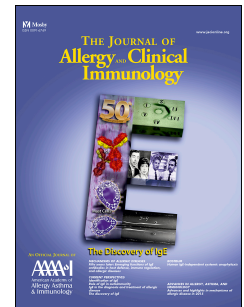


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Building Bridges for Asthma Care: Reducing School Absence for Inner City Children with Health Disparities

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Abstract

Background: Children with asthma are at increased risk for experiencing health and educational disparities because of increased school absence. School nurses are well-positioned to support asthma management and improve school attendance.

Objective: To implement and assess the effect of the Building Bridges for Asthma Care Program on improving school attendance and measures of asthma control.

Methods: Children with asthma, ages 5 through 14 years, in the Denver Public School System (n=240) and the Hartford Public School System (n=223) were enrolled in the Building Bridges Program during the 2013-2014 and the 2014-2015 school years and followed until the end of the second school year. The primary outcome was school absence with secondary outcomes including asthma control measured by the Childhood Asthma Control Test (cACT) or the Asthma Control Test (ACT), and rescue inhaler use.

Results: Participants experienced a 22% absolute decrease in school absenteeism; the number of children with an ACT/cACT score below the control threshold of 20 decreased from 42.7% to 28.8% and bronchodilator use >2 times per week declined from 35.8% to 22.9% (all changes were significant, $p<.01$).

Conclusions: Children enrolled in the Building Bridges for Asthma Care Program experienced reduced school absence and improved asthma control.

Clinical Implications: A systematic, school-centered asthma program implemented in a partnership among school nurses, families, and primary care clinicians can significantly reduce asthma morbidity and improve asthma control.

Clinical Summary: Implementation of the Building Bridges for Asthma Care Program for students with at-risk asthma resulted in reduced school absence, improved asthma control and a decreased need for rescue medication.

Key words: African American, asthma, case management, care coordination, children, disease management, Hispanic, partnerships, school

Abbreviations:

ACT – Asthma Control Test

BB - Building Bridges for Asthma Care

DPS – Denver Public Schools

cACT – Childhood Asthma Control Test

ED – Emergency Department

FERPA – Family Educational Rights and Privacy Act

HCP – Health care practitioner

HIPAA - Health Insurance Portability and Accountability Act

HPS – Hartford Public Schools

MCID – Minimal clinically important difference

SABA – Short acting β -agonist

Introduction

More than 5 million school-aged children in the United States have a current diagnosis of asthma [1]. Asthma is the leading cause of disease-related school absenteeism and children with asthma miss 13.8 million days of school each year [2]. Socioeconomically disadvantaged children and minority children are disproportionately affected by asthma and, in addition, have higher rates of school absenteeism [3-5]. Poorly controlled asthma disrupts sleep and can negatively affect a child's ability to learn and perform at school [6, 7]. Children with asthma may be placed at greater academic disadvantage as a result of their asthma-related absences [8-10] and loss of educational hours.

Schools are favorable environments to address the burden of asthma. Children spend a large proportion of their day at school and may interact with the school nurse more frequently than any other health care provider [11]. Although school nurses are thus well-positioned to take a lead in supporting asthma population health management [12], they are challenged by limited available time and resources to support management of students with chronic diseases. Multiple studies have examined the utility of the school setting for screening and asthma case finding [13, 14], asthma education and management [15, 16] and directly observed administration of daily preventive asthma medications by school nurses [17] with mixed results.

The Building Bridges for Asthma Care Program was developed to serve as a school-centered asthma program that could be a model for other school systems [18]. It

represents a novel combination of two existing asthma programs, one with an asthma counselor oriented school-centered asthma program, the Colorado Step-Up Asthma Program [19], and the other a primary care provider oriented program, Easy Breathing[®] in Hartford, Connecticut [20]. The Building Bridges Program provides the background, tools and support for school nurses to identify students with at-risk asthma, indicated by poor asthma control, high asthma morbidity and frequent school absenteeism, to intervene with targeted case management, tailored care coordination, and to serve as a communication bridge between students, families and clinicians. We hypothesized that such a program would be capable of reducing school absenteeism and improving asthma control. It is the first step to determine the feasibility, acceptability, and initial efficacy in a school nurse intervention in two different school systems.

Methods

Program Description

The goals of the Building Bridges program are to 1) identify students with asthma; 2) assess asthma risk/control; 3) enroll students at-risk for adverse asthma outcomes and their families in the Building Bridges program; 4) provide case management and care coordination; and 5) prepare students and their families for improved asthma management in the coming school years.

