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A Matched-Cohort Evaluation of a Bedside Asthma Intervention for Patients Hospitalized at a Large Urban Children's Hospital

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ABSTRACT *Emergency care and hospitalizations account for 36% of asthma-related medical expenses for children. National asthma guidelines emphasize the need for asthma self-management education at multiple points of care, including the hospital, to help prevent acute exacerbations. The integration of a bedside asthma education program into discharge planning at a busy urban children's hospital aimed to reduce repeat emergency department (ED) visits and hospitalizations by educating the community's highest-risk children and their families about asthma. A trained respiratory professional provided 45 minutes of individualized bedside education to families at the hospital and one follow-up support phone call within 3 weeks after discharge. Children receiving the intervention were matched to a control group of children not receiving the intervention by age and 2 markers of past utilization using data obtained from hospital records. Repeat ED utilization was analyzed using a Cox proportional hazards model controlling for sex, residence, race or ethnicity, and year. Compared to 698 matched controls, no significant improvement was observed in the 698 intervention participants or any subgroups followed for 12 months after the intervention.*

KEYWORDS *Inpatient, Hospital-based, Discharge, Education, Readmission, Hospital, Emergency room, Acute care, Asthma, Minority, Children, Urban, Teachable moment, Intervention, Management*

INTRODUCTION

Hospitalizations and emergency department (ED) visits account for 36% of direct medical expenses for childhood asthma.[1] Studies report that as many as 25% of children hospitalized for asthma will be readmitted within a year.[2] Clinical guidelines for asthma emphasize the need to reinforce asthma self-management education not only at the primary care provider's office but also at multiple points, including before hospital discharge.[3] Most evaluated inpatient programs have served adults with mixed success.[4-7] Of hospital-based programs targeting children, 3 were

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multifaceted and included provider quality improvement activities, education, and support.[8-10] Three other studies, each reaching fewer than 100 children, focused primarily on patient/caregiver education and support in the hospital during the child's stay.[11-13] These latter studies demonstrated a reduction in repeat ED visits and hospitalizations among participants.

From a public health perspective, the inpatient setting has several advantages over other sites for reaching high-risk patients. By definition, patients are at the site, eliminating the need to seek them out in the community. Moreover, the acute care visit has been described as a "teachable moment" for asthma education.[14] This paper examines whether a brief hospital-based asthma intervention, delivered on a large scale in a busy urban hospital setting, can significantly change patterns of children's ED visits and hospitalizations. It also explores the challenges of evaluating such an intervention in a non-research context.

BACKGROUND

Children's Hospital and Research Center Oakland (CHRCO), a not-for-profit hospital in Oakland, California, serves a regional population. The majority of patients are Medicaid-eligible. A total of 5,246 children seen at the CHRCO ED in 2008 received a primary or secondary diagnosis of asthma, and 2,046 (39%) were admitted to the hospital.[15] Asthma is the most common cause of hospitalization at CHRCO, and approximately 24% of these visits are repeat visits within 1 year. Of children hospitalized for asthma in 2008, 49% were Black and 25% were Hispanic. As CHRCO is the only public facility in the area offering inpatient services for children with asthma, it is reasonable to assume that almost all hospitalizations for asthma among children living in and around Oakland were in the CHRCO patient database.

Before this intervention, standard pre-discharge education for CHRCO patients with asthma was minimal and few staff had training to provide it. The intervention sought to provide routine pre-discharge asthma education and referral services to all families of children with asthma, with the goal of preventing repeat ED visits and hospitalizations for asthma. The intervention needed to be affordable and easily integrated into routine care. CHRCO's Institutional Review Board gave approval for the project.

METHODS

Major funding provided by the Centers for Disease Control and Prevention (CDC) Controlling Asthma in American Cities Project enabled CHRCO to employ a nurse with experience as a professional asthma educator and a respiratory therapist certified as an asthma educator (AE-C). Between them, the asthma educators worked approximately 4 hours at a time, 5 days a week, for an average of 20 hours per week. They worked primarily in the afternoon when caregivers were most likely to visit or pick up their children at the hospital.

