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Evaluating the Clinical Impact of a Novel Pediatric Emergency Medicine Curriculum on Asthma Outcomes in Belize

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Background: Respiratory-related complaints prompt most pediatric visits to Karl Heusner Memorial Hospital Authority's (KHMHA) Emergency Department (ED) in Belize. We developed and taught a novel pediatric respiratory emergencies module for generalist practitioners there. We assessed the curriculum's clinical impact on pediatric asthma emergency management.

Objective: This study assesses the clinical impact of a pediatric emergency medicine curriculum on management of pediatric asthma emergencies at KHMHA in Belize City, Belize.

Methods: We conducted a randomized chart review of pediatric (aged 2–16 y) visits for asthma-related diagnosis at the KHMHA ED between 2015 and 2018 to assess the training module's clinical impact. Primary outcomes included time to albuterol and steroids. Secondary outcomes included clinical scoring tool (Pediatric Respiratory Assessment Measure [PRAM]) usage, ED length of stay, usage of chest radiography, return visit within 7 days, and hospital admission rates. Kaplan-Meier survival analysis and Cox proportional hazard regression were used.

Results: Two hundred eighty-three pediatric asthma-related diagnoses met our inclusion criteria. The patients treated by trained and untrained physician groups were demographically and clinically similar. The time to albuterol was significantly faster in the trained (intervention) group compared with the untrained (control) physician group when evaluating baseline of the group posttraining ($P < 0.05$). However, the time to steroids did not reach statistical significance posttraining ($P = 0.93$). The PRAM score utilization significantly increased among both control group and intervention group. The untrained physician group was more likely to use chest radiography or admit patients. The trained physician group had higher return visit rates within 7 days and shorter ED length of stay, but this did not reach statistical significance.

Conclusions: The curriculum positively impacted clinical outcomes leading to earlier albuterol administration, increased PRAM score use, obtaining less chest radiographs, and decreased admission rates. The timeliness of systemic steroid administration was unaffected.

Key Words: asthma, educational initiative, outcomes, Belize, beta agonist, steroid

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Belize is a small, English-speaking middle-income country of approximately 380,000 inhabitants.¹ Although located in Central America, Belize is also a Caribbean nation, included among the 20 members of the Caribbean Community. Most Belize physicians are medically trained outside the country and return to practice with a diverse wealth of knowledge applied to clinical care.² Most physicians in Belize qualify as general practitioners; few of the physician population are residency-trained in a specialty. As such, generalists manage most acutely ill pediatric patients in emergency departments (ED), pediatric wards, intensive care units (ICUs), and clinics with limited access to pediatric specialists for consultation. Although physicians must complete continuing medical education to practice, there are limited in-country protocols, and practitioners tend to subscribe to various international protocols and algorithms.² Acute pediatric care is dependent on guidelines set by other countries and the World Health Organization, an individual's training and experiences, and local practice patterns.

We performed a needs assessment in 2016 of pediatric emergency care at Karl Heusner Memorial Hospital Authority (KHMHA). Our needs assessment identified pediatric respiratory complaints as an area of focus.² Respiratory complaints were the prevailing reason for pediatric patients presenting to KHMHA either as direct admissions, ED visits, or transfers. The predominant noncommunicable disease of childhood in the pediatric ED population at KHMHA was asthma. Acute respiratory complaints comprise 48% of pediatric visits to KHMHA ED² and are the leading noninfectious disease leading to childhood hospitalization. With this identified need, we created an educational module as part of a larger pediatric refresher curriculum focused on the identification and acute stabilization of the child with acute respiratory distress: asthma, pneumonia, bronchiolitis, and the pediatric airway. This curriculum could propose a framework for those more experienced or those formally trained in pediatric emergencies to positively affect the clinical practices of those less experienced or those not formally trained in pediatric emergencies. This study assesses the clinical impact of the module on pediatric asthma emergency management at KHMHA.