Identifying students for the Building Bridges project was a 2-stage process. The first step, screening, was typically conducted at the beginning of the school year with school nurses or their designee identifying students with asthma using district health forms in Denver Public Schools (DPS) or the Connecticut Health Assessment record and medication authorization forms in Hartford Public Schools (HPS). Using this information, students with asthma were

assessed for their risk for adverse asthma outcomes, including asthma-related school absenteeism (Asthma Intake Form).

Students with asthma at risk for adverse outcomes were subsequently invited to enroll in the program and provided detailed information regarding the student's asthma. School-aged children, pre-K through grade 8, ages 5 to 14 years at enrolment, were defined as "at risk for adverse asthma outcomes" and eligible for the Building Bridges Program if they met any of the following risk criteria from the Asthma Intake Form: >2 urgent care/ED visits for asthma in the last 12 months, hospitalization for asthma in the last 12 months, >2 courses of prednisone or systemic corticosteroids for asthma in the last 12 months, > 5 missed school days due to asthma in the last school year OR had current uncontrolled asthma as indicated by one or more of the following: daytime symptoms >2 days per week, night time awakenings >2 times per month, quick-relief inhaler used >2 times per week, limiting activity level due to asthma "often" or "all of the time". All information was self-reported. At risk children with asthma were targeted for case management and care coordination and comprised the study population.

Parents of children at-risk were contacted by study staff members; the goals of the Building Bridges program were explained and informed consent (and assent for students 7 years and older), and Health Insurance Portability and Accountability Act (HIPPA) and Family Educational Rights and Privacy Act (FERPA) permissions were obtained. A structured interview (15-30 minutes) was conducted by study staff (Getting to Know You [21, 22]) and identified learning needs and barriers. This information was then used by the school nurse or a member of the Building Bridges staff to plan case management activities which consisted of asthma education, both general and tailored to asthma, medication use, inhaler technique coaching, and care coordination.

On-going assessment activities occurred throughout the school year and included three face-to-face visits with the child at school to assess asthma control, inhaler technique and provide asthma education and two additional visits with the parent(s)/guardian(s) to provide general and asthma-tailored education. Asthma control was assessed using the Childhood Asthma Control Test (cACT) for children 5-11 years and the Asthma Control Test (ACT, Quality Metric Inc.) for those ≥ 12 years [23, 24]. Educational activities with students and parents included short summaries on the management of asthma triggers, medications, asthma control, and working with health providers. The Inhaler Technique Assessment Tool was used to standardize the assessment of inhaler technique by school nurses [21, 22, 25].

Care coordination activities were tailored to the students' needs and included securing a health care provider and obtaining health insurance if the child did not have these, identification of barriers and facilitators to asthma management, and closing of gaps. School nurses also confirmed that participating students had a reliever inhaler at school, were actively participating in physical education, and monitored absenteeism. Copies of School Asthma Care Plans and Home Asthma Action/Treatment Plans were requested from health care practitioners (HCPs), entered into the school electronic systems and recorded in the Building Bridges program portal.

The final component of care coordination included communication with the child's health care provider and consisted of letters that were sent to the child's health care provider(s) and the family three times (beginning, mid and end) during the school year. These letters used a standardized template individualized to provide information about the student's asthma control, school absenteeism, self-reported use of prescribed medications, and the availability of a school asthma care plan and rescue inhaler in school. Letters, if needed, also included a

request for the HCP to contact the family to schedule an appointment, complete and submit a school asthma care plan and/or provide an additional reliever inhaler for the school. A copy of the letters was also provided to the parent.

During the school year, care coordination continued with reassessment of the child's asthma control at mid-year and at the end of the year using the cACT/ACT as well as reinforcement of the care coordination plan. Inhaler technique coaching and asthma education were on-going and detailed in a follow-up letter to the primary care clinician. Absenteeism was tracked throughout the school year.

At the end of the school year, a Back to School Asthma Packet was sent to families of Building Bridges. This packet included a blank school asthma care plan for completion by HCPs and a Back to School with Asthma Checklist. The Checklist was to be completed over the summer and included: making an appointment with the HCP, requesting a reliever inhaler for school use, and completing the necessary school forms.

Program Implementation

In year 1, the feasibility of the program was assessed in five elementary schools in Denver, CO and three elementary schools in Hartford, CT. In year 2, the program was implemented in a total of 20 additional elementary schools (18 in Denver and 10 in Hartford). The target of this school-based intervention is asthma morbidity, but with the ultimate goal of showing a reduction in school absences. Therefore, the primary outcome was defined as the percent of school days absent for children enrolled in the program as compared to non-Building Bridges controls. Secondary outcomes included frequency of short-acting β agonist use >2 times/week, and changes in ACT/cACT scores.