The educators used CHRCO's patient database to identify hospitalized patients. Program inclusion criteria included (a) asthma (ICD-9 of 493.00–493.99) as the primary or secondary diagnosis; (b) age over 12 months; and (c) the presence at the hospital of an adult caretaker, with whom the child lived, who was willing to participate at the time of the intervention. Immediately before the education session, the educator administered a brief questionnaire to the caretaker to assess symptom

history, functional limitations, and medication use over the previous 4 weeks. This information helped the educator tailor messages to family needs. On-site interpreters were available for non-English speakers.

The family received 45 minutes of education in the patient's room. Children's level of involvement depended on their age and maturity, with age-appropriate messages typically provided to children ages 6 and older. The standard curriculum used photos, demonstration devices, and lung models to deliver a didactic session covering the basic physiology of asthma; the role of medications and the asthma action plan; warning signs; communicating with the provider; identifying, avoiding, and remedying asthma triggers; and brief interactive training on delivery devices. Topics such as tobacco cessation and avoidance, nebulizers, and insurance were addressed at the educator's discretion and as time allowed. Families received information about asthma-related community services and were encouraged to follow up with their regular medical provider to obtain an asthma action plan or adjustments to their existing plan. Families also received simple 12-page booklets illustrating most topics covered in the session.

Three weeks after discharge, an asthma educator phoned the child's caretaker who had participated in the asthma education session to ask how the child was doing, reinforce key messages, and provide information about additional community resources. Phone calls lasted an average of 9 minutes. The asthma educator made up to 3 calls at different times, leaving voicemail messages inviting the family to call back during working hours.

Analysis

The intervention group consisted of children who met all inclusion criteria, received standard care, and participated in the program from its initiation on July 5, 2005 to August 30, 2007, regardless of whether or not their caretakers were reached by follow-up calls. Many hospitalized children met the first 2 inclusion criteria, but were unable to participate because the educator and their caretaker were not available at the same time during their hospital stay, thus not meeting the third criterion. Those children received standard inpatient care only and were included in the pool of potential controls.

The control group consisted of patients hospitalized for asthma (ICD9: 493.00–493.99) at CHRCO between May 5, 2005 and August 30, 2007 for whom data were gathered from the CHRCO database and de-identified. These data included admission and discharge dates for all asthma-related ED visits and hospitalizations, sex, race, ethnicity, birth date, the ZIP code of primary residence, and insurance type at each visit. The control group was created by direct, paired matching with the intervention group using a matching macro procedure in SAS 9.1.3 (Cary, NC). Potential matching variables, which appear in Table 1, were selected because they showed an association with an ED visit for asthma in this dataset. Past ED utilization was the strongest predictor of subsequent ED utilization.

Two different strategies were used to match the intervention group to the control group. The first strategy matched all variables listed in Table 1. The second strategy matched only age and the 2 past ED and hospitalization utilization variables, i.e., total hospitalization days and number of ED visits in the preceding 24 months as described in Table 1. For the first strategy, data used for matching (age, sex, residence, race/ethnicity, and year of intervention) were taken directly from the CHRCO database. For the intervention children, past utilization was measured for the period prior to the intervention hospitalization. The controls did not have an intervention hospitalization; therefore, any of their hospitalizations could have been chosen as the

TABLE 1 Variables used for matching intervention patients with controls

Variable (no. of levels)	Categories	Comments
Age (7)[a]	1, 2, 3, 4, 5, 6–12, 13–18	Age at time of intervention/matched date
Race/ethnicity (6)	Asian/Pacific Islander, Black, Latino, White, Native American, Other	
Gender (2)	Male, Female	
Insurance status (3)	Public, Private, Changed status during evaluation period	Refers to a patient's status at the time of the intervention or a control's status at the corresponding matched hospitalization date (reference date)
Hospital utilization history	Range: 0–73	Calculated as "total summed hospital days" at CHRCO with a first-degree or second-degree diagnosis of asthma in the 24 months prior to the intervention date or corresponding matched hospitalization date (reference date)
ED utilization history	Range: 0–38	History of asthma-related ED visits w/o hospitalization: This variable was calculated as the total number of visits to the ED that did not result in an overnight hospitalization in the 24 months prior to intervention date or corresponding matched hospitalization date
Residence	Local or non-local	Local was defined as having a primary residence in the cities of Oakland or Berkeley
Year of hospitalization	2005, 2006, 2007	Year during which the intervention hospitalization (or reference hospitalization for controls) occurred

