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Early Administration of Steroids in the Ambulance Setting: Protocol for a Type I Hybrid Effectiveness-Implementation Trial with a Stepped Wedge Design

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Abstract

Background: Pediatric asthma exacerbations are a frequent reason for emergency care. Early administration of oral systemic corticosteroids (OCS) in the emergency department (ED) decreases hospitalization rates and ED length-of-stay (LOS). However, it is unknown whether *even earlier* OCS administration by emergency medical services (EMS) in the prehospital setting further improves outcomes.

Purpose: To describe the background and methods of a type 1 hybrid effectiveness-implementation trial of EMS-administered OCS for pediatric asthma patients incorporating a stepped wedge design and the RE-AIM framework.

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Methods: The study employs a non-randomized stepped wedge design where multiple EMS agencies adopt OCS as a treatment for pediatric asthma exacerbations at varying times. This design accommodates ethical considerations of studying pediatric subjects in the prehospital setting where informed consent is not feasible. We will compare hospitalization rates, ED LOS, and short-term healthcare costs between pediatric asthma patients who do and do not receive OCS from EMS. Using geographic information systems (GIS), we will measure how differences in outcomes scale with increasing EMS transport time. We will use the RE-AIM framework to guide a mixed methods analysis of barriers and enablers to EMS administration of OCS for pediatric asthma patients, including quantitative measures of adoption and uptake and qualitative EMS provider focus group data.

Conclusion: This trial will determine if earlier EMS administration of OCS to pediatric asthma patients decreases hospitalizations, ED LOS, and short-term healthcare costs, and if those outcomes scale with longer EMS transport times. We will identify barriers and enablers to implementing EMS-administered OCS for pediatric asthma patients.

Keywords

Pediatric Asthma Emergency Medical Services Systemic Corticosteroids Hybrid Implementation-Effectiveness Trial REAIM Framework

1. Introduction:

An estimated 7 million children suffer from asthma in the United States (US), the majority of whom experience at least one exacerbation annually.^{1–6} Of the 1–2 million annual pediatric emergency medical services (EMS) encounters,^{7,8} an estimated 15% are for asthma exacerbations.⁹ For children suffering from an asthma exacerbation, guidelines recommend early systemic corticosteroid (CS)¹ administration in combination with inhaled bronchodilators.^{10,11} While inhaled bronchodilators are the most frequently administered medication to children by EMS,⁹ less than 10% of EMS' pediatric asthma patients receive CS from EMS.^{12,13} CS' effects are time-dependent: every 30-minute delay in CS administration corresponds to a 1 hour increase in emergency department (ED) length-of-stay (LOS), and early CS administration is associated with decreased risk of hospitalization.^{14–17} Given CS' positive and time-dependent impacts, EMS administration of CS to pediatric asthma patients prior to ED arrival has the potential to further improve outcomes.

Both oral and intravenous (IV) CS are options for treating pediatric asthma exacerbations.¹⁰ Yet, IV methylprednisolone is the most commonly used CS by EMS, and is the first-line CS in the National Association of State EMS Officials model clinical guidelines.^{18,19} Therefore, a potential explanation for the low rates of EMS CS administration to children is the IV requirement, as IVs are attempted in only 11–14% of pediatric EMS encounters.^{9,20} Oral CS (OCS) for EMS administration is a logical alternative, but is not included in most EMS treatment guidelines.^{18,19} To our knowledge, benefits of early OCS administration by EMS for pediatric asthma have not yet been prospectively studied.

¹CS = corticosteroids, OCS = oral corticosteroids, EMS = emergency medical services

EMS is a vital public service, yet there is a paucity of prospective EMS research,^{21,22} and pediatric EMS research is even more rare.²³ A systematic review found few EMS studies analyze cost, transport time, distance / geography, and other implementation considerations for adopting evidence-based guidelines into prehospital practice.²⁴ That review also described several high-profile guidelines with low adherence by EMS providers.²⁴ Qualitative studies of EMS providers reveal education, training, and practical barriers (e.g., low frequency of encounters compared to adults, difficulty obtaining IV access, drawing up weight-based medication doses, communicating with parents, emotional difficulty in treating ill children) to pediatric EMS care.^{25–27} Therefore, in addition to evaluating clinical outcomes, EMS studies (particularly pediatric EMS studies), must systematically evaluate how best to implement evidence-based practices in the unique prehospital setting. This trial employs a hybrid effectiveness-implementation design to determine if EMS-administered OCS improves clinical outcomes for pediatric asthma, the cost of EMS OCS administration, how EMS transport time affects clinical and economic outcomes, and implementation considerations.