According to World Health Organization estimates, asthma is the most common childhood disease, affecting 339 million individuals.³ It is globally underdiagnosed and undertreated, with more than 80% of asthma-related deaths occurring in low- and middle-income countries (LMICs).^{3,4} Access to timely diagnosis and treatment, principally with corticosteroids and β -agonists, has been shown to reduce symptoms, hospitalization, mortality, and health resource usage.^{5–7} Despite guidelines and evidence for corticosteroids decreasing admission rates and ED returns in pediatric asthma patients, they are often underprescribed.^{8–10}

National organizations have created varying guidelines for acute pediatric asthma care to improve implementation measures. Many research groups have actualized evidence-based pediatric asthma pathways in EDs adhering to national guidelines. This approach has generally resulted in positive clinical outcomes. Adherence to a clinical pathway decreases hospitalizations.¹¹ Well-designed,

evidence-based care plans improve the quality and efficiency of ED asthma care while also reducing hospital admissions.¹² In addition, a standardized asthma severity score improves the time to administering asthma treatment.¹³ Many of these pathways use a scoring tool to assess the severity of the asthma exacerbation and direct care along a given pathway. These scores normalize communication across the health care team and facilitate assessment, treatment, and disposition of the patient. There are multiple scoring tools available. The Pediatric Respiratory Assessment Measure (PRAM) is a validated clinical scoring tool for measuring asthma severity for all pediatric ages with good interrater reliability.^{14,15}

We hypothesized that by using a novel pediatric asthma educational curriculum and implementing an evidence-based clinical care protocol for pediatric asthma exacerbations in the ED, we could improve the timeliness of clinical interventions and streamline asthma care in accordance with current standards of pediatric asthma care.

METHODS

Ethics

This study was approved by the UTHealth Institutional Review Board (HSC-MS-17-0729), Baylor College of Medicine Institutional Review Board (H-38422), and by the leadership of KHMHA.

Study Design and Setting

Karl Heusner Memorial Hospital Authority has the largest ED in the country of Belize and serves as both a regional and national referral hospital, with approximately 27,000 patient visits per year.² The study team developed a novel pediatric emergency curriculum targeting physicians and nurses at KHMHA (henceforth, “providers”). The physician and nursing participants were recruited by general e-mail invitation by department leadership without compulsion or reward for their availability. The curriculum was delivered via didactic lectures, small-group discussions, procedure laboratories, and medical simulation. The asthma segments focused on early clinical identification of asthma and introducing the PRAM score to measure disease severity. Using the PRAM score, we also introduced a protocol guiding provider interventions based on many factors: disease severity, emphasizing early β -agonist administration, early oral or intravenous steroid administration, limited chest radiograph usage, considerations for asthma-adjunct medications, and appropriate disposition of the child with asthma. We introduced the curriculum and clinical intervention to the group in 2016 as a pilot to optimize curriculum development and implementation. It was then formally implemented

in 2017 as part of a clinical protocol for pediatric asthma exacerbation in the KHMHA ED. Postcurriculum analysis showed that it was an appreciated intervention and it demonstrated improvement in clinical knowledge and provider confidence. A total of 26 learners participated in educational programs offered. The participants included 14 physicians (11 of 16 practicing in the KHMHA ED) and 11 nurses (11 of 22 practicing in the KHMHA ED).¹⁶

A retrospective chart review was conducted in 2019 to assess the curriculum’s clinical effectiveness, focusing on key process markers as a proxy for clinical impact (see Data Collection and Outcomes section).

Study Population

Karl Heusner Memorial Hospital Authority ED pediatric patients aged between 2 and 16 years with an asthma-related diagnosis (eg, “wheezing associated with respiratory illness”, “asthma attack”, “status asthmaticus”, etc) during the study periods defined.

Data Collection & Outcomes

Primary outcomes included time to albuterol use and time to steroid use. Secondary outcomes included using PRAM scores, ED length of stay, chest radiography usage, return visit within 7 days, and hospital admission rates.

We identified 4 distinct study periods: preintervention baseline (T0), immediate postpilot intervention (T1), immediate postasthma module intervention (T2), and 6-month follow-up postasthma module intervention (T3). Figure 1 shows the specific timeline. We used a random number generator to select patient encounters for chart review. Our power calculation before reviewing preintervention data determined we would need 125 individual charts to evaluate for any significant change. Chart retrieval and review were performed by a single in-country researcher. For the baseline (preintervention) data, we reviewed randomly selected charts through a 12-month period from January to December 2015 to account for seasonal variability (n = 50). The hospital used paper patient records for documentation. Because of a considerable number of incomplete charts with missing data in each of the postintervention periods, we did not randomly select charts; rather, included all complete charts meeting the inclusion criteria (n = 75). The postintervention data were divided into control (physicians who did not participate in the training) and interventional (physicians who did complete the training) groups for analysis.

