comprehensive data to compare results in different schools, compare methods of administration and record keeping, and more importantly submit results for continued funding support. As a result, documentation of correct administration is of utmost importance for data collection and preventing medication errors. Inaccurate documentation threatens the data validity and weakens any findings that may come about in data analysis and the need for these programs (Nicholson & Johnson, 2020). Proper medication documentation and administration following the protocol doses help achieve the program goal of reducing emergency visits and appropriately treats the acute asthma symptoms the student may be experiencing.

Medication administration education and follow-up are essential in providing the knowledge on when an administration might be considered an error. Initial training when registering for the program is vital to providing foundational knowledge. However, the training must be geared towards the right population. Currently, the program in Maricopa County allows nurses, health aids, and office administrative staff to complete the training and administer the medications. This stipulation was created due to each school's need for more registered nurses. Training must focus on what the drug does, how to administer it, how to store it, and how to

assess the child appropriately to determine the correct dose. The education should mimic the protocol, considered a standing administration order prescribed by a provider.

The existing method is a lengthy file describing the factors surrounding the Albuterol inhaler and its administration. Staff that thoroughly read the file submit a survey link to obtain their training certification and can administer the inhaler at their registered school. The education is not explicitly directed towards nurses or administrative staff and is not interactive. These trained individuals must also document each use in an online documentation log that submits the data to the agency. This data consists of student demographics, information about the administering personnel, dose administered, and disposition of the student. The submitted data needs to be regularly reviewed to assess inaccuracies, request clarification and address any documentation and medication administration errors.

Currently, standardized documentation is not in effect in state emergency medication programs. There are no regulations that determines what standardized documentation should entail (Lowe et al., 2021). The current position of the National Association of School Nurses on medication administration is that there is a decrease in errors when there are adequate guidelines and education, particularly in areas with unlicensed personnel (Hinkson et al., 2017). Without a review of the documentation and guidance, there is more susceptibility to errors in future documentation and medication administration. Therefore, correct documentation is critical to collecting important data that provides evidence to inform and transform policy, and promote student health outcome in schools (Nicholson & Johnson, 2020). Correcting medication errors not only improves patient or student health outcomes, but also continues to support the foundation and continuation of the program in schools.

The emergency medication administration program dramatically improves the health outcome of students with respiratory emergencies in schools. The program has successfully obtained legislation to support the growth and advancement of the program across the state. However, a lack of proper training, guidance, and follow-up results in medication errors occurring and being documented negatively affecting the growth and development of the program. Although not all trained personnel are nurses, it is essential to develop a target training that addresses how the medication should be given and in what doses to provide the best treatment and benefit to the user. Consequently, this would result in a significant improvement in student health outcomes, decrease school absence, and provide evidence for continued need for funding for this program in all schools across Arizona.

A literature review led to the clinically relevant PICOT question: “In school emergency medication programs, does using an interactive education module along with an audit and feedback system compared with current processes prevent medication administration inaccuracies?”

Internal Data

A state-level agency that focuses on school public health incorporated the emergency medication administration program in 2017. The state agency provides the registered schools with the medications, supplies (such as inhaler spacers), and training regarding administering emergency medications in the event of a medical emergency. The state agencies are not regulatory agencies but they focus on public health resources. Annually, they seek grant funding to apply toward medications and supplies. Although they were still assessing the program's effectiveness, they found inconsistent documentation of the administered medications, failure to follow protocol, and vague information about the emergency episode. Consequently, funding

has become more difficult for the agency due to a lack of data to compare and support the need for this program in schools. Further, the need for more guidelines on required documentation developed by the agency and the fact that it is not included in the state regulation complicates the issue.

Search Strategy

A review of related evidence included major databases to explore and answer the research question. PubMed, CINAHL, Scopus, and ERIC databases were extensively searched. These databases best address the topic of medication errors and have extensive research relevant to the medical and public health fields available.

Keywords used to search each database addressed all of the PICOT question features including *school medications*, *documentation guide*, *protocol*, and *administration inaccuracy.* Specifying with *inhaler* or *bronchodilator* was not used as that did not yield any research. Combining *medication error* and *algorithm* resulted in the most relatable research however, the quantity was limited. To obtain a more extensive variety, the following terms were used for the intervention: *checklist, log, guidelines, documentation, and electronic documentation*. To specify the outcome, the following terms were added: *errors, record, administration, and documentation*. Adding identifying words such as *nurse* or *school personnel* yielded minimal data. The results in all databases were further narrowed by publication year (2018-2023) and research type including clinical trials, meta-analysis, randomized controlled trial, and systemic review. Mesh and Boolean terms were used to combine the terms for the intervention with the outcome.

An initial search of PubMed was performed using the terms *medication administration error, log, algorithm,* and *guide*. This yielded over 4,000 results and was filtered further with

terms such as *reduced, error,* and *checklist*. After applying the terms, specified results ranged from 16 to 96. The initial search of CINAHL consisted of similar terms with adding *children*, *adolescents*, and *youth*. This yielded over 200 results and was adjusted with terms such as *nurse, medication error, five rights, checklist, protocol*, and *tool*. The results consisted of 39-53 documents.

An initial search of Scopus was performed with terms including *algorithm, guide, medication,* and *error*. The initial search produced over 1,000 results. Further filters included terms such as *log, nurse,* and *charting*, with focused results of around 20 to 50 articles. On the contrary, a search in ERIC yielded over 10,000 results. The search terms were similar to other databases including *nurse, inhaler, medication, documentation,* and *log*. Terms such as *errors, checklists,* and *medication administration* were added to specify the research question further. Regardless of filters, results yielded irrelevant results to the research question and were not used to appraise any research critically.

Limitations, Inclusion, and Exclusion Criteria

Reviewing all relevant articles and publications in the databases, 30 relevant studies were included, and two were obtained by checking the systemic review references. Rapid critical appraisal checklists were used to narrow down the ten most relevant studies (see Appendix A, Table A1). These included one systematic review, three prospective cohort studies, two quasi-experimental studies, one randomized control trial, two cross-sectional studies, and one quality improvement study.

Inclusion criteria included interventions that targeted medication error improvement and inpatient or clinic settings. Exclusion criteria included interventions that targeted physician prescribing or at-home medication administration. Overlap in the studies within the systematic

reviews could have been more extensive as they evaluated interventions within different patient settings. Selecting higher levels of evidence, such as systematic reviews, randomized control trials, and quasi-experimental studies, were considered in the final ten articles to be included in the evaluation table.

Critical Appraisal and Synthesis of Evidence

The rapid critical appraisal process developed by Melnyk and Fineout-Overholt (2019) was used to determine final high-quality studies. Most of the studies had higher levels of evidence, including levels one and two (see Appendix A, table A2). Although pediatrics is a sensitive population for research, more than half of the high-quality studies chosen were focused on the pediatric population. The lower levels of evidence were kept due to their focus on pediatrics, the nursing profession, and their theory/conceptual framework examples. Four of the studies observed combined intervention methods that resulted in decreased medication error rates. Those combined interventions in each study involved education, checklists, and audits. Similarly, four of the studies were based outside of the United States but had high levels of evidence for the previously stated interventions and were therefore kept as final studies. The four foreign studies were not found to have bias and were considered relevant to answering the research question (see Appendix A, table A1). It was essential to include studies focusing on the nursing profession and on multidisciplinary team members as the SSMP is not only comprised of nursing staff administering medication. Interventions for the interdisciplinary teams still showed a decrease in medication error rates. Two of the studies that showed success with education and checklists based their framework around the Plan-Do-Study-Act model, also referenced as Plan-Do-Check-Act (see Appendix A, table A2). In addition to providing an appropriate theoretical

framework for the PICO question, the interventions within these studies were feasible and applicable to the current organization.

Discussion

Treating asthma in school is vital to preventing emergency department visits and school absences. Creating a program that provides schools with stocked Albuterol inhalers helps tackle asthma exacerbations when they occur. However, this treatment comes with responsibility of medication administration. Documentation of albuterol inhaler uses in schools serves as the evidence and tracking mechanism for the administration. Despite being documented, the current documented medication administration does not correspond to the written protocols. The literature review reveals various strategies to curtail or ameliorate medication discrepancies, encompassing educational initiatives, audit, and feedback mechanisms, and the integration of electronic medication systems. There appears to be a dearth of research concentrating specifically on medication administration within educational institutions, with a scant two studies directing their focus on school settings. The sample sizes in the extant literature are notable expansive, indicative of the considerable impact these interventions have on reducing the frequency of medication errors. While the majority of research is grounded in acute care contexts, a substantial portion is also devoted to pediatric care. Although the school setting varies greatly from critical care, medication administration standards by either a licensed professional or trained personnel remain the same. All researched interventions can be applied across various clinical settings and are not limited to registered nurses, they can also include any trained individual performing the medication administration. The research examined in this literature review has substantiated that an emphasis on education and direction, coupled with a tailored audit and feedback mechanism, leads to enhancement in the management of medication errors.

While a variety of interventions have yielded benefits in addressing medication discrepancies, those that concentrate on the personnel responsible for dispensing medication have proven particularly advantageous to the respective agencies and programs.