Statistical Analysis

Data sources: History of asthma diagnosis, severity, symptoms and medical services utilization were obtained from parent self-report. School absenteeism data were obtained from the respective schools' electronic data capture system (*Infinite Campus* for Denver schools and *Power School* for Hartford schools).

Analysis techniques: Comparisons between Building Bridges and non-Building Bridges students were performed with a chi-square test for categorical outcomes and a t-test for continuous outcomes. The percent absent measure reported in the figures was calculated for each student as the number of school days missed divided by the number of days enrolled within a school year. Students who were enrolled in school for less than twenty-five days inclusively were removed prior to the analysis since it was assumed that they no longer attended that school.

The primary outcome for the Building Bridges Program was student school days absent and reported as a percentage of the number of days enrolled. Absence rates were estimated using an over-dispersed Poisson model and reported as percents. The number of days missed was the dependent variable and a group variable (Building Bridges vs. non-Building Bridges students) as the independent variable with the log-transformed number of days enrolled at school as the offset variable. The back-transformed least squares mean estimates from the model are reported as percent absent and the relative ratio, the percent absent in the Building Bridges group relative to the percent absent in the non-Building Bridges control group, and 95% confidence intervals are estimated using the same model.

The analysis of school absenteeism was conducted for both the 2013-14 (Year 1) and 2014-15 school years. Therefore, some children (n=73) were enrolled in the Building Bridges Program for two consecutive years, but only data from their first year of enrollment were included in the analysis of absenteeism.

School absence data are especially challenging to analyze, given that they vary dramatically by age/grade, race/ethnicity and asthma status (see Figure 1). To make the most relevant comparison between the Building Bridges and non-Building Bridges groups, the Building Bridges students were compared to children with asthma who were not enrolled in the program, but who met the same eligibility criteria based on the Asthma Intake Form. Furthermore, a matched case-control method was employed to pair each Building Bridges participant with a non-Building Bridges student on school, grade, sex, ethnicity, program eligibility, asthma severity and program year. Asthma severity was based on information from the Asthma Intake Form regarding symptoms and exacerbations. The CRAN statistical package MatchIT was used to statistically match each case with a control using the nearest-neighbor matching method with the distance measure being estimated using logistic regression [26]. SAS version 9.4 software (SAS Institute, Inc., Cary, NC) and R were used for all statistical analyses [27].

Results

The Student Population. The demographic characteristics of the Building Bridges students from the 28 schools in the Denver and Hartford School Districts where the Building Bridges Program was implemented compared to the remaining school student populations based upon the initial screening data are provided in **Table 1**. This table compares the Building Bridges students to the remaining school student population based upon the initial screening data. Consistent with asthma prevalence in the general population, the Building Bridges students with asthma are more likely to be male and younger, as reflected by their grade in school. The Building Bridges program population has proportionally larger numbers of minority children, with Hartford having more Puerto Rican Hispanic students in the program and Denver having more Mexican Hispanic children. A total of 2,178 students with asthma were identified in the two schools using health forms (14%). Of these students, 1390 (64%) returned an Asthma Intake Form and 781 were determined to be at-risk for adverse asthma outcomes. Of at-risk students, 463 (59.3%) were enrolled (292 declined to participate and 26 were lost to follow up).

Asthma morbidity, healthcare access and environmental exposures. **Table 2** provides a comparison of the Building Bridges students at Denver and Hartford schools. It should be noted that the Hartford population experiences greater asthma morbidity and environmental exposures than the Denver Building Bridges population which is characteristic of New England areas as compared to the West.

Most participants reported having a primary care physician at the beginning and at the end of the program. Approximately 85% were insured by Medicaid and 1% were without insurance of any type. Nearly all (95%) indicated they were receiving asthma medication at the time of enrollment. In response to questions about identifying potential asthma triggers, 24% reported tobacco smoke, and 41% reported pets; approximately 2% of participants in Denver and 17% of participants in Hartford reported cockroach and/or rodent exposure, with 3% in Denver and in Hartford noting exposure to a wood burning stove or fireplace. Participants in Building Bridges received a total of approximately 60 minutes of asthma education, improved their inhaler technique scores from 2.9 (0.11) to 3.9 (0.11) ($p<.01$) and completed three ACTs during the school year.