Analysis

Demographical data, vital signs, and intervention-related outcomes for postintervention study periods (T1–T3) were compared with the baseline (preintervention, T0) period using the Wilcoxon rank sum test for continuous data and χ^2 or Fisher exact

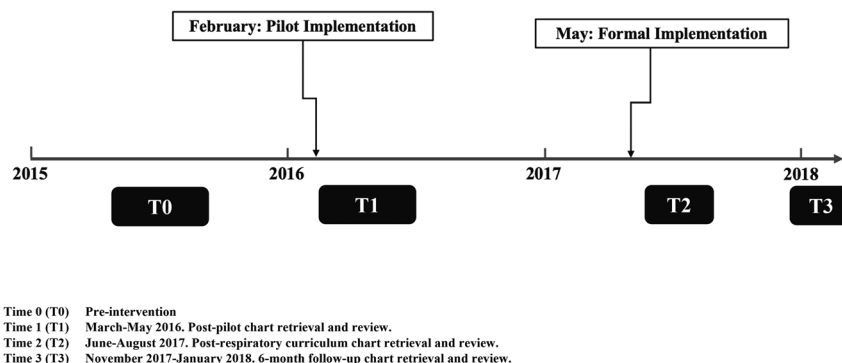


FIGURE 1. Timetable of data collection.

TABLE 1. Cox Proportional Hazard Regression Models for Association of “Time to Albuterol” and “Time to Steroids”

Posttraining Period	Time to Albuterol (min)		Time to Steroids (min)	
	Unadjusted HR (95% CI)	Adjusted HR (95% CI)*	Unadjusted HR (95% CI)	Adjusted HR (95% CI)*
Postpilot (T1)	0.99 (0.5–1.87)	0.96 (0.49–1.87)	2.49 (0.50–12.3)	2.54 (0.49–13.08)
Immediate postintervention (T2)	1.73 (0.90–3.33)	1.88 (0.95–3.75)	1.08 (0.21–5.62)	1.15 (0.19–6.90)
6-mo postintervention (T3)	1.55 (0.88–2.71)	1.96 (1.07–3.60)	0.95 (0.22–4.03)	0.94 (0.19–4.72)

*Adjusted for age, sex, heart rate, respiratory rate, SpO₂.

test for categorical data (Table 1). We used the Kruskal-Wallis test to compare demographical data, clinical characteristics, and intervention-related data for the 4 study periods. Kaplan-Meier plots and Cox regression models were used to evaluate time to medication. Cox proportional hazards regression was used to calculate hazard ratios (HR) and 95% confidence intervals (CI) for the association between each postintervention study period and primary outcomes. For the Cox regression models, primary outcomes were defined as the time (minutes) from in-person examination by a physician to medication administration (albuterol or steroids). All models were adjusted for age, sex, heart rate, respiratory rate, and oxygen saturation (adjusted hazard ratio, aHR) to denote the likelihood of our measured events, particularly time to albuterol and time to steroids (Table 2). We performed all statistical analyses using STATA version 16.1 (Stata Corp, College Station, TX).

RESULTS

The patients in all groups were similar in sex, race, and clinical characteristics such as temperature, weight, heart rate, respiratory rate, and oxygen saturation, except that the posttraining period patients were slightly older (Table 1). There was a total of 11,775 pediatric visits during the study period. Of those, 969 (8%) had a clear asthma-related diagnosis based on documented diagnostic key words/descriptors. Three hundred ninety-three patients met inclusion criteria. However, 110 (28%) were excluded because of missing data. Of 283 patients, 195 patients were treated by module participants (Fig. 2).

The overall use of PRAM score in the ED increased from 5.6% in postpilot period (T1) to 37.8% in the immediate postintervention period (T2) and declined to 24.2% in the 6-month postintervention period (T3, $P \leq 0.01$). There was no significant difference in ED length of stay, return visit within 7 days, or hospital admission rates between all study periods. The PRAM score usage significantly increased among both the intervention (T2 37.8%, T3 24.2%) and control group physicians (T2 55.6%, T3 24.3%) with no statistically significant difference between groups (T2 $P = 0.45$, T3 $P = 0.98$). The control physician group was more likely to use chest radiographs (56.8% vs 23.2%, $P \leq 0.01$) and admit patients (35.1% vs 8.5%, $P \leq 0.01$). The intervention group had higher rates of return visits within 7 days (9.5% vs 0%) and shorter ED length of stay (median 3 h vs 4.6 h), but neither of these measures reached statistical significance ($P = 0.06$) (Table 3).