[a]Each integer should be interpreted as $X < (X + 1)$. Thus, age 1 represents any age between the first birthday and the day before the second birthday

reference event (before which prior utilization would be assessed and after which subsequent hospitalizations would be measured). The matching procedure considered each hospitalization for a control child as a possible match for an intervention child. The reference hospitalization for controls was selected so as to match the past utilization for a child in the intervention group who was similar on all other matching variables. Control children were matched to only one intervention child.

Age and past utilization were selected for matching in the second strategy because preliminary analysis indicated that they are the strongest predictors of subsequent utilization. A reference matched visit was selected for the controls as in the first strategy. This strategy produced 2 groups that were quite similar on all other characteristics (Table 2), yet yielded over twice as many matched pairs as the first strategy (see "Results"). Preliminary analysis using both strategies did not produce statistically different results. A decision was made to use the second matching strategy and statistically control for the other variables in the analysis.

The 2 primary outcomes of interest were the number of ED visits during a 365-day follow-up period and time until the next ED visit for which asthma was a primary or secondary diagnosis, and whether or not the ED visit resulted in an overnight hospitalization (all hospitalizations for asthma at CHRCO are preceded by an ED visit). The number of ED visits leading to hospitalizations was insufficient to conduct a sub-analysis of that group. Two or more ED visits within a contiguous 2-week period were counted as a single visit because they were probably due to the same exacerbation. Only the first participation was counted for the analysis of individuals who participated in the intervention more than once.

A Cox proportional hazards model was the statistical method used to determine whether a significant difference existed between the intervention and control groups in the time until the next event or the number of events during the follow-up period.* This method was chosen because it accommodates a non-normal distribution of events, analysis of matched intervention–control pairs, and a large proportion of patients with missing data for the time of an event (many patients did not have a subsequent visit during the 365-day follow-up period).[16]

The first step was to create a basic model. "Treatment" was the main covariate in this model; gender, race, reference year, and insurance status were added to control for their effects. The "reference year" covariate refers to the calendar year in which the intervention or reference hospitalization occurred. Each person had a 365-day follow-up period from the hospitalization.† The basic model did not test any of the covariates for statistical significance, nor did it test for interaction effects.

The next step involved refining the model to create a "fitted model" by testing each covariate's statistical significance and the validity of the assumption of proportionality in the Cox proportional hazards model. Covariates that did not meet the assumption of the model were dropped from the model in accordance with the methodology. Subsequently, all remaining covariates and all possible 2-way interactions between these covariates were checked for statistical significance using a backward selection method, removing one at a time and then rerunning the model. Statistically significant covariates ($p \leq 0.12$) were left in the model as well as covariates which were insignificant but involved in an interaction effect that was significant. Analysis used 2 definitions of asthma: visits in which asthma was the primary diagnosis and visits

*Detailed statistical methodology is available upon request.

†Anyone who did not have a follow-up visit within 365 days was "right censored."

TABLE 2 Characteristics of intervention and control groups before and after matching by age and past utilization