Theory/Theoretical Framework Application

The foundation of this literature review aligns with the tenets of renowned quality improvement models, paralleling the evolutionary development of such theories. W. Edwards Deming was a physicist studying agricultural production in Japan after World War II when he developed a quality improvement theory that focused on quality over quantity (Butts & Rich, 2018). He brought the idea back to the United States that concentrating on the process was more important than focusing on the outcome or product. The terms for his theory are interchangeably used as The Deming System or the Deming Theory of Profound Knowledge (see Appendix B, Figure B1). The Theory of Profound Knowledge consisted of first understanding a system's components from the outside before being able to initiate any process improvement (Roehrs, 2018). The theory is continuous and starts with an appreciation for a system followed by a theory of knowledge that comes from studying the system. The third element is understanding variation to avoid overlooking opportunities to fix a problem. The final component is the psychology of change within the system to understand the motivations of the people within it as well as provide adequate support to assist in the shift (Roehrs, 2018). Although the system and theory were based on industrial work environments, the theory worked its way into healthcare and care delivery improvements over time.

Similar to how the theory was developed through study and observation, the theory itself starts with observing the current functionality of the SSMP. This literature review focused on the theory of knowledge element to understand the system and to understand various existing

process improvements. The literature review revealed the most effective ways to address medication or documentation errors within the program. However, different interventions showed benefits in different environments. Therefore, effectively implementing change within the organization must reflect a continuous process with frequent evaluation and endless improvement imitating The Deming System.

Implementation Framework

Quality improvement projects in healthcare are continuous and require a framework to test any change. Aligning with the steady quality improvement theory is the Plan-Do-Study-Act (PDSA) cycle (see Appendix B, Figure B2). It is an ongoing act of initiating a plan, monitoring, evaluating, and starting a new cycle of change (Butts & Rich, 2018). Each plan approaches a smaller scale problem and as it continues through the revolving cycle, it can affect change quickly. Reducing medication errors is a continuous process particularly with a relatively new program that is in the first steps of improving outcomes on school asthma management. More minor scale interventions will result in change that further initiates transformations to impact the final goal of the program. Before the plan, data must be collected on interventions that may successfully change and improve a process (Christoff, 2018). This literature review results in potential plans such as checklists to improve medication administration errors. The second stage of the cycle, the *do* stage, will be incorporated into the SSMP documentation process. Modifying the online documentation log, new prompts, drop-down menus, and algorithms will facilitate proper medication administration. In the third stage, *study* the plan is evaluated to determine whether or not it is working. To compare data effectively, documentation logs for the same time in the school year would be obtained before and during the intervention (i.e., Fall semester 2022 and Fall semester 2023). At this stage, the intervention's success and any problems or

unexpected outcomes are examined to make appropriate modifications (Christoff, 2018). The *act* stage may be considered the final stage. However, the model is cyclical and the act refers to the intervention being adopted into practice, modified, or completely altered, resulting in further study and adaptations.

Implications for Practice Change

To order to begin any change initiative, it is imperative to understand the motivations behind the stakeholders within the organization. The SSMP is only one aspect of the public health functions that the organization is involved in. Collaboration with stakeholders to develop an intervention that will be accepted and achievable requires understanding their goals for the program. It is necessary to evaluate the problem and collect current medication error data from the documentation log to make changes. To determine medication error, collections would be performed of any log that deviates from the protocol for Albuterol administration. An analysis of the data and a literature review of possible interventions for reducing errors should be presented to the involved stakeholders. Those stakeholders at this organization include the program lead, information technology specialists, medical directors, and prescribing providers. Education, audits and individualized guidance were among the most successful interventions within the literature review and are attainable with modifications to online education and the consistent evaluation of submitted documentation logs. Comparison data would be collected between the intervention fall semester and the control fall semester in the previous year. The exact time of year must be chosen as environmental factors such as weather, pollen, and physical activity or sports can affect the prevalence of asthma attacks. To evaluate changes, rates of medication errors documented in the log would be compared between chosen semesters. To reflect the cyclical PDSA cycle, results would lead to further modifications until the program's goals are

met, high-quality documentation is achieved, and a significant decrease in medication errors is noted.

Potential Outcomes

For newer programs such as the SSMP, adjustments to the education and follow-up will not only help improve rates of medication errors but also provide sufficient evidence that the program is meeting its original goals of returning students to class and avoiding emergency calls. To meet those goals, medications must be administered and documented correctly.

Methods

Ethical Considerations

Three ethical principles guided this project: respect for person(s), beneficence, and justice. Respect for persons is allowing the participant to make autonomous decisions (Miracle, 2016). This means that the participants receive all information on participation, risks, and benefits of the study. Data was extracted from a source that collected the logs through the organization before this survey. Therefore, there was no need to obtain consent. Beneficence means protecting the participant's welfare and safety and goes along with non-maleficence by not harming (Miracle, 2016). The project adhered to this principle by protecting the safety of all administrating personnel at the school and the students by avoiding using data for exploitation (Miracle, 2016). All data collected, such as documentation logs, remain protected for the study and will be not be used for other means. Justice is the final principle, allowing for fair treatment and privacy (Miracle, 2016). The project adhered to this principle by protecting participating schools and faculty and any information regarding the students in the documentation logs. There was no exclusion in seeking out particular participants as all the enrolled schools and personnel were provided with the intervention (Miracle, 2016). Additionally, any data collected for this

study, such as medication documentation logs, will not contain any faculty or student identification.

IRB Approval

Internal review board (IRB) approval was obtained through Arizona State University (ASU) before beginning any data collection (see Appendix C). An IRB modification was submitted and obtained for project title changes that did not affect any project processes (see Appendix D). The project site/organization does not require an internal review board application or approval as the data is collected at a secondary level through an existing collection system.

Setting and Stakeholders

The emergency medication program is monitored by a county organization focusing on various tasks including public health monitoring. The school health division oversees the enrollment, training, and documentation of the program and manages the medications and equipment. The lead public health registered nurse is the point of contact for schools enrolled in the program. Schools can opt for their own provider to prescribe the medication order or obtain orders under the organizational medical director. In either case, the prescribing physician orders the albuterol inhaler to be administered per the written program protocol.

The lead public health nurse, medical director, information technology department, and any current pharmaceutical companies working with the organization to provide the medication and supplies are directly involved in the program. These individuals work yearly to obtain state grant money to fund the medication and supplies for the enrolled schools. This consists of collecting data to prove the effectiveness and need of the program. On the delivery end of the program are the school faculty trained to administer the inhaler, including nurses, health aids,

emergency medical technicians, teachers, and administrative office staff. They enroll in the school, complete the annual training, administer the medication and document the incident/administration. Agencies that oversee these individuals may also be stakeholders in this project as those licensed may have practice and ethical standards to adhere to. For this reason, improving medication errors may benefit those individuals and their licensing agency by complying with written physician orders.

Finally, the students at the receiving end of the medication are the main priority and top stakeholders. They ensure their trust in the trained individuals to administer the appropriate dose of the inhaler to address their acute needs. The patients are the students at the enrolled schools and include elementary, middle, and high school ages. They are a part of public, private and charter schools. They do not have direct participation in the project but are affected directly by the improper medication administration.

Participants and Recruitment

The source of medication administration errors comes at the delivery point with the trained school staff. The intervention focused on changing aspects contributing to the administration process to address this. Participants are trained school staff including nurses, health aids, emergency medical technicians, teachers, and administrative office staff. The individuals were the same individuals who are registered in the program to administer the medication. Over four hundred schools are registered in Maricopa County under the emergency medication program. After internal data review, most medication administration errors occur within a few commonly occurring school districts. However, participation included all registered schools and trained staff to avoid any unintentional exclusion. Since no patient or staff information is being collected for this study, no recruitment letter was sent out.

Participation begins with an organizational letter sent to all registered schools and personnel before the 2023-2024 school year. The letter explained the changes in the new school year, including the revised education module. Training is renewed annually; therefore, those with training expiring before the 2023-2024 school year or between July and December completed the new education module for the purposes of this project. The amount of personnel that met the further revised training were accounted for when collecting final data.

Intervention

Planning consisted of creating the education module to evaluate if using education and feedback systems improves medication error rates for emergency albuterol administration. The education closely focused on the Albuterol order and protocol (see Appendix E) to most accurately promote adherence. The education was approved by the county organization and was constructed to fit any government requirements and protect the students' privacy. Data collection before initiating the intervention was obtained to determine a control data set. This data set contained the years before the new education module and the consistent feedback system.

The schools were notified on July 1st of the new education module available for the upcoming school year. As mentioned, training is renewed on an annual cycle. Therefore, those with renewals starting in July through December completed the new education module at some time during the project timeframe. Those with training scheduled to be renewed in the months of January through June will meet the unique training at their designated renewal time outside of this study timeframe. This was accounted for in the final data collection to reflect how many trained personnel have reviewed the revised education and if that may contribute to the change in medication compliance. The education included a protocol-heavy focus, information on the inhaler’s storage, and quizzes throughout the module to verify the personnel’s knowledge.

All other medication administrations, such as epinephrine provided by the same program, continued to have the same education and were not modified. Barriers included seeking assistance to fully ensure the trained personnel have read all aspects of the training. This is addressed with intermittent quizzes throughout the module. Other barriers were addressed as they surfaced throughout the project, including uncompleted training modules, newly registered schools and new staff.

Additionally, every two weeks starting July 1st, the assigned nurse auditor revieed documented logs and highlighted any that deviate from the protocol. The nurse auditor contacted those individuals, and reasons for deviation were discussed. At this time, education was provided pending the reason for deviating from the protocol. If the deviation was documented in error, changes were made by the nurse auditor after the communication and feedback. The process repeated every two weeks and continued through December. The trend of medication errors or deviations from the protocol every two weeks were collected along with how many personnel completed the new training before or during the project's duration.