Kaplan-Meier survival analysis (Fig. 3) showed that in the immediate postintervention period (T2), “time to albuterol use” was improved (median: 0 min; interquartile range [IQR]: 0–0) compared with the preintervention period (T0) (median: 0 min; IQR: 0–15, $P = 0.02$). This improvement was again demonstrated in the 6-month postintervention period (T3) (median: 0 min; IQR: 0–0, $P = 0.05$). However, the multivariate analysis did not show that time to albuterol use was significantly improved

in the immediate postintervention (T2) period (aHR: 1.88; 95% CI: 0.95–3.75) but was significant in the 6-month follow-up period (T3) (aHR: 1.96; 95% CI: 1.07–3.60) compared with the preintervention period T0 (Table 3). Times of “0” typically indicate that the triaging nurse was concerned for asthma on the patient’s arrival, leading the patient to the treatment area for immediate therapeutic measures.

“Time to steroid use” in the immediate postintervention (T2) (median: 135 min; IQR: 55–150) and 6-month postintervention (T3) periods (median: 120 min; IQR: 35–190) were similar compared with the preintervention (T0) period (median: 112.5 min; IQR: 30–195) in Kaplan-Meier survival analysis ($P = 0.93$ and $P = 0.96$, respectively) (Fig. 4). The multivariate analysis also did not show that time to steroid use was significantly different in T2 (aHR: 1.15; 95% CI: 0.19–6.9) or T3 periods (aHR: 0.94; 95% CI: 0.19–4.72) (Table 3).

DISCUSSION

Our findings demonstrated that implementation of this novel pediatric asthma curriculum was associated with improved acute pediatric asthma care and outcomes through earlier albuterol administration, increasing objective assessments of asthma severity (using the PRAM score) and reducing chest radiograph use and admission rates. However, our primary outcome of increased early steroid administration was not as well adopted after the educational intervention. This observation demonstrates introducing and using novel clinical care protocols is a complex process. Such changes are likely best implemented with short, frequent, real-time interventions in addition to our approach of a single, longer training session with protocol introduction.

Scribano et al¹⁷ found clinical practice guidelines (CPGs) are effective tools for optimizing asthma care in the ED. Some prospective studies demonstrate reduced times to β -agonist and steroid administration, increased CPG adherence, and decreased hospital rates.^{12–14} We established a CPG for pediatric asthma exacerbation at KHMHA using a clinical assessment score and treatment protocol. This protocol was introduced via a multimodal educational intervention intentionally combining physician and nursing staff to improve communication and teamwork via didactics, simulation and small-group discussion. Although the curriculum was well received and effective, as evidenced by postintervention scores and qualitative feedback,¹⁶ the effects on clinical outcomes were limited. Interestingly, however, 9% of the control group were also using the PRAM score in some capacity at long-term follow-up. This may be because of modeling behavior by the intervention physician group, peer teaching, or changes in departmental expectations.

Both our primary outcomes focused on improvement in clinical care processes, specifically timeliness measures. Although the time to albuterol improved both immediately and 6 months after the intervention, there was no improvement in time to steroids. There were many missed opportunities for systemic steroid

TABLE 2. Characteristics of Pediatric Asthma Patients Treated by Intervention Group (Trained Physicians) in All Study Periods.