2. Primary Research Goals:

This trial employs a type I hybrid effectiveness-implementation design to test i) the effect of EMS OCS administration on pediatric asthma patient clinical outcomes, ii) the comparative cost of EMS OCS administration (versus ED administration), and iii) how clinical and cost outcomes scale with EMS transport time (i.e., time from leaving the prehospital scene to arrival at the ED). Given the ethical considerations of studying EMS' treatment of pediatric patients in the prehospital setting where encounters are unpredictable and informed consent is not feasible,²⁸ we make novel use of the stepped wedge design to compare outcomes between patients treated by multiple EMS agencies as they separately adopt OCS into their pediatric asthma treatment guidelines. The implementation evaluation uses the RE-AIM framework to determine barriers and enablers to EMS adding OCS to their prehospital treatment guidelines for pediatric asthma exacerbations.²⁹

3. Methods:

Development & Overview of Trial Design:

This study is well-suited for a type I effectiveness-implementation design. EMS administration of OCS is understudied. However, there is strong face validity for OCS as a beneficial prehospital/EMS intervention.³⁰ OCS are an established and recommended treatment for pediatric asthma exacerbations.¹⁰ Additionally, extrapolating OCS' time-dependent effects from ED-based studies provides indirect evidence that *even earlier* OCS administration in the prehospital environment will be beneficial to pediatric asthma patients.^{14–17} Lastly, one-dose OCS for pediatric asthma exacerbations carry minimal to no risk of adverse events,³¹ and this trial essentially compares early EMS administration of OCS versus usual but later ED administration of OCS, with patients receiving other usual care in both situations.¹⁰

The effectiveness component of the trial tests whether EMS administration of OCS (as compared to OCS administration later in the ED) improves pediatric asthma clinical

outcomes and decreases healthcare costs. We will also test whether clinical and economic outcomes scale by EMS transport time given the known time-dependent effects of CS. We hypothesize that clinical and economic benefits will grow larger with longer EMS transport times. As mentioned, EMS encounters are unpredictable, treatment is rendered within minutes, and legal guardians of pediatric patients are not always at the prehospital scene (i.e., child suffers an asthma exacerbation while in school). Without the ability to perform informed consent, we consulted with interested EMS agencies, our institutional review board (IRB), and outside consultants experienced in pediatric EMS research and trials granted waivers of informed consent.²⁸ Initially, we considered a stepped wedge randomized design wherein different ambulance stations from participating EMS agencies are randomized to incorporate OCS into their protocols at different time intervals, with all stations eventually adopting OCS. However, that design was not approved by the IRB. Given that there was interest from several EMS agencies in participating in the study, we modified the stepped wedge design such that OCS was implemented by an entire EMS agency at one time. The participating EMS agencies naturally would adopt OCS into their treatment guidelines at varying times (Table 1). The length of the trial was extended to account for the new design and asthma exacerbation seasonality. The OCS guideline update is the ‘intervention’, and the final design is a unidirectional crossover model where the guideline update will not be removed once implemented. The final study protocol was approved by the University of Florida IRB and is registered on [clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT03962894) (NCT03962894).

The trial’s implementation evaluation uses the RE-AIM framework and mixed methods to study the uptake and sustainability of OCS in EMS pediatric asthma treatment guidelines.²⁹ We will measure reach, effectiveness, and adoption through quantitative measures, and implementation and maintenance with both qualitative and quantitative measures. Qualitative data will come from focus groups of EMS providers from participating EMS agencies.

Study Setting:

Our goal is to enroll at least four EMS agencies. Currently, two EMS agencies (Nassau County Fire Rescue Department – “Agency 1” and Lee County EMS – “Agency 2”) thus far have agreed to participate (Figure 1). Both agencies’ medical directors independently made the decision to incorporate OCS as part of their treatment guidelines for pediatric asthma exacerbations. Both agencies independently selected to purchase oral prednisolone, dosed in their guideline at 2 mg/kg, with a maximum dose of 60mg. Nassau County Fire Rescue Department serves Nassau county, the northeastern most county in Florida. Nassau County’s estimated population is just over 88,000, 20% of whom are under 18 years of age, and 5% of whom are under 5 years of age.³² Nassau County Fire Rescue Department is staffed solely by approximately 120 EMT-Paramedics. Lee EMS serves Lee County, located in southwestern Florida with a population of approximately 739,000 persons, 18% of whom are under 18 years of age, and 5% of whom are under 5 years of age.³³ Lee County EMS responds to over 70,000 annual calls using 36 EMS stations, and the workforce is comprised of both emergency medical technician (EMT)-paramedics and EMT-Basics (EMT-Paramedic is the highest level of EMS provider, certified to perform advance life support-

level care). Per usual 911 dispatch and Lee EMS treatment guidelines, pediatric asthma patients experiencing an acute exacerbation are treated and transported by EMT-paramedics.