Data Collection and Instrumentation

Chart auditing is used to evaluate medication error reduction for error rate comparison between the 2022 and 2023 school year's fall semester. The chart auditing is individualized to this project and no studied validity or reliability is available. Many interventions not only work to increase or decrease numbers, but they also aim to become a new accepted process of the staff that it is implemented on. In the case of medication errors in the emergency school medication program, a new education module, in addition to consistent feedback will be implemented to evaluate effectiveness at decreasing medication errors. Those giving the medications and participating in the further education requirement include nurses, health aides, emergency medical technicians,

and administrative office personnel. The goal of the intervention is not only to reduce medication errors but also provide the above individuals with a sense of protection by adhering to the correct medication doses, particularly those licensed by a state or national agency. This sense of security and reassurance in administering medications appropriately and in good faith comes is a secondary outcome to the project.

Data Analysis Plan and Funding

Descriptive statistics was used to describe the set sample and outcome variables using Intellectus Statistics (Intellectus Statistics, 2022). The Friedman test was used to compare the four months of the average dosages administered. A two-tailed test was run and the critical value was set at $p < 0.05$. The data collected contained the inhaler dose, time administered, respiratory distress level, administering staff credentials, education completion, and student disposition. Currently, no identifying student information is placed into the log when medication uses are documented. No identifying information was collected for the project. Demographics were collected, including age, ethnicity, gender, and race of the student receiving the administration.

There is no required funding for this project. The organization has covered costs for the online platform “Moodle” to create the education modules. The staff participating, including the nurse auditor, information technology specialist and research physician, complete any work during their regular working hours and require no additional pay. Overall funding for the medication program is obtained through state grants and, currently, is funded by the Mercy Care Grant for the 2023-2024 school year. This grant funding supports the medications, supplies, and any online platforms or software that contribute to the development of the program.

Results

Intellectus Statistics (Intellectus Statistics, 2022) was used to store, manage, and analyze the data containing the inhaler administration logs (*n* = 434). Data was obtained as a secondary source from the primary source at the organization through their logging system. Data collection occurred at two intervals; once in October and once in December. The data reviewed looked at any logs documented from July 1st to December 21st. During the two data collection periods, the lead public health nurse at the organization ran the report of logs documented prior to the collection time (i.e. in October, all logs prior from July 1st were reviewed and in December, all logs after October 20th through December 21st were reviewed). Each log was manually entered by the researcher into a separate data collection audit form (see Appendix F). Intellectus Statistics (Intellectus Statistics, 2022) was used to store, manage, and analyze the data containing the inhaler administration logs (*n* = 434).

The data included collecting student demographics that did not include identifying information. The average age of the students in years was ten (SD = 4.97). The ages range from three to fifty-three years. (see Appendix G, table G1). The maximum age is above a typical school-age child as the inhalers are statutorily approved for use within the school including staff members suffering from respiratory distress. Due to this, an outlier of one staff member receiving the inhaler administration was documented while the rest were students. The majority of the sample were male, 251 (60%) with the rest of the students identifying as female or other (see Appendix G, table G2). Most of the students were white (53%) and non-Hispanic/ non-Latino (64%) (see Appendix G, table G2).

In relation to the administrator of the inhaler, credentials, level of distress identified, emergency medical services (EMS) calls, and student disposition were the variables observed. The most common administrator credential documented was school nurse (74%) followed by

health/medical assistant (25%) (see Appendix H, table H2). For the purposes of the study and narrowing down credentials/roles, health/medical assistant including any personnel that identified as a medical assistant, an emergency medical technician, or a health office aid. The most occurring level of distress documented in the student was mild/moderate (92%) with severe occurring at 8% (see Appendix H, table H2). With this level of distress identified, the most common dose of Albuterol administered was 4 puffs (SD = 1.22) which correlates with the mild/moderate category (see Appendix H, table H1). 75% of students were returned to class with 23% sent home with a parent/guardian. Less than 3% of the events documented required an EMS call with or without ambulance transport to the emergency room (see Appendix H, table H2).

Intervention variables were evaluated to include completion of new education by the administrator documenting the log and if one on one feedback was provided to the administrator of the inhaler. 61% of the logs were documented by an administrator that completed the new education (see Appendix H, table H2). Only 10% of the logs required feedback by the auditing nurse at the organization (see Appendix H, table H2). This correlated with the number of correct logs during the four-month study timeframe.

To evaluate the outcome of the student after receiving the inhaler administration, the EMS calls and student disposition were accounted for within the levels of distress. For the mild/moderate levels, less than 2% of the students required an EMS call and 78% of them were returned to class following the administration (see Appendix I). For the severe level, 12% of the students required an EMS call with 41% of them returning to class following the administration (see Appendix I). This does not correlate with the recommended protocol as each student identified within the severe level of distress is required to have an EMS call made.

When identifying levels of distress, the breakdown between administrator credentials was reviewed. School nurses identified more severe levels of distress (9%) compared to health/medical assistants (6%) and administrators (0%) (see Appendix J). This information can imply that school nurses are more trained at identifying signs and symptoms of respiratory distress due to their educational background and are vital in identifying appropriate levels.

To evaluate the trend of correct administrations, descriptive statistics were used to determine month and correct administration frequency. The most documented uses of Albuterol administration occurred in November (25%) followed by October (20%) (see Appendix K, table K1). This information can stand to identifying that winter allergies or environmental triggers during fall school sports accounted for more inhaler need. In total, 90% of the administrations throughout the four-month timeframe were administered correctly and required no one on one feedback by the auditing nurse at the organization (see Appendix K, table K1). With November being the month with the most inhaler uses, it was also the month with the most correct administration (25%) (see Appendix K, table K2). August was the month with the most incorrect administration (35%) interestingly followed by December (24%). The assumption can be made that August was close to the start of the school year and staff were still adjusting to administration guidelines and new education changes. There can also be a link between a large pool of inhaler administration occurring midway in October and November and therefore there is a larger sample to deduct errors from.

Continuing to look at correct administration trends, we can compare to the administrator's credentials, level of distress identified, and the disposition of the student. Since the most common administrator credentials were school nurses, they also consisted of the top category in both correct (74%) and incorrect (71%) administrations (see Appendix K, table K2)

therefore, this data cannot be reliably used to determine which credentials were most correct in their administration. However, we can refer back to the credentials that were able to identify more of the severe levels of distress to make this conclusion. Mild/moderate levels of distress were the most common category overall and therefore consisted of 93% of the correct administrations and 81% of the incorrect administrations (see Appendix K, table K2). Equally, the most common student disposition overall was their return to class and therefore appeared as the most frequent category in correct (76%) and incorrect (64%) administration.

Finally, to outline the frequency of the new education completed, descriptive statistics were obtained with education completion and correct administration. Those that completed the new education administered the inhaler correctly per the protocol 92% of the time in comparison to those that did not complete the education administering the inhaler appropriately 87% of the time (see Appendix L). From this we can deduct that those that completed the education were more likely to administer the inhaler appropriately per the protocol as the education heavily outlines administration guidelines and examples.

Friedman Rank Sum Test

To evaluate the outcome variable of correct administration, the research question was asked if there are difference amongst the variables. The null hypothesis is that there are no differences among the variables with the alternative hypothesis that there are differences among the variables. A Friedman rank sum test was conducted to examine whether the medians of month, administrator credentials, albuterol dose, level of distress, and disposition of student were equal amongst the correct administrations. The Friedman test is a non-parametric alternative to the repeated measures one-way ANOVA and does not share the ANOVA's distributional assumptions (Conover & Iman, 1981; Zimmerman & Zumbo, 1993).

The results of the Friedman test were significant based on an alpha value of .05, $\chi^2(4) = 1{,}438.64$, $p < .001$, indicating significant differences in the median values of month, administrator credentials, albuterol dose, level of distress, and disposition of student amongst the correct administration. Appendix M, table M1 presents the results of the Friedman rank sum test. Figure M1 presents boxplots of months, administrator credentials, albuterol dose, level of distress, and disposition of student. Observed differences that are greater than critical differences indicate significance at the $p < 0.05$ level (see Appendix M, table M2).

Clinical Significance and Impact

Breaking down each variable is important in determining clinical significance. Demographic information solely provides a snapshot into what the sample looks like for further study purposes but it does not reflect any relationship to the outcome variable. The credentials of the administrators of the inhaler along with their assessment details such as level of student's distress, if EMS was called, and if the student was sent home or back to class is relevant in determining significance of the education impact and supporting various levels of school funding. In this case, the most common credential that administered inhalers during the study timeframe was a school nurse. Equally, school nurses were able to identify more cases of severe respiratory distress than the health assistants and administrative staff. Although the number of administrations that occurred under a school nurse were a larger sample than the other credentials, we can deduct that the nursing education supplements better assessment of respiratory distress. Although the inhaler education provides information about what symptoms display as mild/moderate versus severe distress, this education does not replace that of a nurse

and their ability to assess visually and physically. It also does not replace the education and knowledge in differentiating an allergic reaction versus respiratory distress as symptoms often overlap. With this, we can support the need for schools to obtain nurses across all campuses for better emergency symptom identification.