	Baseline 2015 (N = 27) N (%)	Postpilot 2016 (N = 36) N (%)		Posttraining 2017 (N = 37) N (%)		Follow-up 2018 (N = 95) N (%)	P*	P†
Demographics								
Age (y)‡	8 (4–10)	7.5 (6–10)	0.65	10 (8–12)	0.01	7 (4–11)	0.97	0.02
Race			0.59		0.84		0.38	0.74
African American	0	0		0		1 (1.1)		
Creole	22 (81.5)	28 (77.8)		33 (89.2)		65 (69.2)		
East Indian	1 (3.7)	0		0		0		
Garifuna	1 (3.7)	1 (2.8)		1 (2.7)		6 (6.4)		
Mestizo	1 (3.7)	2 (5.6)		2 (5.4)		9 (9.6)		
Other	1 (3.7)	0		0		1 (1.2)		
Spanish	1 (3.7)	2 (5.6)		1 (2.7)		6 (6.4)		
Unknown	0	3 (8.3)		0		6 (6.4)		
Sex			0.18		0.76		0.74	0.31
Female	9 (33.3)	18 (50)		11 (29.7)		35 (36.8)		
Male	18 (66.7)	18 (50)		26 (70.3)		60 (63.2)		
Transferred from another facility	1 (3.7)	1 (2.8)	1.00	1 (2.7)	1.00	2 (2.1)	0.53	0.92
Asthma clinical data								
Temperature (°C)‡	36.8 (36.1–37)	36.7 (36.2–37.1)	0.81	36.9 (36.3–37.2)	0.37	36.7 (36.2–36.9)	0.72	0.47
Weight (kg)‡	25.5 (16.3–30.8)	25 (22.5–32)	0.37	30.35 (22.2–38)	0.08	21.3 (15.9–32.3)	0.91	0.17
Heart rate (bpm)‡	106 (90–131)	113 (103.5–129.5)	0.40	112 (97–124)	0.83	120 (104–132)	0.16	0.23
Respiratory rate (/min)‡	26 (24–30)	25 (24–27)	0.51	24 (23–26)	0.10	26 (24–28)	0.73	0.19
SpO ₂ %‡	98 (95–99)	97 (95–99)	0.52	98 (96–99)	0.80	96 (94–98)	0.11	0.11
Intervention-related outcomes								
CXR usage	4 (14.8)	7 (19.4)	0.63	8 (21.6)	0.49	22 (23.2)	0.35	0.81
PRAM usage	Not available	2 (5.6)	NA	14 (37.8)	NA	23 (24.2)	NA	<0.01
PRAM score§	Not available	2.5 (2–3)	NA	2 (1–3)	NA	3 (1–3)	NA	NA
β-agonist dose (mg)‡	2.5 (2–2.5)	2.5 (2.25–2.5)	0.36	2.5 (2.5–2.5)	0.03	2.5 (2–2.5)	0.45	0.18
Median time to albuterol (min)‡	0 (0–15)	1 (0–30)	0.89	0 (0–0)	0.05	0 (0–0)	0.02	<0.01
Mean time to albuterol (min), mean (SD)	18.7 (34.8)	20.1 (41.9)	NA	2.7 (11.6)	NA	4.0 (17.7)	NA	NA
Inhaled steroids use	3 (11.1)	4 (11.1)	1.00	2 (5.4)	0.64	11 (11.6)	1.00	0.77
Systemic steroids use	4 (14.8)	11 (30.6)	0.15	5 (13.5)	1.00	34 (35.8)	0.04	0.03
Median time to steroids (min)‡	112.5 (30–195)	30 (1.75–60)	0.50	135 (55–150)	1.00	120 (35–190)	0.96	0.29
Mean time to steroids (min), mean (SD)	112.5 (116.6)	49.5 (63.3)	NA	114.1 (85.5)	NA	129.7 (118.5)	NA	NA
ED length of stay (h)‡	2.5 (1.8–4)	2.3 (1.7–4.5)	0.63	2.17 (1.6–3.5)	0.42	3 (1.5–6.7)	0.58	0.50
Admission	1 (3.7)	1 (2.8)	1.00	2 (5.4)	1.00	8 (8.5)	0.68	0.72
PICU admission	0	0	NA	1 (2.7)	1.00	2 (2.1)	1.00	1.00
Pneumonia diagnosis	0	1 (2.9)	1.00	2 (5.4)	0.50	8 (8.4)	0.20	0.45
Return visit <7 d	3 (11.1)	3 (8.3)	1.00	4 (10.8)	1.00	9 (9.5)	0.73	0.95

*P value for comparison with baseline; †P value for comparison in all groups; ‡median (IQR); §available for only 39 (20%).

BPM indicates beats per minute.

administration. At most, approximately one third of all physicians administered steroids (35.8% at T3), and there was a surprising increase in use of nebulized steroids (11% at T3). The reason for these findings may be multifactorial. One important consideration is that according to the PRAM calculation, a “mild” exacerbation should cause a practitioner to only consider steroid administration, whereas “moderate” and “severe” exacerbations request steroid administration. Although the asthma severity among the groups was overall comparable, we cannot assess if the steroid administration was appropriately deferred in concordance with the cases presented based on our current data. Moreover, in

2018, the hospital redesigned the ED spaces to accommodate more oxygen and air tanks and treat more patients with bronchospasm with nebulized albuterol. There may have already been a high importance placed on albuterol treatment by the department and the institution, emphasized further by our educational curriculum. We noticed that it was not uncommon for patients to be taken to this care area for nebulizer therapy as soon as wheezing was identified in triage, leading to median times of albuterol administration to be “0.” Moreover, it may be more consistent with the regional patterns of care for practitioners to highlight the administration of nebulized β-agonists. In Trinidad, patients