	Before matching		After matching	
Characteristics	Intervention group (%)	Non-intervention group (%)	Intervention group (%)	Control group (%)
Total	786	1951	698	698
Gender				
Female	307 (39)	706 (40)	263 (38)	259 (37)
Male	479 (61)	1,059 (60)	435 (62)	439 (63)
Age[a]				
1–2	NA	NA	170 (24)	170 (24)
2–3	NA	NA	89 (13)	89 (13)
3–4	NA	NA	77 (11)	77 (11)
4–5	NA	NA	54 (8)	54 (8)
5–6	NA	NA	42 (6)	42 (6)
6–12	NA	NA	199 (29)	199 (29)
13+	NA	NA	67 (10)	67 (10)
Race[b]				
Don't know	4 (1)	17 (1)	4 (1)	8 (1)
Missing	0 (0)	1 (0)	0 (0)	1 (0)
African American	354 (45)	701 (40)	304 (43)	247 (35)
Hispanic/Latino	174 (22)	516 (26)	156 (22)	185 (27)
White	70 (9)	256 (13)	65 (9)	108 (15)
Native American	0 (0)	2 (0)	0 (0)	0 (0)
Other	184 (23)	388 (20)	169 (24)	149 (21)
Past utilization: Summed hospital days[c]				
0	NA	NA	170 (24)	170 (24)
1	NA	NA	90 (13)	90 (13)
2	NA	NA	192 (28)	192 (28)
3	NA	NA	101 (14)	101 (14)
4	NA	NA	52 (7)	52 (7)
5	NA	NA	36 (5)	36 (5)
6–8	NA	NA	46 (7)	46 (7)
9+			11 (2)	11 (2)
Past utilization: Number of ED visits[d]				
0	NA	NA	494 (71)	494 (71)
1	NA	NA	125 (18)	125 (18)
2	NA	NA	42 (6)	42 (6)
3	NA	NA	18 (3)	18 (3)
4	NA	NA	4 (1)	4 (1)
5+	NA	NA	15 (2)	15 (2)
Insurance[e]				
Private	161 (20)	505 (26)	144 (21)	196 (28)
Medicaid	586 (75)	1352 (69)	522 (75)	474 (68)
Changed Insurance During Study	39 (5)	94 (5)	32 (5)	28 (4)
Residence[f]				
Not Local	390 (50)	960 (49)	349 (50)	378 (54)

TABLE 2 (continued)

Characteristics	Before matching		After matching	
	Intervention group (%)	Non-intervention group (%)	Intervention group (%)	Control group (%)
Local	367 (47)	922 (47)	333 (48)	309 (44)
Moved during Study	29 (4)	69 (4)	12 (2)	11 (2)

[a]For the intervention group, age refers to age at time of admission preceding the intervention. For the non-intervention, it refers to the age at the matched admission

[b]Race and ethnicity were separate variables in the original data. Children with Latino/Hispanic ethnicity were defined as such, regardless of race

[c]Refers to total number of days spent in the hospital between September 15, 2003 and the date of first intervention, or corresponding matching date. This cannot be calculated prior to matching as there is no reference date for those who were not in the intervention

[d]Refers to total number of visits to the ED between September 15, 2003 and the date of intervention or corresponding matching date. This cannot be calculated prior to matching as there is no reference date for those who were not in the intervention

[e]Refers to insurance at time of intervention or corresponding matching date

[f]Refers to residence at time of intervention or corresponding matching date. "Local" was defined as having a residential ZIP Code in Oakland or neighboring Berkeley

in which asthma was either the primary or secondary diagnosis. Results are limited to the second definition because there was virtually no difference in outcomes.

RESULTS

Between March 15, 2005 and August 30, 2007, a total of 2,737 patients over 12 months of age were hospitalized at CHRCO with a primary or secondary diagnosis of asthma. Of those, 786 (29%) participated in the intervention. Of the 29%, 698 (89%) could be matched to a control using age and the 2 past utilization variables. The characteristics of the treatment and control groups before and after matching appear in Table 2. Of the 698 included in the analysis, 67% were reached for the follow-up phone call.

Table 3 displays a simple frequency distribution of both the total number of visits to the ED for asthma and total days spent in the hospital due to asthma in the 365 days after the reference date. The intervention group spent significantly more days in the hospital for asthma and had significantly more ED visits than the control group.