Although the one-on-one nurse feedback was not the primary intervention, the purpose of this was for repeated education and discussion to promote future correct administration. Additionally, this supports the need for individual public health departments that run similar programs to obtain an auditing or feedback nurse to review the logs. Almost one third of the administrators of the inhaler were not licensed nurses and therefore, one-on-one feedback opened up a door for free discussion about the student's presenting symptoms, how to identify different levels of respiratory distress, and how to appropriately proceed through the administration protocol to provide the student with the safest relief. Additionally, the feedback system allowed an open door for discussion for the school nurses as well. Common questions arose throughout those feedback sessions where nurses expressed concerns about their license in the administration of the inhaler. Those repeated concerns contained questions such as if their license is protected when administering the protocol doses, what to do if parents or students refuse or request a specific dose, and if they are able to make a nurse judgement on which dose to administer outside of the protocol. A document was created to address some of these frequently asked questions and was incorporated as official internal agency files. Therefore, it was asked not to be included in the study manuscript due to its ongoing modifications.

The completion of the new education module was the primary intervention studied in improving the outcome variable of medication errors. Prior to the 2023-2024 school year, the program required two individuals from each school to review the education material to become

“certified” to administer the inhaler. This education material was a PDF document that required an attestation through a survey. Based on the evidence in this study, those that completed the new interactive education module were more likely to administer the correct dose of the inhaler than those that did not complete it. The education is renewed on an annual basis and those that were due for renewal during the study period or were new staff members had the privilege of completing the new education. It is expected that by July 1st of 2024, all current staff members will have reviewed the new education module.

Sustainability

Implementing online education modules creates the ease of noy only access to the trainees but also for updating any new information. Since it is a requirement to complete the education annually, the staff is able to access any dosing or protocol changes during that time. The training provides information on recognizing symptoms, dosing appropriately per the protocol, and the functionality of using the inhaler. Although this may benefit from in-person teaching for the non-healthcare staff, the education encompasses all of the important concepts and can be accessible from anywhere.

The feedback system incorporated into this school year was achievable by adjusting roles within the public health department that oversees the program. The lead public health nurse took on the role of the auditor to provide the one-on-one feedback individually to school staff members. This took time away from other tasks within the organization and for future modifications of this role, it would require a separate individual dedicated to this job. Additionally, they oversee other county schools as well as not every county in Arizona has a public health department. This also creates difficulty in sustainability as the lead public health

nurse dedicated to providing the feedback cannot oversee every school in the state. The benefit of this feedback system can entice the need for health or safety departments in other counties to obtain nursing oversight for auditing and feedback.

For the benefit of the organization, this evidence can provide some guidance in modifying the statutory requirements for future programs. Other states and counties across the country have reached out to this agency for guidance on adapting similar programs as theirs is one of the first that implemented emergency medications in schools. With this new evidence, statutes can be revised to include information about required education, dosing, and maintenance of the charting with consistent log reviews. This is beneficial in upholding the value of the program as it reinforces correct administration as a licensed or unlicensed staff member.

Discussion

Benefits of emergency medication programs in schools revolve around the ability to acutely address the emergency situation and prevent further emergency services that require students to leave school. This benefits both the student, their family, and school staff in avoiding absences and hospital bills. To do this, correct administration of the medication must occur. Not only did we find that those that completed annual education had a high probability of administering the correct inhaler dose, but we also found information that supports funding and maintenance of these important roles. Nurses were the most common administrator and were therefore able to identify the most severe cases of respiratory distress in comparison to the other certified staff members. Without the nurses, the likelihood of severe respiratory distress going unnoticed or undertreated is high as no amount of online module education can compare to extensive nursing education. Additionally, we were able to find that the early winter months of

October and November called for more inhaler uses as environmental changes occur and fall sports begin in schools. This also supports the need for increased nursing staffing amongst schools particularly during those high traffic times.

Strengths and Facilitators

Many components of this study not only contributed to the ease of data collection for the purposes of the project but also for the sustainability and long-term plans of the medication program. The new education module was implemented purposefully prior to the new school year to start the year with fresh education. This allowed any newly registered staff or schools to complete and view the new information available. Currently, the staff is on an annual renewal schedule with the education. With this, most of the staff's renewal aligns with the beginning of the school year and small rates of staff have renewals due beyond the study's time period. Regardless of this, the education is easily accessible by being online and can be completed from home or out of office without imposing on other work-related tasks that the staff member may have.

Additionally, the feedback system was provided by a registered nurse within the organization. This was beneficial in many ways as the feedback emails opened up conversation and discussion regarding various aspects of the administration from symptoms to doses. The nurse is able to relate to other nurses at the school in their thought process and experience and can serve as an education model for those staff members not in healthcare as nurses often do on a regular basis. Although a strength, this can also be a barrier to future adaptations of this program if it were to become a requirement.

Limitations, Barriers, and Challenges

To be able to have the registered nurse at the organization provide the one-on-one feedback, her role had to be re-defined within the organization and opened up to the time that it takes to send out feedback emails on incorrect administrations and also be available for frequent phone calls or return messages. This has proved to be beneficial in promoting staff to adhere to protocol requirements but sustainability and adaptation become a question. Smaller counties throughout the state would need to obtain a nurse to fulfill this role within their area and if that were to become a requirement of the program, the adaptation rates may fall. Nursing is already a specialty with a lot of shortages and funding a nurse to review and provide log feedback may be difficult to obtain.

This data in this study consisted of a retrospective chart audit over a six-month timeframe, the first half of the 2023-2024 school year. Prior data available reflect adherence rates over the entirety of the school year being July to May. Although the data showed high significance and relevance to the purpose, it is not evenly comparable to the prior school years without studying the remainder five months. We can assume that similar results would continue in the spring semester of the school year however, the frequency of inhaler use may increase due to continued winter weather and respiratory illnesses as well as spring allergies and spring sports.

Overall, the purpose of evaluating education and one-on-one feedback within an emergency medication program is to promote adherence to administering the correct dose. Administering the correct dose leads to proper respiratory distress treatment in the students and upholds the value of the medication program with state law requirements and standards of providing adequate healthcare. The data has shown that frequent education amongst nurses and non-licensed staff members in the form of education modules and open discussion encourages proper dosing administration and following protocol orders. Additionally, supporting data has

shown the necessity of having school nurses available across all campuses. Although education can be provided to non-healthcare professionals such as in cardiopulmonary resuscitation (CPR) training, the education in identifying specific symptoms of respiratory distress can only be achieved at the highest level with a healthcare background. Future studies to evaluate the knowledge base of respiratory distress versus similarly presenting conditions such as allergic reactions amongst nurses and other trained non-healthcare staff is recommended to further support this statement. As new data appears, statutory modifications can occur to support sustainability in education and personnel for future program adaptations nationwide.

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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
Abuelsoud (2018), Pharmacy quality improvement project to enhance the medication management process in pediatric patients **Country:** Cairo, Egypt – Saudi Arabia **Funding:** not stated **Bias:** author if faculty of pharmacy, states no conflict of interest	FOCUS PDCA technique	**Design:** Prospective cohort **Purpose:** improve quality of medication management process within pediatrics, to decrease medication error rates in prescribing, administration, and monitoring	**N=** 900 medical files (100 reviewed monthly) **Demographics:** physicians, nurses, pharmacists **Setting:** pediatric specialty charts in maternity and children's hospital in Saudi Arabia **Exclusion:** files selected at random **Attrition:** n/a	**IV1:** educational program including implementation of clinical pharmacy and drug information services **DV1:** decrease medication error rates in: prescribing, administration, and monitoring stages	**Tools: quality tools used:** -Brainstorming -Fishbone chart -Questionnaire -Voting **Validity/Reliability:** -No values report. - Test- re-test method is possible, no value to determine likelihood of obtaining same results.	**Statistical Tests Used:** No test stated	**DV1:** -Error rates decreased from 47%, 60% and 56% to 10%, 10% and 15% respectively in all stages (prescribing, administration, monitoring)	**LOE: 2** **Strengths:** -Included more error types than other studies of similar nature **Weakness:** -Some medications did not have pediatric use approval **Feasibility:** -Comparison studies are conducted in adult patient settings. Pediatric patients are typically not used for research

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
								Application: -Can be applied to various patient units, use of multidisciplinary team
Craig et al., (2021), Simulation strategies to increase nursing student clinical competence in safe medication administration practices: A quasi-experimental study **Country:** United States **Funding:** Virginia School of Nursing Jeanette Lancaster Endowment Fund of Faculty Excellence	Jeffries Simulation Framework	**Design:** Quasi experimental study **Purpose:** examine effects of education strategy using a simulation program with a focus on medication administration	**N=** 83 (IG n=45, CG n=35) **Demographics:** -3rd year BSN students **Setting:** large mid-Atlantic public university (name not disclosed) **Exclusion:** -students that have not taken a medical-surgical course **Attrition:** 3 students	**IV1:** additional clinical simulation experience and debriefing sessions focused on medication safety **DV1:** Increase in post test scores (Medication Safety Knowledge Assessment **DV2**: increased scores on Medication Safety Critical Element Checklist)	**Tools:** -pre and post-test Medication Safety Knowledge Assessment and Medication Safety Critical Element Checklist **Validity/Reliability:** -Medication Safety Knowledge Assessment (Cronbach's alpha r < 0.73 and r < 0.73) (Validity – CVI - 0.94) -Medication Safety Critical Element Checklist (Cronbach's alpha 0.69-0.72) (Validity – CVI 0.92)	**Statistical Tests Used:** -Two-sided independent t-tests ($\alpha = 0.05$)	**DV1:** IG scored higher than CG in the Medication Safety Critical Element Checklist ($p < 0.001$)	**LOE:** 2 **Strengths:** -Evaluating students already exposed to clinical practice **Weakness:** **-**IG received additional simulation 1st wk - Simulation time 15 minutes -Inconsistency in debriefing sessions **Feasibility:** **-**Can be replicated using the same tools