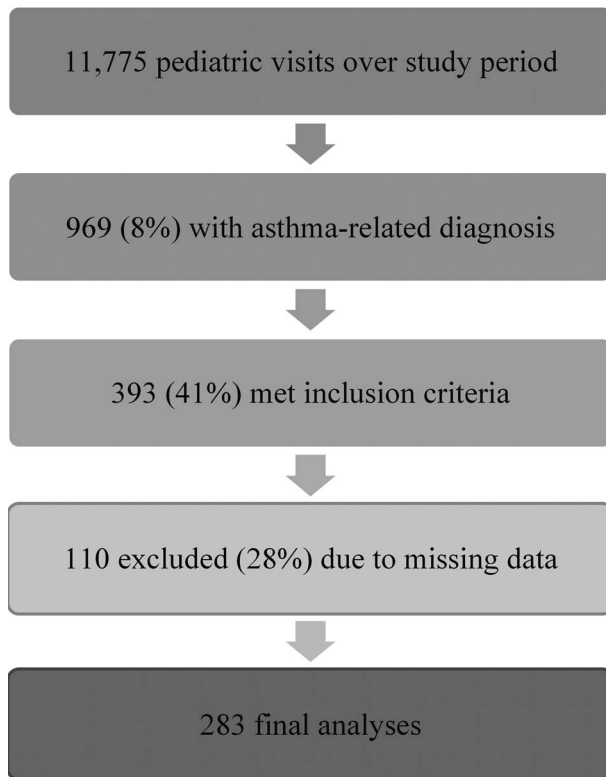


FIGURE 2. Data collection.

received β-agonists regularly (up to 85% of ED visits) compared with systemic corticosteroids (up to 51% of patients), contrary to Caribbean guidelines for asthma care.¹⁸ Outside of the region, in Saudi Arabia, patients received systemic steroids 46% of the time, contrary to national recommendations.¹⁹ Consistent early

steroid administration may simply be a global shortcoming that will require more targeted intervention.

The timing of steroid administration was generally unchanged among our groups, yet the rates of steroid administration by physicians in the intervention group were overall higher than those in the control group at posttraining (T2) and at follow-up (T3) (Appendix A, <http://links.lww.com/PEC/B30>). Unfortunately, this tendency was not statistically significant based on our data set, although it shows promise for our interventions. Early systemic steroid administration may be a more critical clinical outcome to target in optimizing pediatric asthma care. The earlier steroids are administered, the sooner it can address asthma-related bronchial inflammation, given that the onset to action for these drugs takes hours as opposed to the onset of inhaled β-agonists, which is a matter of minutes. Although the introduction of a CPG significantly decreased the time to albuterol administration, perhaps the more impactful behavior change, early steroid administration, fell short. The frequent time of “0” for albuterol administration also suggests that nursing interventions may have a greater impact on timeliness of treatment than physicians, and emphasis on early systemic steroid administration in nursing educational interventions in the future may have a more substantial yield.

Finally, it is commonplace in medical practice to guide group clinical behavioral changes using quality improvement (QI) interventions. Quality improvement takes a systematic approach to analyzing and intervening on provider performance. For example, Watnick et al²⁰ implemented a CPG but found persistently elevated chest radiograph rates. By implementing QI methodology and targeted interventions, they achieved a decreased rate of chest x-ray (CXR) usage in asthma.²⁰ Other studies have shown that QI-targeted interventions for ED asthma management have been successful for β-agonist administration, steroid use, and asthma bundled care.^{21–23} We postulate that it may be beneficial to implement a QI initiative in addition to refresher educational courses to implement more noteworthy and lasting provider behavioral changes in asthma care. A QI initiative using a model such as a

TABLE 3. Intervention-Related Clinical Outcomes of Pediatric Asthma Patients Treated by Intervention Group (Trained Physicians) in All Study Periods.