Patient Inclusion & Exclusion Criteria:

Pediatric patients ages 2–18 years treated for an asthma exacerbation by participating EMS agencies are eligible for inclusion in the trial (Table 2). We chose a lower age limit of 2 years to avoid confounding with bronchiolitis, a common condition in young infants that also causes wheezing and difficulty breathing. Because EMS encounters are unpredictable, patient recruitment is not applicable. Additionally, included patients must be linked to the ED electronic medical record (EMR) to obtain clinical and cost outcomes.

Data Linkage:

Data will be abstracted from EMS and receiving ED EMRs. Participating EMS agencies and receiving EDs will execute data use agreements (DUAs) with the principal investigator's home institution. Each participating EMS agency will send 18 months of pre-OCS data to the study team, and after implementation of OCS, a weekly report of all pediatric asthma patients. The study team will probabilistically link the EMS to ED record (using an algorithm including patient name, sex, age, time / date of service, and destination ED), after which data will be de-identified. All data will be exchanged through secure, password-protected portals and housed on University of Florida IRB-approved network drives.

Study Measures:

The effectiveness component of the study will compare ED outcomes (hospital admissions, ED LOS for those discharged, ICU admissions for those admitted) between patients who do and do not receive OCS from EMS. We will also compare short-term healthcare costs for patients who do and do not receive OCS from EMS. We will quantify the relationship between increasing EMS transport time and i) clinical outcomes and ii) short-term healthcare costs. Then we will estimate EMS transport time ranges where clinical outcomes improve, costs decrease, and both clinical outcomes improve *and* costs decrease.

Measures for the implementation evaluation are detailed in Table 3 within the RE-AIM framework.²⁹ In addition to quantitative assessments of reach, adoption, effectiveness, maintenance, we will qualitatively measure implementation and maintenance using post-OCS implementation EMS provider focus groups to determine barriers and enablers to use of OCS for the prehospital treatment of pediatric asthma exacerbations. Each focus group will have 6–8 participants and we will perform 1–2 focus groups per participating EMS agency. See Figure 2 for study diagram detailing all components of the hybrid effectiveness-implementation design.

Sample Size Calculation:

We calculated sample size for the primary outcome of hospitalizations (a measure of asthma exacerbation treatment failure) at the individual patient level. Using an estimated 30% hospitalization rate in the no OCS group and 15% in the OCS group, we require 121 patients per group to achieve 80% power at a two-tailed α of 0.05.^{12,13} We conservatively plan for 20% unsuccessful EMS to ED record linkage, therefore we require 152 patients per group.

Based on preliminary data from Lee County and Nassau County combined, we estimate 374 eligible patients for the initial 18-month pre-OCS data period. Therefore, we anticipate exceeding the sample size requirement and having additional power to detect a smaller effect size with recruitment of additional EMS agencies, and/or be adequately powered for cluster-level analysis. If we do not achieve the required number of patients, we can recruit additional agencies beyond our target of four, and/or extend the pre- and post-OCS data collection periods.

Data Analysis:

Both individual-level (patient) and cluster-level (EMS agency) outcomes will be examined. We will analyze the primary outcome (hospitalization) with first univariate analysis and then generalized linear mixed models (GLMM). GLMM was chosen because we anticipate EMS agency (cluster) sizes to be unequal. Based on prior studies, our model will account for patient-level variables such as: vital signs (including pulse oximetry), proper dosing of OCS, other EMS/ED medications administered, age, sex, race, ethnicity, and seasonality at the time of EMS encounter; and EMS-level variables: ambulance station pediatric patient volume (low, medium, high), environment (urban, suburban, rural), and EMS provider years of experience. To address variation amongst the EMS agencies, we will perform within-cluster and between-cluster analyses using hierarchical GLMM. To avoid confounding by severity, we will repeat our individual-level analyses using inverse probability of treatment weighting using the propensity score. We will analyze ICU admissions with the same methods as for hospitalizations. We anticipate ED LOS will not be normally distributed.¹⁷ If traditional transformations or Box-Cox transformation cannot achieve normality for a linear regression, then ED LOS will be categorized (low, medium, high) and analyzed with an ordinal regression model.