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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
Bias: do not disclose any bias, disclose no conflict of interest. Group selection was made by program manager who was not associated with the study to avoid bias.								**Application:** **-**Cost not disclosed -Can be applied into nursing programs at different time intervals
Hebbar et al., (2018), A quality initiative: A system-wide reduction in serious medication events through targeted simulation training **Country:** United States **Funding:** not disclosed **Bias:** Author declares no	Conceptual model supported by Institute for Safe Medication Practices and Solutions for Patient safety 3 main elements: The Five Rights, MedZone, and Independent Double Check	**Design:** Prospective cohort study **Purpose:** improve adherence to best practice, decrease MAEs, decreased cost related to error reduction rates	**N=** 1434 nurses **Demographics:** Nurses from intensive care units, emergency departments, and general care inpatient units **Setting:** **Exclusion:** -nonpediatric nurses -nonnurses **Attrition: n/a**	**IV1:** simulation training focusing on : The Five Rights, MedZone, and Independent Double Check **DV1:** adherence to best practice **DV2:** MAE **DV3:** cost related to error	**Tools:** -Bedside auditing for 18 months post intervention -2012 Healthcare Cost and Utilization Project Kids' Inpatient Databased and 2014 Children's Hospital Association, Pediatric Health Information system databased : used to estimate cost **Validity/Reliability:** **-**No reliability or validity of the	**Statistical Tests Used:** Mann-Kendall nonparametric test = 0.673 Poisson test ($p = 0.029$ for error rate change) ($p < 0.001$ for practice adherence)	**DV1: adherence increased 33%** **DV2:** decrease in error rate from 2.5 events per month to 0.86 events per month **DV3:** savings of $90,000 to $130,000 per year	**LOE: 2** **Strengths:** - Trained over 50% of the staff at 2 hospitals, results lasted 3 years (decreased MAEs) **Weakness:** -During project, various initiatives to decrease MAE were also implemented **Feasibility:**

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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
conflict of interest. -Within study, nursing leaders performed auditing of their own units					assessment tools used - 95% confidence interval = 1.2-8.5			-large scale, system wide initiative - Requires 2 hours of each nurse's time **Application:** -requires collaboration with a simulation center -performed in a single healthcare system
Hutchinson et al., (2020), Use of an audit with feedback implementation strategy to promote medication error reporting by nurses **Country:** Australia **Funding:** Australian Government – Australian	-Promoting Action on Research Implementation in Health Services -Theory of Planned Behaviour	**Design:** Quasi-experimental study **Purpose:** To increase rate of voluntary medication error reporting by nurses	**N=** 166 IG CG **Demographics:** -< 60 years of age - >60% bachelor degree ->58% considered grade 2 RN **Setting:** - large nonprofit hospital in Melbourne **Exclusion:** -included neurology/stroke units, general	**IV1**: audit with feedback implementation **DV1:** rate of medication errors reported per month **Definitions:** audit with feedback = summary of clinical performance	**Tools:** -Alberta Context Tool -Post feedback survey **Validity/Reliability:** -Alberta Context Tool (Cronbach's alpha exceeded 0.70)	**Statistical Tests Used:** Poisson distribution Independent samples t-tests 95% Confidence interval (0.92, 1.51) P =0.14	**DV1:** 80% increase in medication errors reports per month	**LOE: 2** **Strengths:** -Real world acute care setting **Weakness:** -Did not account for EMR changes -Researchers were present in units **Feasibility:**

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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
Research council **Bias:** Research council had no role in study			medical units, surgical units. -units in close proximity to each other -nurses from a nurse agency and nursing students excluded **Attrition:** IG lost 8.4% of participants, CG lost 1.1 % of participants					-12 month implementation -Implemented in single acute care hospital **Application:** **-**Can be applied to multiple sites in a cluster experiment
Kanjia et al., (2019), Increasing compliance of safe medication administration in pediatric anesthesia by use of a standardized checklist **Country**: Texas, United States **Funding**: Not disclosed **Bias**:	Model for Improvement Plan-Do-Study-Act Failure Modes and Effects Analysis (FMEA)	**Design:** Quality Improvement study **Purpose:** "develop and promote a safe process for high-risk intraoperative medications", improve communication and therefore reduce acetaminophen medication errors intraoperatively.	**N= 633** **Demographics:** **Setting:** Cincinnati Children's Hospital Medical Center **Exclusion:** Patients not receiving adenotonsillectomy procedures **Attrition:** n/a	**IV1:** 5-step safety checklist **DV1:** Checklist compliance	**Tools:** Physical checklists, EMR **Validity/ Reliability:** Test-re-test reliability is possible	**Statistical Tests Used:** Frequency testing Comparison testing pre and post checklist implementation	**DV1: increase in safe medication compliance to >97% over a 12-month period**	**LOE: 5** **Strengths**: Implementation of checklist into the EMR for convenience. Timely feedback. **Weakness**: May not be easily integrated in all health systems. Paper checklist is time consuming. **Feasibility**:

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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
Disclose no conflict of interest, no bias disclosed.								Studied over 12 months, >600 checklists reviewed, researchers were involved in the anesthesia specialty. **Application**: Methods were generalized to be able to apply to other medications. Can be applied via paper checklist or imbedded into an EMR.
Lowe et al., (2022), Compliance to a standardized protocol for stock albuterol medication among school staff **Country:** Pima County,	N/A Hypothesis: researchers hypothesized that licenses nurses were more likely to adhere to protocol compliance than unlicensed school staff	**Design:** Cross-sectional study **Purpose:** To evaluate if school nurses of unlicensed school staff were more compliant to albuterol protocol	**N= 999 events** **Demographics:** -72% nurses administered -96% public school -43% elementary grades -50% male -78% known asthma diagnosis **Setting:** Charter, private, and public schools	**IV1:** standardized protocol for puff administration **DV1:** protocol compliance score **DV2:** experience associated with	**Tools:** Data collection and audit of reported events **Validity/Reliability:** **Reliability:** data can be re-tested, there is no current Pearson's r value in this study	**Statistical Tests Used:** One-Way ANOVAs Pearson's Chi-Squared tests for differences among groups Cragg-Poisson hurdle regression for	**DV1:** 28% of the events were compliant to the protocol DV2: Experience was insignificant to protocol	**LOE: 4** **Strengths:** -different types of schools were examine (public, charter, private) -different age groups/grade levels were examined

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
Arizona, United States **Funding:** Banner University Medical Center – Tucson Campus & Mel and Enid Zuckerman Family Foundation **Bias:** None stated. Researcher is the same the researcher that implemented the program.			in Pima County **Exclusion:** 77 schools that did not report events, 39 events that did not record number of puffs **Attrition:** Total loss of 77 schools and 39 events from data collection	compliance score	Experience yielded a *p* value of 0.41 (nonsignificant) Very first study to examine compliance and staff experience relationships – no comparisons	compliance and staff experience relationship	compliance (*p* value of 0.41) School organization type influenced protocol compliance (95^{TH} CI 0.21-0.75 and *p*= 0.004) – this was the only significant *p* value in characteristics	**Weakness:** -Protocol compliance was not fully captured due to lack of documentation detail -staff experience was measured at the school level and not individual level -No identifiers in data to determine if there are repeat students for repeat episodes **Feasibility:** **-Requires data collection over a longer period of time** **Application:** **-I**s to be applied to other counties to benefit further

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
								training and education
Manias, et al (2020), Interventions to reduce medication errors in adult medical and surgical settings: A systematic review **Country:** Melbourne, Australia **Funding:** No financial support **Bias:** Declared no conflict of interest. Study excluded if the results were not showing improvement in medication errors post interventions.	N/A	**Design:** Systematic review of quantitative studies (most commonly pre-post intervention design) **Purpose:** Compare effectiveness of different interventions in reducing medication error in medical and surgical settings	**N=** 34 studies 9 studies -RCT 22 studies - pre-post intervention design 2 studies -quality improvements 1 study - prospective chart review 1 study – interrupted time series design 1 study – prospective observational design **Demographics:** Adult patients **Setting: acute** medical or surgical settings **Exclusion:** -Non full text articles	**IV1:** pharmacist led medication reconciliation, computerized medication reconciliation, pharmacist partnership, computerized order entry, prescriber education, patient education, medication dispensing, automated drug distribution system, electronic medication administration system **DV1:** Effectiveness of	**Tools:** RCA **Validity/Reliability:** RCA Tool used to determine validity, reliability Effect size – no Pearson's r value Level of significance for any interventions with a p value of <0.05	**Statistical Test Used:** Quality Assessment was completed using CONSORT guidelines, TREND guidelines, and SQUIRE uidelines Review Manager, version 5.3 (RevMan) software used for bias assessment	**DV1:** (results relevant to current research) -Pharmacist led intervention (6.9% reduction) (p – 0.008) -Computerized medication reconciliation (12% reduction) (p value not reported) -Computerized order entry (30.1% reduction) (p <0.0001) -Pharmacist partnership (30.4% reduction) (p <0.001)	**LOE: 1** **Strengths:** -examined a variety of single interventions and combination interventions -evaluated interventions encompassing multi-disciplines **Weakness:** -unpublished studies available with clinical significance -medication errors reported in various formats among the studies - data collection methods varied across studies