	Baseline 2015 (T0) (N = 27) N (%)	Postpilot 2016 (T1) (N = 36) N (%)		Posttraining 2017 (T2) (N = 37) N (%)		Follow-Up 2018 (T3) (N = 95) N (%)		
			P*		P*		P*	P†
CXR usage	4 (14.8)	7 (19.4)	0.63	8 (21.6)	0.49	22 (23.2)	0.35	0.81
PRAM usage	Not available	2 (5.6)	NA	14 (37.8)	NA	23 (24.2)	NA	<0.01
PRAM score‡	Not available	2.5 (2–3)	NA	2 (1–3)	NA	3 (1–3)	NA	NA
β-agonist dose (mg)§	2.5 (2–2.5)	2.5 (2.25–2.5)	0.36	2.5 (2.5–2.5)	0.03	2.5 (2–2.5)	0.45	0.18
Median time to albuterol (min)§	0 (0–15)	1 (0–30)	0.89	0 (0–0)	0.05	0 (0–0)	0.02	<0.01
Mean time to albuterol (min), mean (SD)	18.7 (34.8)	20.1 (41.9)	NA	2.7 (11.6)	NA	4.0 (17.7)	NA	NA
Inhaled steroids use	3 (11.1)	4 (11.1)	1.00	2 (5.4)	0.64	11 (11.6)	1.00	0.77
Systemic steroids use	4 (14.8)	11 (30.6)	0.15	5 (13.5)	1.00	34 (35.8)	0.04	0.03
Median time to steroids (min)§	112.5 (30–195)	30 (1.75–60)	0.50	135 (55–150)	1.00	120 (35–190)	0.96	0.29
Mean time to steroids (min), mean (SD)	112.5 (116.6)	49.5 (63.3)	NA	114.1 (85.5)	NA	129.7 (118.5)	NA	NA
ED length of stay (h)§	2.5 (1.8–4)	2.3 (1.7–4.5)	0.63	2.17 (1.6–3.5)	0.42	3 (1.5–6.7)	0.58	0.50
Admission	1 (3.7)	1 (2.8)	1.00	2 (5.4)	1.00	8 (8.5)	0.68	0.72
PICU admission	0	0	NA	1 (2.7)	1.00	2 (2.1)	1.00	1.00
Pneumonia diagnosis	0	1 (2.9)	1.00	2 (5.4)	0.50	8 (8.4)	0.20	0.45
Return visit <7 d	3 (11.1)	3 (8.3)	1.00	4 (10.8)	1.00	9 (9.5)	0.73	0.95

*P value for comparison with baseline; †P value for comparison in all groups; ‡available for only 39 (20%); §median (IQR).

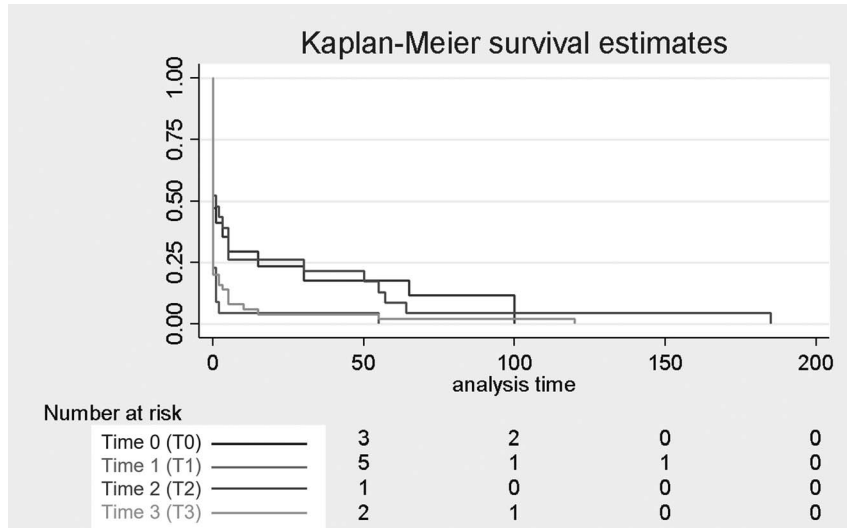


FIGURE 3. Kaplan-Meier survival graphs for “Time to Albuterol”.

Plan, Do, Study, Act cycle could provide a formal framework to identify and address the barriers to the educational module's behavioral changes.

Limitations

There are several limitations to this study, as with many educational studies. There was no randomization of participants; rather, participants volunteered or were recruited by KHMHA, and we are not aware of all biases that may have been involved in the decision to participate. Because of the nature of retrospective chart reviews, a little more than one quarter of the potential patient encounters meeting inclusion criteria were excluded from the final analysis because of missing data, which could have influenced our results. It is quite possible that with a larger sample size of patient encounters, we may have appreciated statistical significance in more of our secondary outcomes such as a reduction in ED length of stay ($P = 0.06$) and return visits within 7 days ($P = 0.06$). Our study was also limited to the major referral hospital in Belize. It may not apply equally to smaller hospitals within

Belize, although our approach might be transferable to other similarly resourced hospitals in other (LMICs). Some aspects of patient care are also traditionally more nursing-based (ie, administration of medication or adequate triage), potentially affecting the timeliness of steroid or albuterol administration because of the nurse's patient load or shift in ED volume—something we did not capture in this analysis even though some nurses did indeed attend the provider training course.