Patients who receive OCS from EMS may receive a second dose in the ED despite EMS reporting to the ED all prehospital medications administered. However, we do not anticipate any adverse events at this OCS dosing and frequency.³¹ A sensitivity analysis will analyze differences in outcomes for patients who receive a second OCS dose in the ED (i.e. difference attributed to a larger total OCS dose or to the earlier EMS-administered OCS). If there is a small number of post-update patients who are eligible for but do not receive OCS from EMS, we will exclude those patients. If that number is a significant proportion, then we will adjust for this in our model and study those patients further in the implementation component. We will not employ an intent to treat analysis. To account for differences in ED treatment patterns and/or admission thresholds we can adjust for the receiving ED in our models. Transfers from the ED to another facility will be analyzed based on the reason for transfer (e.g., lack of bed capacity, need for ICU, parental request, etc.). We assume most missing EMS/ED data is missing at random, and so we will address missing data using multiple imputation with a minimum of 10 iterations.

We will quantify short-term healthcare costs and outcomes from each patient's acute episode of care using the cost-outcome plane (Figure 3) and the cost modeling strategy proposed by Manning and Mullahy.³⁴ We will model how incremental outcomes and incremental costs co-vary. Cost analysis will include EMS, ED/hospital, physician, and diagnostic evaluations,

measured as net charges (i.e. paid amounts). We will also measure EMS' OCS purchase cost. We will regress ED visit payments against ED LOS in minutes to estimate marginal savings from shorter ED LOS. We will model the relationship between EMS transport time and i) clinical outcomes and ii) cost. For patients who receive OCS from EMS, we will determine if longer EMS transport time corresponds with greater improvement in outcomes and/or greater decreases in cost. We will also model the character of both relationships (e.g., linear, S-shaped). Transport time intervals where EMS OCS administration improves clinical outcomes, cost, and both clinical outcomes and cost will be defined with geographic information systems (GIS) service area analysis – a specific type of network analysis. Extrapolating road network drive distances from transport time (Figure 4), we will identify areas around receiving EDs where EMS OCS administration improves clinical outcomes and/or cost.

Because this study follows short term outcomes, we will not examine quality-adjusted-life-years or other long-term health effects as measures of cost-effectiveness. This study includes a small number of ED facilities whose costs may not be generalizable to all EDs. Therefore, we will compare our cost outcomes with the statewide Florida Health Information and Transparency Center's ED financial dataset.³⁶ If the relationship between transport time and outcomes / cost is positive or negative, that "negative" result is still useful for other EMS agencies in deciding whether to incorporate OCS into their pediatric asthma treatment guidelines.

We will evaluate reach and adoption using run charts and interrupted time series by the unit of measure (e.g., by patient, by provider, etc). We will perform a thematic analysis of focus group transcripts and notes using multidimensional scaling and hierarchical cluster analysis using Atlas.ti© software (Berlin, Germany). We will also analyze themes by provider-level factors (e.g., age, years of practice, gender). To maximize participation, we will offer a \$25 incentive to each focus group participant. Focus group recruitment will target demographically diverse providers with varying years of EMS experience from participating EMS agencies. Focus groups will be held remotely via Zoom (San Jose, California) for ease of recording, to maximize provider participation (can participate from home or other private area), and lower cost / logistical barriers for the study team. Since the implementation component of this type I hybrid study is exploratory in nature, we may not achieve thematic saturation.

Study Monitoring:

Trial oversight will be provided by a data and safety monitoring board (DSMB) independent of the study team and the study sponsor. The DSMB will consist of at least 4 persons qualified in the following areas: pulmonology, pediatrics, critical care, and statistics or data science. The DSMB will elect a chair from amongst those 4 persons, and additionally there will be an executive secretary. The DSMB will meet quarterly to assess study progress and perform safety assessments. Safety assessments will consist of monitoring and reporting adverse events (AEs) and serious adverse events (SAEs) that are considered related to EMS administration of OCS, any deaths, and any additional study specific issue of concern. All SAEs must be reported to the study's IRB and DSMB within 24 hours. There are no planned

interim analysis or study audits. The DSMB may recommend termination or modification of the study if any significant increase in SAEs is observed in the OCS group. In addition, termination or modification may be recommended for any other perceived safety concern based on clinical judgment, including but not limited to a higher than anticipated rate for any outcomes after OCS administration resulting in adverse events, or unexpected SAEs.