The Cox proportional hazards model uses time until subsequent ED visit to estimate the risk for someone in the intervention group compared to the control group. The results of 2 models are shown in Table 4. The basic model (basic model) includes covariates for intervention participation, race or ethnicity, sex, insurance, and reference year. Past utilization and age were not included because they were used for matching. Place of residence was not included because it was not found to be associated with outcomes. The hazard ratio of repeat visits for the treatment group is 2.38, which is statistically significant. Thus, using this model, the risk (hazard) of a child in the intervention group coming back to the ED during the

TABLE 3 Summed hospitalization days and number of ED visits for the intervention and control groups in the 365 days following the index hospitalization date (percentages in parentheses)

	Intervention group (%)	Control group (%)
Summed hospitalization days		
0	524 (75)	625 (90)
1	24 (3)	17 (2)
2	39 (6)	28 (4)
3	26 (4)	15 (2)
4	24 (3)	6 (1)
5	17 (2)	2 (0)
6	8 (1)	1 (0)
7–9	18 (3)	0 (0)
10+	18 (3)	4 (1)
Mantel–Haenszel chi-square[a] test	Q_S 17.96	$p < 0.0001$
No. of ED visits		
0	376 (54)	481(69)
1	146 (21)	118 (17)
2	69 (10)	52 (7)
3+	107 (15)	47 (7)
Mantel–Haenszel chi-square test	Q_S 7.49	$p = 0.0062$

[a]Mantel–Haenszel chi-square test ignoring matched pairs of similarities (without zeros)

365 days after the intervention was significantly higher than the risk for a child in the control group.

Insurance was dropped from the model when a test of proportionality determined that the insurance variable was not consistent across the time period. A test of 2-way interaction between the remaining covariates found that only 1 interaction term improved the model—the interaction between the year 2007 and other ethnicity. Table 4 (fitted model) shows the fitted model results of the proportional hazards analysis. The hazard ratio of repeat ED visits for the treatment group was 2.45, which was not significantly different from that of the basic model.

There was no evidence among the 698 families included in the analysis or for any subgroup that the intervention significantly improved patterns of future ED utilization when compared to a matched group of controls at the same hospital. On the contrary, the intervention group was not only significantly more likely to return within 12 months but also to do so sooner.

DISCUSSION

CHRCO sought to institutionalize a large-scale inpatient asthma education program similar to smaller previous studies.[11-13] This low-cost, high-volume intervention was easily integrated into routine discharge planning for patients at the hospital. Although similar to the smaller programs in intensity, approach, content, and objectives, it differed in its selection of patients and staffing.

The hospital prohibited a randomized design to avoid the exclusion of patients from services. Matching data found in hospital records produced a control group that approximated the intervention group. The control group included some children who received standard inpatient care during the intervention period. The

TABLE 4 Results of 2 Cox proportional hazard models testing the effect of participation in the intervention group on time until subsequent ED visit

Variable	Estimate	Standard error	*p* value	Hazard ratio	Haz. ratio lower CL	Haz. ratio upper CL
Basic model[a]						
Intervention	0.87	0.15	0.00	2.38	1.77	3.22
2006	−0.58	0.26	0.03	0.56	0.34	0.93
2007	−0.51	0.26	0.05	0.60	0.36	1.01
African American	0.76	0.36	0.03	2.14	1.06	4.29
Latino	0.90	0.37	0.01	2.46	1.19	5.07
Other ethnicity	0.23	0.38	0.55	1.26	0.60	2.64
Male	−0.15	0.18	0.41	0.86	0.60	1.23
Public insurance	0.26	0.24	0.27	1.30	0.82	2.06
Fitted model[ab]						
Intervention	0.90	0.15	0.00	2.45	1.82	3.31
2006	−0.56	0.26	0.03	0.57	0.35	0.95
2007	−0.25	0.28	0.37	0.78	0.45	1.35
African American	0.84	0.35	0.02	2.32	1.18	4.59
Latino	1.04	0.35	0.00	2.82	1.41	5.65
Other ethnicity	0.69	0.40	0.09	1.99	0.90	4.40
2007[a] Other ethnicity	−1.04	0.46	0.02	0.35	0.14	0.87

[a]The Cox proportional hazard model requires the covariates to be either 0 or 1, and thus, the covariates with more than 2 terms were classified using dummy variables. The levels for the variables were as follows: Treatment: 0—control (reference level), 1—case/treatment; Gender: 0—female (reference level), 1—male; Year: 2005 is the reference level; Race: African American (0—no, 1—yes), Latino (0—no, 1—yes), Other Race (0—no, 1—yes), reference level is White; Insurance (not included in fitted model): 0—private (reference level), 1—public insurance

[b]Backward selection used a cutoff of $p = 0.12$. Terms with a $p < 0.12$ were kept in the model

intervention and control groups may have differed on factors other than those accounted for by matching or controlled for in the model. Collection of additional data was beyond the scope of this evaluation.