School absence. Utilizing school absences as an outcome measure presents some statistical challenges. School absences are more common among those with asthma, but also strongly related to age and grade (Figure 1) (as well as race/ethnicity – data not shown). The mean percent absence for all students at the Denver and Hartford Public schools for the 2012-2013, 2013-2014 and 2014-2015 school years combined show the same general pattern for those with and without asthma: students tend to have higher percent absences in the earlier and later grades (**Figure 1**). Students with asthma also showed a higher percent absence as compared to students without asthma. To account for the inherent differences in absenteeism between grade levels and asthma status, as well as the baseline differences in asthma morbidity levels between Denver and Hartford, a case-control analysis was utilized to match Building

Bridges participants to controls (i.e., children with asthma who were eligible but not enrolled in Building Bridges) based on school, grade, sex, ethnicity, program eligibility, asthma severity and program year (Figure E1). **Table 3** presents the demographic and baseline asthma morbidity characteristics of the Building Bridges students and the matched analytic comparison group. We were unable to find a comparable match for 12 students from the Denver Building Bridges group and 69 students from Hartford, resulting in a matched sample size of 228 at Denver and 154 at Hartford. The students who were matched were comparable to those who did not match, except for a few differences within the school system and between school systems as noted in Table E1.

Figure 2 shows the estimated percent absence among children enrolled in the Building Bridges Program (9.3%) compared to the non-Building Bridges control group (11.8%, $p < 0.001$). Both Denver and Hartford showed a significant decrease, 24% and 19% respectively, in percent absence when stratifying the analysis by school district. The typical school year consists of 170 to 185 days and this decrease in absences results in approximately 5½ additional days of school attendance per student. All absenteeism estimates were adjusted to the actual number of school days a child was enrolled.

Clinical outcomes. Changes in asthma clinical outcomes from enrollment to follow-up for the Building Bridges students are shown in **Table 4**. Significant reductions were observed in the proportion of students in the Building Bridges cohort requiring short-acting β -agonists more than two times per week. There were consistent improvements in Asthma Control Test (ACT) control cut-point score of 20 and above,

455 including 37.4% that demonstrated improvements above the minimal clinically important
456 difference (MCID) of 3 [28].

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Discussion

The Building Bridges for Asthma Care Program was designed to serve as a model program for school systems to support asthma care for children with asthma not well controlled. This program confirms the important role that school nurses can play in coordinating asthma care with children, their parents/guardians and clinicians. The program led to significant improvements in asthma control and a 22% reduction in school absence. This reduction in school absence was accompanied by a reduction in the proportion of children requiring short-acting β -agonists more than 2 times per week and improved asthma control test scores.

Since the number of school days varies across schools and school systems, we assessed school absence based on the percent of school days missed. This can be translated back to number of days missed with a high degree of accuracy. Most schools do not record the actual reason for a school absence and therefore, we were unable to study absences specifically for asthma. We carefully matched students with similar levels of asthma morbidity and baseline demographics to assess school absenteeism between those who did and did not enroll in the program.

The benefits of identifying children at risk who had an exacerbation in the prior year or who missed a significant amount of school in the prior year are multiple. First, these children could be selected for careful observation in a program such as Building Bridges. Second, preventive measures such as assurance of regular medical follow-up, adherence to the home management plan, and close observation for symptoms during the coming school year could be applied. Third, a pattern of school absence reflective of poor asthma control could be identified in real time and a plan to re-assess

the child's asthma management could be recommended before additional educational hours are lost. Fourth, asthma has a seasonal pattern and preventive measures could be used to step-up treatment prior to a season associated with a high frequency of exacerbations, such as the fall season [29-33]. Prior assessments of academic performance related to school attendance estimate that 10%, or approximately 15 days, of school absence affect school performance [34]. Only 31.9% of the Building Bridges students were absent more than 10% of their school days, while 45.5% of the matched non-Building Bridges students were absent more than 10% of their school days. In a study of children with hemophilia, preventive care resulting in decreased school absences led to improvements in both academic achievement and even IQ [34]. Early recognition of poor asthma control could lead to identification of children with poor adherence to asthma medications, or poor medication inhalation technique despite appropriate therapy and adherence. This would prompt an assessment for environmental control, a step-up in the asthma therapy/treatment or other considerations of family support that would address social determinants of health [35]. While the program components responsible for the decrease in school absenteeism are not known, the additional asthma education, the awareness of how to assess their asthma control and respond to a loss of control and technical improvements in use of their asthma medication may be contributing factors.