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
			-Full text articles with wrong outcome, setting, population, or study design -Records excluded with wrong outcome -Duplicate studies removed **Attrition:** 33 included studies with 21 studies containing details about clinical significance Loss of 12 studies without clinical significance	interventions on reducing medication errors **Definitions:** -medication errors: broad definition encompassing any preventable medication event that may lead to harm				**Feasibility;** -Limited RCTs available with clinical significance outcomes Application: -More research is needed on the clinical significance of medication error interventions
McSweeney et al., (2019), Improving safety of intravenous prostacyclin administration to pediatric patients with pulmonary hypertension	No theory disclosed. Multi-faceted approach: Policy, process, education and hospital wide safety initiatives were followed as an intervention structure.	**Design:** Prospective cohort **Purpose:** Reduce medication errors through inpatient program to improve, standardize and	**N=** 22 errors analyzed **Demographics:** pediatric pulmonary hypertension patients receiving prostacyclin therapy	**IV1:** Policy, process, education, safety initiatives **DV1:** Number of safety errors of prostacyclin therapy **Definitions:**	**Tools:** Data collection using computerized safety event reporting system that hospital staff directly use **Validity/Reliability:** -p values varied greatly in each year (see data analysis	**Statistical Tests Used:** Chi-square analysis - p values of 0.666, 0.35, 0.16, 0.09, 0.03, 0.12, and 0.25 for 2010-2016	**DV1:** decrease in medication errors by 69% over 8 years	**LOE: 2** **Strengths:** -Focused on one class of medication eliminating further results variability **Weakness:** -Long-term study

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
Country: United States **Funding:** not disclosed **Bias:** Authors are healthcare providers or directors in pediatric pulmonary or cardiology programs in Boston. No bias or conflict of interest disclosed.		disseminate practice guidelines	**Setting:** Boston Children's Hospital **Exclusion:** Any other drug class or insufficient documentation. **Attrition:** 3 studies excluded due to insufficient documentation	-Prostacyclin = medication used as a vasodilator – used for pulmonary **hypertension patients**	column) with 2014 being most significant p value (0.03) -Variability is due to inconsistency in number of prostacyclin therapy days each year	respectively to IV1		-Cannot establish cause-effect relationship **Feasibility:** -Error reports over 8 years, long term evaluation -Cost not disclosed **Application:** -Can be applied in various patient units/settings
Westbrook et al., (2022), Short- and long-term effects of an electronic medication management system on paediatric prescribing errors **Country:** Sydney, Australia **Funding:** Funded by the	Mixed effects negative binomial model	**Design:** Step wedge cluster randomized controlled trial **Purpose:** To reduce medical errors and promote clarity in prescribing medications	**N (errors evaluated)** = CG: 9635 IG at 7 months: 16,734, IG at 1 year: 8891 **Demographics (patients):** CG: 1686 , 40% female, mean age 73 months. 70 day eval: 2096, 39% female, mean age 88 months. IG: 1039, 44% female,	**IV1:** electronic medication management system (e-prescribing) **DV1:** medication prescribing error rates per patient -day **DV2:** adverse drug events from errors	**Tools:** Five-point scale to determine severity of medication error Medical chart auditing **Validity/Reliability:** **P values ranged from <0.001 to 0.45 (indicating that the results are replicable and**	**Statistical Test Used:** X^2 test Data management in SAS version 9.4 Data analysis in R version 4.2	**DV1:** error rates declined by 36% in the one-year interval **DV2:** Adverse drug event rate was similar to control rate **DV3:** **d**etection increased by	**LOE: 1** **Strengths:** One of the few studies that also access harm associated with medication errors. Provided extensive training to staff prior to implementation of the electronic system

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
National Health and Medical Research Council **Bias:** Researchers were blinded to the ward identity, were not a part of the hospital and were randomly assigned to a cluster of data			mean age 86 months. **Setting:** Sydney Children's Hospital **Exclusion:** oncology and intensive care units excluded as the electronic system was not able to be implemented there **Attrition:** evaluations were completed at specific time intervals meaning different participants were present at those time.	**DV3:** evidence of error detection by staff **Definitions:**	**shows that the effect is large)**		8% by one year	**Weakness:** Limited to specialist pediatric hospital, data was limited to quality of medical record documentation **Feasibility:** Requires extensive staff training prior to implementation Long term interval evaluation does not evaluate the same patients or medications **Application:** Study was limited to specialist pediatric hospital
Wondmieneh et al., (2020), Medication administration errors and		**Design:** Cross-sectional study **Purpose:** assess magnitude and factors contributing	**N =** 298 nurses **Demographics:** Mostly aged 25-29 years old, female, single, Bachelor	**IV1:** Checklist and self-reporting	**Tools:** -structured self-administered questionnaire	**Statistical Tests Used:** Hosmer-Lemeshow test	**DV1:** Inadequate training, unavailability of a guideline,	**LOE: 4** **Strengths**: -used two methods to evaluate (self-

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
contributing factors among nurses: a cross-sectional study in tertiary hospitals, Addis Ababa, Ethiopia **Country:** **Funding:** funded by Addis Ababa University. **Bias:** funding university had no role in study. Data was self-reported. The data collectors were diploma educated nurses (from a different hospital but same profession)		to medication administration errors among nurses in tertiary care hospitals	degree prepared nurses, received an educational award from a government institution **Setting:** Tertiary care hospital in Addis Ababa, Ethiopia **Exclusion:** any nurses who did not have a diploma qualification, less than 1 year of work experience or did not work in direct patient care. **Attrition:** n/a	of medication errors **DV1:** contributing factors to MAE **Definitions:** n/a	-observational check list **Validity/Reliability:** -data was obtained using two approaches (Self report and direct observation) -adopted a survey questionnaire from a previous similar study (re-creation) -tools underwent expert review -randomly selected participants -data collectors were not from the testing hospitals -observation was blinded	Multivariable logistic regression analysis	inadequate work experience, interruption during medication administration, and night shift duty were predictors of medication errors at $p < 0.05$.	report and observation) -randomly selected participants -data collectors were nurses/familiar with medications administration **Weakness**: -only tertiary hospitals in Ethiopia -could not draw cause and effect relationship -based on self reported info **Feasibility**: There was no proposed plan or method. **Application**: Has been replicated from other studies

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
								in Iran, southern Ethiopia and University of Gonder referral hospital.

Key: **CG** control group, **DV** Dependent Variable, **EMR** electronic medical record(s), **IG** intervention group, **IV** Independent Variable, **LOE** Levels of Evidence, **MAE** medication administration error **RCT** randomized control study, **RN** registered nurse, **SWCRCT** stepped-wedge cluster randomized control trial

Table A2

Synthesis Table

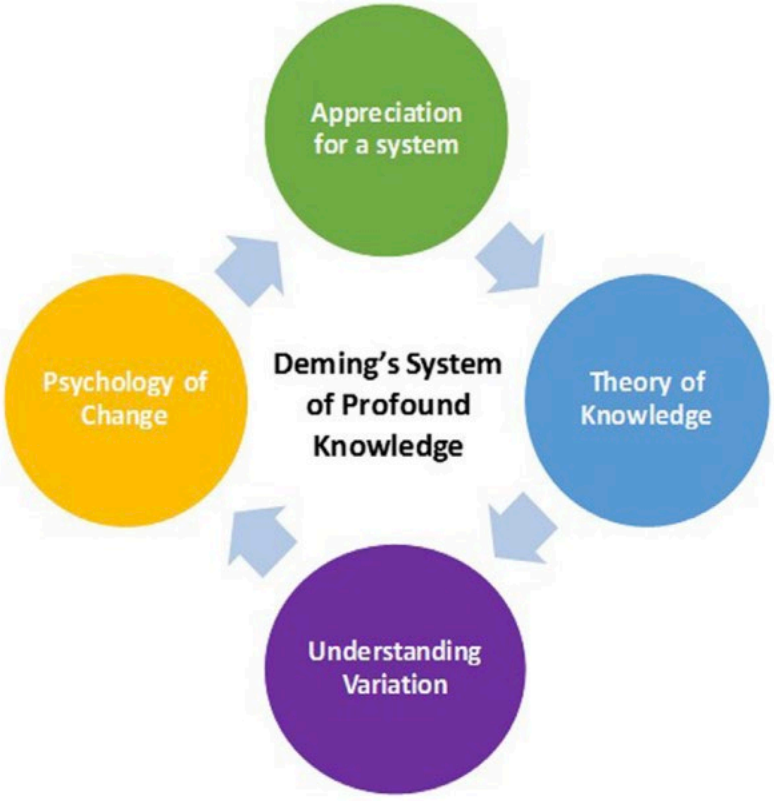
Study (Author, year)	Abuelsoud (2018)	Craig et al., (2021)	Hebbar et al., (2018)	Hutchinson et al., (2020)	Kanjia et al., (2019)	Lowe et al., (2022)	Manias et al., (2020)	McSweeney et al., (2019)	Westbrook et al., (2022)	Wondmieneh et al., (2020)
Design **LOE**	PC Level II	QE Level II	PC Level II	QE Level II	QI Level V	CS Level IV	SR Level 1	PC Level II	RCT Level 1	CS Level IV
Sample										
N (sample size or # of files/studies reviewed)	900 patient files	83	1434	166	633	999	34	22	9,635	298
Nurse Focused	-	X	X	X	-	X	-	-	-	X
Multidisciplinary (nurse, pharmacy, physicians)	X	-	-	-	X	X	X	X	X	-
Setting										
Acute care hospital	X	-	X	X	X	-	X	X	X	X
Outpatient	-	-	-	-	-	-	-	-	-	-
School		X	-	-	-	X	-	-	-	-
Pediatrics	X	-	X	-	X	X	-	X	X	-
U.S Located Study	-	X	X	-	X	X	-	X	-	X
Interventions										
Education	X	X	X	-	-	-	X	X	-	-
Checklist	-	X	-	-	X	-	X	-	-	X
Guideline	-	-	-	-	X	X	X	-	-	-
The Five Rights	-	-	X	-	-	-	-	-	-	-
Audit Tool	-	-	-	X	-	-	-	-	-	-
Electronic medication system	-	-	-	-	-	-	-	-	X	-
Outcomes/ Themes										
Medication error rates	↓	↓	↓	-	↓	-	↓	↓	↓	↓
Adherence to best practice	-	-	X	X	-	X	-	-	-	-
Measurement tools	DA	PP	Auditing	ACT	PP	Auditing	RCA	DA	FPS	Questionnaire
Theory/Conceptual Framework	FOCUS PDCA	Jeffries Simulation	FR, MZ, IDC	TPB	PDSA, FMEA	-	-	-	MENB	-