The educators typically had time to see about 4 patients per day. They had no specific protocols for selecting patients on busy days. The educators might have biased results by consciously or unconsciously selecting patients they perceived as having greater need. However, the educators knew nothing about the patient before visiting the room other than that the patient had been coded as being hospitalized for asthma. On days when more than 4 patients were in the hospital for asthma, the overriding selection criterion was the availability of the patient and a guardian for an hour when the educator was available. Those children may have had characteristics different from those whose caretakers were not present during those times.

A longer hospital stay might have increased the likelihood of an individual receiving the intervention, might have been a marker for future risk, and might have helped explain the results. However, the mean length of hospital stay for the intervention and control groups was virtually identical.

The intervention may have been effective at improving outcomes other than ED visits, such as knowledge or skills gained, medication use, frequency of symptoms, quality of life, or self-confidence. Resources for collecting such data were not available. ED visits and hospitalizations, the main contributors to preventable asthma costs, were the outcomes of greatest interest to the various stakeholders.

The curriculum itself might have been inadequate for any number of reasons. The time spent with families could have been too short for adequate discussion of the concepts. The educators, who were unaware of challenges families might be facing, provided only a broad overview when in-depth coverage of fewer points might have been more appropriate. Also, the curriculum did not include follow-up support to help families make behavioral changes. Had more time been dedicated to each family, fewer families would have been seen.

Whatever the reason, the negative findings of the CHRCO program suggest that the intervention did not adequately address specific factors that would reduce the probability of this population's ED use. These might include environmental factors at home and school or barriers to accessing primary medical care or proper medications. Evidence that respiratory infections contribute to the majority of acute asthma episodes [17] might also lead one to conclude that interventions which do not address that risk factor will have a limited impact. Moreover, educational interventions might have limited impact upon ED use by families for whom routine ED care may be logical behavior because the ED requires no appointment, is always open, and, for patients or families with Medicaid, has negligible cost. Indeed, a study of ED encounters in a hospital serving a lower socioeconomic status population found that the majority of asthma patients presented with mild symptoms.[18] Lastly, the intervention might have increased caretakers' awareness of the dangers or warning signs of a serious asthma exacerbation, resulting in earlier or more frequent use of emergency services.

Although the inpatient asthma education program at CHRCO did not result in a positive outcome, it had several strengths. It involved the largest sample size of any hospital-based asthma program targeting either children or adults and was one of only 2 studies assessing a hospital-based strategy for a largely lower-income, minority-child population. The use of several years of hospital records was another strength. The availability of hospital records for the years preceding the intervention

made possible a close match between the intervention and control groups on 2 measures of past utilization, which was the strongest risk factor in the preliminary analysis for future utilization.

Moreover, despite the negative findings, hospital administrators have chosen to support program continuation financially. This decision is based primarily on the overwhelmingly positive feedback from families and hospitalists and the hospital's aim to be consistent with NAEPP guidelines, which recommend asthma self-management education "at all points of care where health professionals interact with patients who have asthma, including…EDs and hospitals."[3]

CONCLUSION

Hospitals represent a venue for reaching large numbers of a community's highest-risk asthma patients. The inpatient asthma program at CHRCO represented an attempt to evaluate a "real-world" asthma intervention in a non-research context, reaching approximately 400 high-risk families *per year* using only a half-time health educator position. Similar interventions in the future could possibly result in more positive outcomes by selecting families with histories of frequent utilization and dedicating more time and support to them. Future research should focus on identifying additional characteristics that can influence utilization for asthma, beyond those typically found in health records, and determining reasonable goals and priorities for inpatient education. Evaluation should include intermediate outcomes, such as symptom frequency, quality of life, medication use, and follow-up visits to a primary care provider, following a strict selection protocol to minimize the possibility of selection bias.

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DISCLAIMER

The findings and conclusions in this manuscript are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

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