Discussion and Conclusion:

It is well established that early administration of OCS in the ED setting improves outcomes for pediatric patients with asthma exacerbations.^{10,11,14–17} However, it is an unresolved question as to whether EMS should devote time, resources, and training towards *even earlier* administration of OCS to potentially further improve outcomes. EMS agencies nationwide serve urban, suburban, and rural areas with a range of transport times, finances, and other resources.^{37,38} Therefore, beyond answering if EMS-administered OCS has clinical benefits, we also analyze short-term healthcare costs and how both clinical and cost outcomes scale with EMS transport time. With regards to cost, the US healthcare system spends an estimated \$8.3 billion annually on asthma care, 25% of which are ED / hospital charges.³⁹ Accordingly, decreases in both hospital admissions and ED LOS resulting from EMS OCS administration may lower healthcare costs.⁴⁰ EMS costs are seldom analyzed,⁴¹ despite their role in operational decisions.²⁴ Yet such analysis is feasible – for example, EMS administration of tissue plasminogen activator for adult stroke (usually given in the ED setting) was evaluated for cost-effectiveness.⁴² Although EMS research is typically from urban areas,^{22,38} we previously found in Florida that rural EMS transport times for pediatric asthma patients are significantly longer than urban (interquartile range 15–35 minutes versus 9–13 minutes, respectively, p -value < 0.0001).¹² Using cost and transport time to frame evidence-based clinical recommendations has been requested by EMS (especially rural agencies) as early as 2001, but is rare in practice.^{24,38} Therefore we will leverage the fact that the participating EMS agencies that serve a mixture of urban, suburban, and rural areas to frame our results in the context of useful operational information such as cost and transport time.^{32,33}

As highlighted in a systematic review by the Prehospital Guidelines Consortium and by others, there is sparse implementation research specific to the unique prehospital EMS environment.^{21,24,43} Yet implementation is crucial to improving prehospital patient outcomes. Several high profile EMS evidence-based guidelines (from the American Heart Association, Centers for Disease Control and Prevention, among others) suffered from incomplete adoption by EMS providers, resulting in patient outcomes that diverged from those predicted based upon the original studies.²⁴ Specific to the prehospital treatment of pediatric asthma, Houston's EMS agency reported that after adding dexamethasone as a CS option, only 18% of eligible patients received CS.⁴⁴ EMS guideline recommendations and implementation solutions must also be customizable. EMS agencies are heterogeneous, with different geography (urban vs. rural), provider types (paid vs volunteer), and scopes of practice (advanced versus basic life support).²⁴ Provider focus groups have proven useful in identifying both provider-level and system-level barriers and enablers to EMS guideline adherence.⁴⁵ Therefore, combining clinical and cost analysis framed by transport time with

implementation data (including provider focus groups) will lay the evidentiary foundation to guide other EMS agencies on whether to adopt OCS based on the results of this trial.

We report this study's design not only for its unique combination of clinical, cost, GIS, and implementation analysis, but also because of the adaptation to accommodate ethical, regulatory, and logistic considerations of treating children in the prehospital setting. While the non-randomized stepped wedge design is not as strong as alternatives, it was the most rigorous prospective design our team and the IRB felt was justifiable. A placebo-controlled RCT raised logistical issues (i.e., how to blind for EMS and then unmask for ED physicians so patients would receive OCS at some point in their exacerbation treatment), and ethical issues (e.g., withholding OCS administration for longer in some patients vs others). Our original cluster-randomized stepped wedge design had logistical issues as well (i.e., some providers work at more than one ambulance station, so training and practice would not be consistent amongst stations randomized to OCS treatment versus no OCS treatment). However, that design was not approved by our IRB which ruled it was unethical to have research study team involvement in EMS operations, and that EMS agencies who participated in the study must roll out new prehospital treatments in their usual manner (i.e., implementing a new intervention agency-wide). As a result, our team felt it was important to find a solution that satisfied ethical, regulatory, logistical, and scientific needs. We feel the final design will be advantageous in the long run as we are effectively creating a research consortium of Florida EMS agencies, and establishing supportive framework such as data use agreements and data pipelines that can be used for future research. Additionally, because the design requires multiple EMS agencies, we mitigate a typical limitation of EMS research that is often summarized as 'if you research one EMS agency, you've researched one EMS agency.'²¹ The stepped wedge design still accounts for asthma's seasonality and allows for natural comparisons between patients who do and do not receive OCS from EMS in the same time period (i.e., same winter respiratory season). Most importantly, we adapted to regulatory/IRB concerns and retained a strong study design such that pediatric prehospital emergencies do not become an understudied area of research. Not studying a disease, patient population, or specific setting because there are additional ethical and regulatory barriers would further widen existing health disparities and the knowledge gaps between the hospital and prehospital / EMS setting. Further discussions amongst stakeholders regarding whether emergency waiver of consent research can legally be applied to conditions such as asthma exacerbations (potentially life-threatening, but not always) is needed so that rigorous RCTs can become more commonplace in prehospital (and pediatric prehospital) research.