Key: **ACT** Alberta Context Tool, **CS** cross-sectional, **DA** datasheet, **FMEA** Failure modes and effects analysis, **FOCUS** Find, Organize, Clarify, Understand, Select, **FPS** Five Point Scale, **FR** Five Rights, **IDC** Independent Double Check, **LOE** Level of Evidence, **MENB** Mixed Effects Negative Binomial, **MZ** MedZone, **PC** Prospective Cohort, **PDCA**, plan, do, check, act, **PDSA** Plan, Do, Study, Act, **PP** pre & post-test**, QE** Quasi-Experimental, **RCA** Rapid Critical Appraisal, **RCT** Randomized Control Trial, **SR** Systematic Review, **TPB** Theory of Planned Behavior

Appendix B

Models and Frameworks

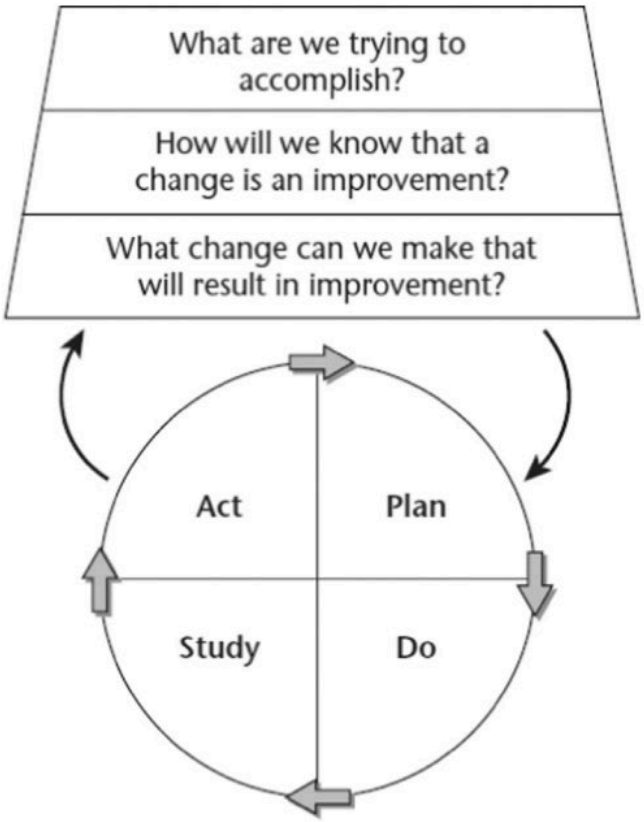
Figure B1
Deming's System of Profound Knowledge



Deming's System of Profound Knowledge or Theory of Profound Knowledge.

(Roehrs, 2018)

Figure B2
The PDSA Cycle



Plan-Do-Study-Act Cycle.

(Christoff, 2018)

Appendix C

Internal Review Board (IRB) Approval

EXEMPTION GRANTED

Judith Ochieng
EDSON: DNP
602/496-0730 Judith.Ochieng@asu.edu

Dear Judith Ochieng:

On 10/19/2023 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Increasing Protocol Compliance in School Albuterol Administration
Investigator:	Judith Ochieng
IRB ID:	STUDY00018760
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• 3rdAnusic_IRB Social Behavioral Protocol_final .docx, Category: IRB Protocol; • Data Collection Document, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Document for one on one feedback/follow-ups, Category: Technical materials/diagrams; • Education Module Objectives, Category: Other; • Letter of Support From Site/Organization, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (4) Secondary research on data or specimens (no consent required) on 10/18/2023.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).
If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Ana Anusic
Ana Anusic

Appendix D

Internal Review Board (IRB) Modification Approval

EXEMPTION GRANTED

Judith Ochieng
EDSON: DNP
602/496-0730
Judith.Ochieng@asu.edu

Dear Judith Ochieng:

On 4/1/2024 the ASU IRB reviewed the following protocol:

Type of Review:	Modification / Update
Title:	Breath of Relief: Upholding Inhaler Administration Adherence in Schools
Investigator:	Judith Ochieng
IRB ID:	STUDY00018760
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• 4thAnusic_IRB Social Behavioral Protocol_final .docx, Category: IRB Protocol;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (4) Secondary research on data or specimens (no consent required) on 4/1/2024.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

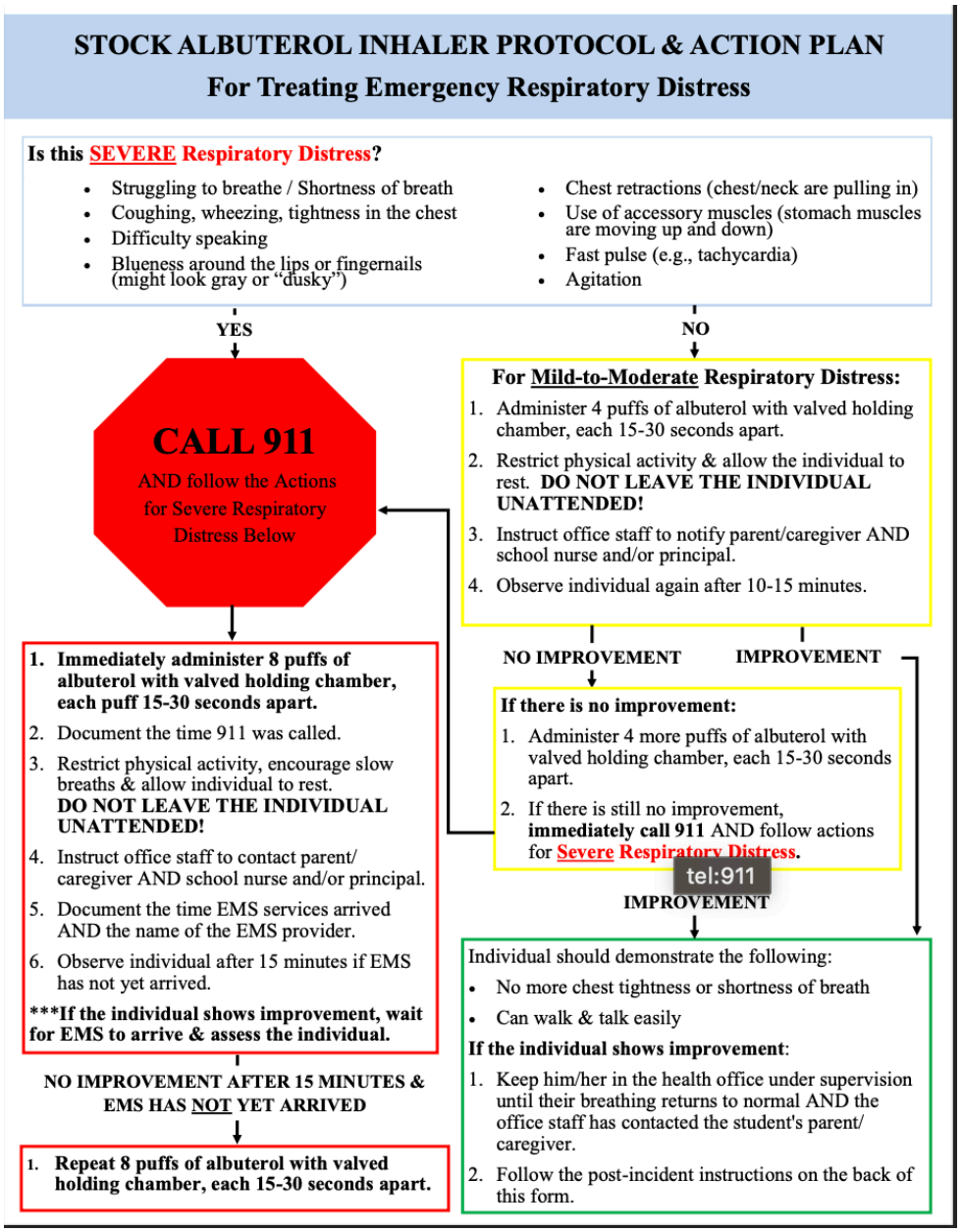
Sincerely,

IRB Administrator

cc: Ana Anusic

Appendix E

Stock Albuterol Protocol



(Arizona Asthma Coalition, 2018)