The Building Bridges Program is consistent with new initiatives to support school nurses in managing chronic diseases [12, 36]. The Building Bridges Program served to focus the limited school resources available rather than requiring significant increases in

the time needed to manage asthma. It requires training a school team composed of a school nurse and possibly a health care assistant to implement the program as well as an organizational plan to initiate and continue the program. Expansion of these programs to a national level could serve to assist more children with asthma and further support school systems with limited resources. The American Academy of Allergy, Asthma and Immunology in collaboration with the National Association of School Nurses developed the School-Based Asthma Management Program to assist schools in accessing these resources [12]. However, individual schools will need to determine their own level of commitment and readiness to apply these resources appropriately.

Several strengths were identified with the implementation of the Building Bridges Program. It was equally successful in two different school systems with different population demographics and a marked difference in the level of support for school nurses (Figure 2); in Hartford a full-time school nurse is present every day while in Denver the school nurse is present only a few days per week with the support of a health care assistant who is present every day at each school. In Denver, non-professional staff, such as health technicians or Unlicensed Assistive Personnel, were trained to assist nurses. In addition, both school systems learned to use technology to help with record keeping. The two school systems learned techniques from each other in enhancing school-based computer systems for record keeping and developing portals and dashboards.

We recognize several limitations. Our control group consisted of a population of children with asthma, defined after the initiation of the study of equal severity and

comparable demographics (school grade, ethnicity, etc.) who did not participate in the program. There are several inherent methodological challenges associated with this non-randomized design including selection bias that could lead to over-estimation of effect sizes. We do not know if the control group of non-participant families was less engaged than the intervention participants or if their ACT/cACT scores changed over time. We also did not collect detailed information on psychosocial or familial factors that might have influenced school attendance by both the control and intervention students.

There were many successes noted during the development, implementation and analysis of this program. The Building Bridges Program has continued in both the Denver Public School System and the Hartford Public School System with some modification and is now being used in additional school districts both in Colorado and Connecticut. School nurses and assistants spent on average 100-126 minutes per week systematically identifying children with asthma at risk for adverse outcomes and program implementation. While Building Bridges added some time to the efforts of school nurses and assistants, this added time may have offset some of the time spent in acute asthma management; the net effect on time was not, however, measured. There are significant benefits of an organized program in identifying, assessing, monitoring and supporting children who might not have access to regularly scheduled medical care. Although nearly 100% of the children in this population had health insurance (typically, Medicaid), barriers to accessing health care are many and significant [37]. This program offers a unique approach to reducing and/or circumventing barriers to asthma care. However, a formal cost analysis for program implementation would be needed to determine feasibility of the program implementation in specific school

systems. School engagement and readiness is a critical feature in introducing the program [38]. There is a critical need to facilitate communication among children, families, schools and clinicians that assure confidentiality but support integrated care [39]. There may be a requirement for additional layers of support for schools with high needs, such as that provided by community health workers, patient navigators, or asthma counselors, as indicated in the Step-Up Asthma Program [19], as well as new technology, such as telemedicine [40]. Professional societies of asthma specialists, primary care physicians, and school nurses should work to collaborate on these efforts and break down the existing silos that have created gaps in communication [41].

In summary, the Building Bridges for Asthma Care Program was developed to serve as a model for a collaborative effort among schools, health care clinicians, and families to support children with asthma who suffer health disparities. Clinical outcomes were notably improved and thus this program demonstrated an immediate impact that could be extended to other school systems. It provided a model of support but also pointed to general areas that must be improved to support children with health disparities as well as children who have access to care but whose asthma is not well managed.

Given that asthma is the number one respiratory disease-related reason for school absences among children, reducing asthma morbidity and the resultant school absences should have a positive impact on the children and their families as well as a reduction in demands on school nurse resources and an improvement in academic performance for these children.

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Legends for figures

Figure 1. Percent of school days absent within a school year by grade for the Denver (a) and Hartford (b) school systems. The figures depict the % school days absent in those with asthma (red) and those without asthma (blue).

Figure 2. Percent of school days absent during the school year following enrollment in the Building Bridges (BB) Program. The bar graph compares the percent of school days absent for the Building Bridges participants and the matched non-Building Bridges (non-BB) asthma controls at Denver and Hartford as well as the combination of the two school systems. The ratio of the percent school absences of the Building Bridges participants relative to the non-Building Bridges controls and the 95% confidence intervals are presented above the set of bars for each of the school systems separately and combined. A rate ratio of less than 1 represents a decrease in absenteeism in the Building Bridges participants compared to controls. The graph depicts a consistent decrease in the percent of school days absent for the Building Bridges participants at the Denver (24%) and Hartford (19%) school systems as well as the combined school systems (22%). All rate ratios are statistically significant.