This novel pediatric prehospital study will have an immediate impact by providing evidence regarding EMS administration of OCS for pediatric asthma. Our results will help define in what clinical, geographic, and economic situations should EMS adopt OCS for pediatric asthma exacerbation treatment. Framing clinical outcomes by such practical considerations allows the heterogeneous EMS agencies nationwide to tailor if and how to incorporate OCS into their pediatric asthma treatment guidelines based on their local population and resources. Our preliminary implementation results will lay the foundation for a longer-term definitive implementation study on how best to implement OCS (and other evidence-based pediatric asthma treatments) into routine EMS provider practice. Taken in consort, our

findings will help EMS agencies effectively adopt interventions that will improve outcomes for pediatric asthma patients.

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Highlights

- Systemic corticosteroids improve ED outcomes for pediatric asthma exacerbations
- *Even earlier*, EMS-administered corticosteroids could provide further benefits
- We will test clinical and cost effects of EMS-administered corticosteroids
- A type I hybrid design incorporates EMS transport time and implementation analyses

Fig. 1.

Stepped Wedge Design as applied to EMS agencies in this study Start date's depend on agency's guidelines update 'go live,' we will collect at least 18 months of pre- & post-OCS data per agency. (OCS = oral systemic corticosteroids)

Fig. 2.
Location of Currently Participating EMS Agencies

Figure 3:
Cost-Outcome Plane³⁴

Fig. 4. Example GIS Service Area Analysis Map³⁵:

For EMS-administration of OCS, red areas could represent EMS scene locations around destination EDs (black dots) where clinical outcomes and cost improve; yellow where only clinical outcomes improve; and green where data is equivocal.

Table 1:

Stepped wedge design as applied to EMS agencies in this study

	Pre-Study – 18 months	Period 1[*]	Period 2[*]	Period 3[*]	Period 4[*]
Agency 1	Baseline Data Collection (No OCS)	OCS	OCS	OCS	OCS
Agency 2	Baseline Data Collection (No OCS)	No OCS	OCS	OCS	OCS
Agency 3	Baseline Data Collection (No OCS)	No OCS	No OCS	OCS	OCS
Agency 4	Baseline Data Collection (No OCS)	No OCS	No OCS	No OCS	OCS

* Start dates depend on agency's guideline update 'go live;' we will collect at least 18 months of pre- & post-OCS data per agency.

Table 2:

Inclusion and Exclusion Criteria

Inclusion	Exclusion
Ages 2–18 years	Unconscious, hemodynamically unstable, or critically ill -> EMS will proceed with usual critical care (includes IV methylprednisolone as per current treatment guidelines).
Primary problem asthma exacerbation	Daily or every other day CS therapy
Stable to take an oral medication	Allergy to prednisolone or another CS
Transported by EMS to an ED	Chronic lung disease besides asthma, airway anatomic abnormalities, tracheostomy, immunocompromised, traumatic injury, pregnancy, law enforcement custody, non-English speaking

Table 3:

Study RE-AIM Framework

RE-AIM	Measurement & Source
Reach	Proportion of eligible EMS patients who receive OCS (overall) – EMS EMR
Effectiveness	Hospitalizations & ED LOS (overall and adjusted statistical analyses) – ED EMR
Adoption	Range & variability of OCS use by EMS provider, station, and agency - EMS EMR
Implementation	Costs – EMS & ED EMR EMS provider Attitudes & Beliefs – Focus Groups
Maintenance	EMS OCS utilization over time (by EMS provider, station, agency) – EMS EMR EMS provider perceptions of OCS utility – Focus Groups

EMR = electronic medical record, EMS = emergency medical services, OCS = oral systemic corticosteroids