Although 21 practitioners in total (nurses and physicians) had taken part in the curriculum, each having volunteered without compulsion, their representation in the ED was varied because of the high turnover rate of ED staffing, clinical obligations, and personal obligations. We did not specifically capture nursing data for this study because of the nursing staffing structure being difficult to trace among the cross-coverage of patient care from triage to disposition of an ED patient, whereas physician coverage was more consistent for each individual patient visit. However, although a participant may not have participated in each of the curriculum testing activities, it does not negate that they may have incorporated some things that they learned during their limited

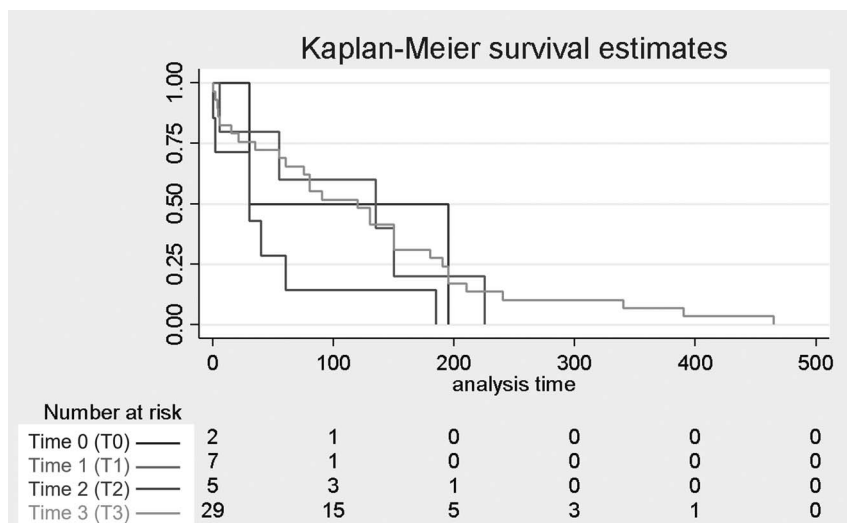


FIGURE 4. Kaplan-Meier survival graphs for “Time to Steroids”.

participation time into practice. Nursing undeniably could have affected time to treatment. Reasons for the lack of significant changes and retention of significant behavioral change are likely multifactorial, including medical knowledge, lack of clinical reminders, paper charts, staff buy-in, understanding/misunderstanding of material presented, and other factors that we may not have directly addressed or considered.

Similarly, we suspect that introducing the PRAM score likely introduced a new way of communicating asthma severity among physicians and nurses regardless of curriculum participation, as demonstrated by a substantial percentage of the control group also incorporating PRAM usage into clinical practice. Peer-to-peer teaching and incorporation of the PRAM score into the standard paper forms for respiratory complaints in the department likely contributed to the gross increase of PRAM score usage in all groups. This is a confounder we could not account for when measuring clinical outcomes of the CPG and curriculum implementation. Nonetheless, this novel pediatric respiratory emergencies curriculum uses minimal resources and has been shown to be a welcome and effective teaching tool to improve pediatric asthma care in Belize.¹⁶ Curriculum revisions to improve clinical behavioral outcomes and maintain behavior changes will be needed in the future, specifically addressing key knowledge gaps and clinical interventions such as timely steroid administration.

CONCLUSIONS

Our study evaluated a novel pediatric respiratory emergencies curriculum's impact on clinical practice. The curriculum was associated with a positive impact on clinical outcomes: earlier albuterol administration, increased PRAM use, and decreased admission rates. However, steroid administration as a key clinical intervention was significantly changed. Revised curriculum delivery and clinical implementation using a systematic QI methodology could be key to successful clinical translation of educational interventions, in addition to focusing on shorter, more frequent training sessions to capture more ED staff, adjust for ED turnover, and encourage positive behavior changes in clinical performance.

Globally, developing emergency medicine systems often seek collaboration with more-resourced systems. In this study, a partnership with educators from US-based academic centers and stakeholders in Belize created a novel pediatric emergency medicine curriculum. This respiratory curriculum was associated with generally positive clinical outcomes for pediatric patients with asthma. Although there were not ubiquitous and consistent behavioral changes of trained providers, there were indeed notable positive behavioral changes for providers who participated in the educational curriculum. This curriculum's success provides a collaborative framework for an education-based approach to improve asthma management in Belize and potentially LMICs worldwide.

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