Appendix F

Chart Audit Data Collection Form

Chart Audit From For Albuterol Administration

Date of Data Collection _____

Log ID	Age (in years)	Gender M- Male F- Female	Race 1. White/Caucasian 2. Black/African American 3. American Indian 4. Asian 5. Native Hawaiian. 6. Other	Ethnicity 1. Hispanic or Latino 2. Not Hispanic or Latino	Administrator : RN, LPN, EMT, administrative staff	New Education Completed (Y or N)	Dose Administered (# of puffs)	Level of Distress 1. Mild 2. Moderate 3. Severe	EMS call (Y or N)	Disposition 1. Return to class 2. Sent home 3. EMS transport	Audit/Feed back provided (Y or N)
100											
101											
102											
103											
104											
105											
106											
107											
108											
109											
110											
110											
112											

Data Entry _____ (entered into Intellectus) Data Validation _____ (data clean up) Data Analysis _____

Appendix G

Student Demographic Descriptive Statistics

Table G1
Frequency Table for Demographic Variables in Students

Variable	*M*	*SD*	*n*	Min	Max
Age (in years)	10.46	4.97	434	3.00	53.00

Note. '-' indicates the statistic is undefined due to constant data or an insufficient sample size.

Table G2
Descriptive Statistics Table for Age of Student in Years

Variable	*n*	*%*
Gender		
Female	171	39.40
Male	261	60.14
Other	2	0.46
Race		
Black / African American	144	33.18
White	228	52.53
Multi-racial	34	7.83
American Indian / Alaska Native	15	3.46
Native Hawaiian / Pacific Islander	3	0.69
Asian	10	2.30
Ethinicity		
non-Hispanic / non-Latino	277	63.82
Hispanic / Latino	157	36.18

Note. Due to rounding errors, percentages may not equal 100%.

Appendix H

Staff Variables

Table H1
Summary Statistics Table for Albuterol Dose

Variable	*M*	*SD*	*n*	Min	Max
Albuterol Dose (in number of puffs)	4.17	1.22	434	2.00	12.00

Note. '-' indicates the statistic is undefined due to constant data or an insufficient sample size.

Table H2
Frequency Table for Administrator and Intervention Variables

Variable	*n*	*%*
Administrator Credentials		
School Nurse	320	73.73
Health/Medical Assistant	108	24.88
Administrators	6	1.38
New Education Completed (Yes or No)		
Yes	266	61.29
No	168	38.71
Level of Distress		
Mild/Moderate	400	92.17
Severe	34	7.83
EMS called (Yes or No)		
Yes	9	2.07
No	425	97.93
Disposition of Student		
Returned to class	325	74.88
Sent home with parent/guardian/caregiver	100	23.04
Called 911 and NO EMS transport	5	1.15
Called 911 and transport via EMS	4	0.92
One on One Feedback Provided (Yes or No)		
Yes	42	9.68
No	392	90.32

Note. Due to rounding errors, percentages may not equal 100%.

Appendix I

Frequency Table for EMS Calls and Student Disposition

	Level of Distress	
Variable	Mild/Moderate	Severe
EMS Called (Yes or No)		
Yes	5 (1.25%)	4 (11.76%)
No	395 (98.75%)	30 (88.24%)
Total	400 (100.00%)	34 (100.00%)
Disposition of Student		
Returned to class	311 (77.75%)	14 (41.18%)
Sent home with parent/guardian/caregiver	84 (21.00%)	16 (47.06%)
Called 911 and NO EMS transport	3 (0.75%)	2 (5.88%)
Called 911 and transport via EMS	2 (0.50%)	2 (5.88%)
Total	400 (100.00%)	34 (100.00%)

Note. Due to rounding error, percentages may not sum to 100%.

Appendix J

Frequency Table for Administrator Credentials Identifying Levels of Distress

	Administrator Credentials		
Variable	School Nurse	Health/Medical Assistant	Administrators
Level of Distress			
Mild/Moderate	273 (91.00%)	94 (94.00%)	3 (100.00%)
Severe	27 (9.00%)	6 (6.00%)	0 (0.00%)
Total	300 (100.00%)	100 (100.00%)	3 (100.00%)

Note. Due to rounding error, percentages may not sum to 100%.

Appendix K

Month and Correct Administration Variables

Table K1
Frequency Table for Month and Correct Administration Variables

Variable	*n*	*%*
Month		
July	9	2.07
August	70	16.13
September	76	17.51
October	86	19.82
November	109	25.12
December	84	19.35
Correct Administration (Yes or No)		
Yes	392	90.32
No	42	9.68

Note. Due to rounding errors, percentages may not equal 100%.

Table K2

Frequency Table for Correct Administration per month, administrator credentials, level of distress, and disposition of student

	Correct Administration (Yes or No)	
Variable	Yes	No
Month		
July	9 (2.30%)	0 (0.00%)
August	55 (14.03%)	15 (35.71%)
September	72 (18.37%)	4 (9.52%)
October	82 (20.92%)	4 (9.52%)
November	100 (25.51%)	9 (21.43%)
December	74 (18.88%)	10 (23.81%)
Total	392 (100.00%)	42 (100.00%)
Administrator Credentials		
School Nurse	290 (73.98%)	30 (71.43%)
Health/Medical Assistant	99 (25.26%)	9 (21.43%)
Administrators	3 (0.77%)	3 (7.14%)
Total	392 (100.00%)	42 (100.00%)
Level of Distress		
Mild/Moderate	366 (93.37%)	34 (80.95%)
Severe	26 (6.63%)	8 (19.05%)
Total	392 (100.00%)	42 (100.00%)
Disposition of Student		
Returned to class	298 (76.02%)	27 (64.29%)
Sent home with parent/guardian/caregiver	87 (22.19%)	13 (30.95%)
Called 911 and NO EMS transport	5 (1.28%)	0 (0.00%)
Called 911 and transport via EMS	2 (0.51%)	2 (4.76%)
Total	392 (100.00%)	42 (100.00%)

Note. Due to rounding error, percentages may not sum to 100%.

Appendix L

Frequency for Education and Correct Administration Variables

	New Education Completed (Yes or No)	
Variable	Yes	No
Correct Administration		
Yes	246 (92.48%)	146 (86.90%)
No	20 (7.52%)	22 (13.10%)
Missing	0 (0.00%)	0 (0.00%)
Total	266 (100.00%)	168 (100.00%)

Appendix M

Friedman Rank Sum Test

Table M1
Friedman Rank Sum Test

Variable	Mean Rank	χ^2	*df*	*p*
Month	4.44	1,438.64	4	< .001
Administrator Credentials	2.16			
Albuterol Dose	4.45			
Level of Distress	1.83			
Disposition of Student	2.13			

Figure M1

Boxplots of Month, Administrator Credentials, Albuterol Dose, Level of Distress, and Disposition of Student

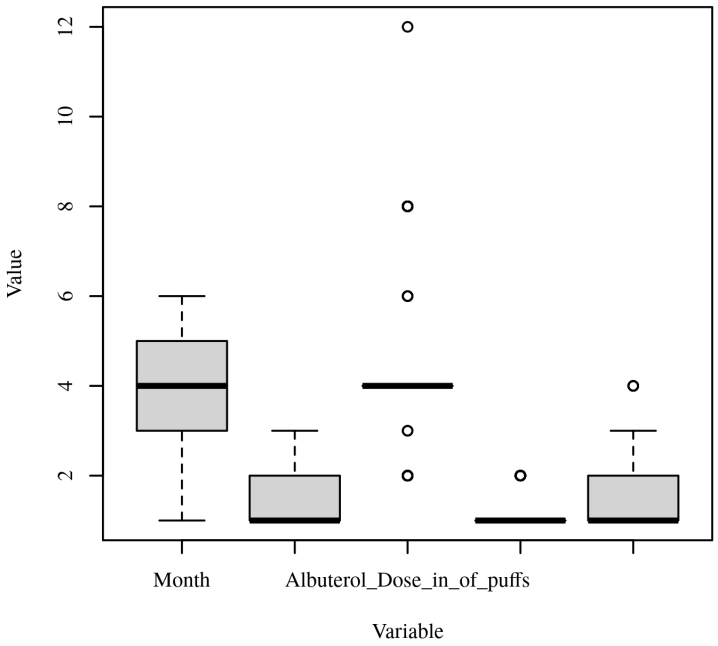


Table M2

Pairwise Comparisons for the rank-sums of Month, Administrator Credentials, Albuterol Dose, Level of Distress, and Disposition of Student

Comparison	Observed Difference	Critical Difference
Month-Administrator Credentials	990.00	130.76
Month-Albuterol Dose	4.50	130.76
Month-Level of Distress	1,131.00	130.76
Month-Disposition of Student	1,003.50	130.76
Administrator Credentials -Albuterol Dose	994.50	130.76
Administrator Credentials -Level of Distress	141.00	130.76
Administrator Credentials -Disposition of Student	13.50	130.76
Albuterol Dose -Level of Distress	1,135.50	130.76
Albuterol Dose -Disposition of Student	1,008.00	130.76
Level of Distress-Disposition of Student	127.50	130.76

Note. Observed Differences > Critical Differences indicate significance at the $p < .05$ level.