Table 1: Comparison of Screening Data for Building Bridges and non-Building Bridges Students at Denver and Hartford

	Denver			Hartford			Total		
	Building Bridges N=240	Non- BB N=12,519	p-value	Building Bridges N=223	Non- BB N=7,805	p-value	Building Bridges N=463	Non-BB N=20,324	p-value
Gender (Male)	156 (65.0%)	6281 (50.2%)	<.01	117 (52.5%)	3950 (50.6%)	0.58	273 (59.0%)	10231 (50.3%)	<.01
Grade			<.01			<.01			<.01
Pre-K	15 (6.3%)	1362 (10.9%)		9 (4.0%)	656 (8.4%)		24 (5.2%)	2018 (9.9%)	
K	32 (13.3%)	1861 (14.9%)		27 (12.1%)	1244 (15.9%)		59 (12.7%)	3105 (15.3%)	
1	27 (11.3%)	1343 (10.7%)		43 (19.3%)	874 (11.2%)		70 (15.1%)	2217 (10.9%)	
2	34 (14.2%)	1261 (10.1%)		36 (16.1%)	881 (11.3%)		70 (15.1%)	2142 (10.5%)	
3	37 (15.4%)	1291 (10.3%)		27 (12.1%)	835 (10.7%)		64 (13.8%)	2126 (10.5%)	
4	38 (15.8%)	1203 (9.6%)		31 (13.9%)	770 (9.9%)		69 (14.9%)	1973 (9.7%)	
5	21 (8.8%)	1064 (8.5%)		15 (6.7%)	794 (10.2%)		36 (7.8%)	1858 (9.1%)	
6	15 (6.3%)	1281 (10.2%)		16 (7.2%)	560 (7.2%)		31 (6.7%)	1841 (9.1%)	
7	11 (4.6%)	917 (7.3%)		10 (4.5%)	591 (7.6%)		21 (4.5%)	1508 (7.4%)	
8	10 (4.2%)	936 (7.5%)		9 (4.0%)	600 (7.7%)		19 (4.1%)	1536 (7.6%)	
Race/ Ethnicity			<.01			<.01			0.14
Hispanic/ Latino	163 (67.9%)	9528 (76.1%)		159 (71.3%)	4678 (59.9%)		322 (69.5%)	14206 (69.9%)	
Black/African American	45 (18.8%)	1330 (10.6%)		50 (22.4%)	2202 (28.2%)		95 (20.5%)	3532 (17.4%)	
White	16 (6.7%)	1009 (8.1%)		11 (4.9%)	604 (7.7%)		27 (5.8%)	1613 (7.9%)	
Other	16 (6.7%)	652 (5.2%)		3 (1.3%)	321 (4.1%)		19 (4.1%)	973 (4.8%)	
School Days Enrolled									
N	240	12519	0.05	223	7805	0.89	463	20324	<.01
Mean (SD)	168.5 (19.7)	159.6 (34.6)		178.5 (21.4)	165.6 (41.9)		173.3 (21.1)	161.9 (37.7)	
Range	(49-191)	(26-194)		(62-191)	(26-200)		(49-191)	(26-200)	
School Days Absent									
N	240	12519	<.01	223	7805	<.01	463	20324	<.01
Mean (SD)	15.8 (14.2)	14.7 (15.9)		18.3 (15.5)	13.9 (13.7)		17.0 (14.9)	14.4 (15.1)	
Range	(1-94)	(0-145)		(0-114)	(0-177)		(0-114)	(0-177)	
Asthma (Yes)	240 (100%)	780 (6.2%)		223 (100.0%)	1393 (17.8%)		463 (100.0%)	2173 (10.7%)	
Eligible (Yes)	240 (100%)	269 (2.1%)		223 (100.0%)	180 (2.3%)		463 (100.0%)	449 (2.2%)	

Comparisons are performed using the Chi-Square test and Kruskal Wallis test for discrete and continuous variables, respectively

Table 2: Comparison of Denver and Hartford Building Bridges Children at Screening

	Denver N=228	Hartford N=154	Total N=382	
Asthma Morbidity	n (%)	n (%)	n (%)	p-value
ER/Urgent Care Visit (2 or More Times Last 12 Months)	86 (37.7)	87 (56.5)	173 (45.3)	<.01
Hospitalized (1 or More Times Last 12 Months)	50 (21.9)	29 (18.8)	79 (20.7)	0.48
Oral Steroid Use (2 or More Uses Last 12 Months)	96 (42.1)	88 (57.1)	184 (48.2)	<.01
Rescue Medication Usage (3 or More Days/Week Past 4 Weeks)	90 (39.5)	68 (44.2)	158 (41.4)	0.36
Daytime Disruption (3 or More Days/Week Past 4 Weeks)	54 (23.7)	59 (38.3)	113 (29.6)	<.01
Nighttime Disruption (3 or More Times/Month Past 4 Weeks)	50 (21.9)	53 (34.4)	103 (27.0)	<.01
Activity Disruption (Often or All of the Time Past 4 Weeks)	43 (18.9)	31 (20.1)	74 (19.4)	0.73
Healthcare Access				
Healthcare Provider for Asthma	218 (95.6)	152 (98.7)	370 (96.9)	0.24
Medicaid Health Insurance	184 (80.7)	142 (92.2)	326 (85.3)	<.01
Asthma Medications at Enrollment	214 (93.9)	150 (97.4)	364 (95.3)	0.36
Environmental Exposures				
Child Exposed to Smoke	54 (23.7)	38 (24.7)	92 (24.1)	0.92
Child Exposed to Pets	108 (47.4)	50 (32.5)	158 (41.4)	<.01
Child Exposed to Cockroaches	4 (1.8)	24 (15.6)	28 (7.3)	<.01
Child Exposed to Rodents	5 (2.2)	27 (17.5)	32 (8.4)	<.01
Child Exposed to Fireplace/Wood _ Burning Stove	7 (3.1)	5 (3.2)	12 (3.1)	0.95

Table 3: Screening Data Comparison of Denver and Hartford Building Bridges Students with non-Building Bridges Students Matched on Age, Grade, Race/Ethnicity, and Asthma Severity

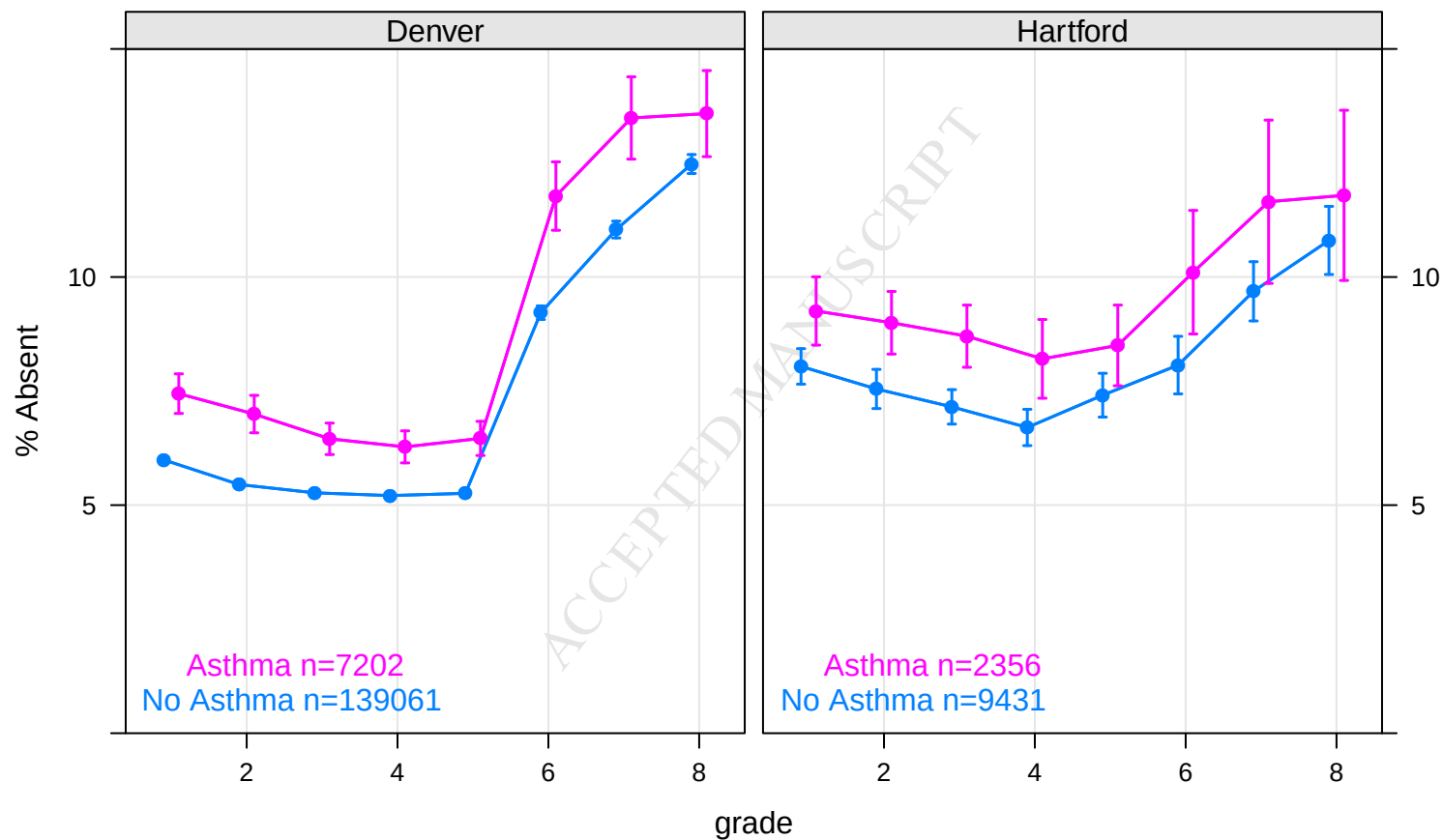
	Denver			Hartford			Total		
	Building Bridges N=228	Matched Non- BB N=228	p-value	Building Bridges N=154	Matched Non-BB N=154	p-value	Building Bridges N=382	Matched Non-BB N=382	p-value
Gender (Male)	146 (64.0%)	135 (59.2%)	0.29	90 (58.4%)	88 (57.1%)	0.82	236 (61.8%)	223 (58.4%)	0.34
Grade			0.72			0.26			0.39
Pre-K	15 (6.6%)	15 (6.6%)		8 (5.2%)	8 (5.2%)		23 (6.0%)	23 (6.0%)	
K	30 (13.2%)	28 (12.3%)		16 (10.4%)	19 (12.3%)		46 (12.0%)	47 (12.3%)	
1	26 (11.4%)	30 (13.2%)		33 (21.4%)	25 (16.2%)		59 (15.4%)	55 (14.4%)	
2	31 (13.6%)	24 (10.5%)		29 (18.8%)	23 (14.9%)		60 (15.7%)	47 (12.3%)	
3	35 (15.4%)	32 (14.0%)		17 (11.0%)	22 (14.3%)		52 (13.6%)	54 (14.1%)	
4	34 (14.9%)	25 (11.0%)		20 (13.0%)	19 (12.3%)		54 (14.1%)	44 (11.5%)	
5	21 (9.2%)	25 (11.0%)		11 (7.1%)	19 (12.3%)		32 (8.4%)	44 (11.5%)	
6	15 (6.6%)	22 (9.6%)		9 (5.8%)	6 (3.9%)		24 (6.3%)	28 (7.3%)	
7	11 (4.8%)	18 (7.9%)		7 (4.5%)	13 (8.4%)		18 (4.7%)	31 (8.1%)	
8	10 (4.4%)	9 (3.9%)		4 (2.6%)	0 (0.0%)		14 (3.7%)	9 (2.4%)	
Race/ Ethnicity			0.87			0.17			0.53
Hispanic/ Latino	156 (68.4%)	150 (65.8%)		107 (69.5%)	107 (69.5%)		263 (68.8%)	257 (67.3%)	
Black/ African American	41 (18.0%)	48 (21.1%)		38 (24.7%)	43 (27.9%)		79 (20.7%)	91 (23.8%)	
White	16 (7.0%)	15 (6.6%)		7 (4.5%)	1 (0.6%)		23 (6.0%)	16 (4.2%)	
Other	15 (6.6%)	15 (6.6%)		2 (1.3%)	3 (1.9%)		17 (4.5%)	18 (4.7%)	
ER/Urgent Care Visit (Yes)	86 (37.7%)	83 (36.4%)	0.77	87 (56.5%)	70 (45.5%)	0.05	173 (45.3%)	153 (40.1%)	0.14
Hospitalized (Yes)	50 (21.9%)	44 (19.3%)	0.49	29 (18.8%)	22 (14.3%)	0.28	79 (20.7%)	66 (17.3%)	0.23
Steroid Usage (Yes)	96 (42.1%)	99 (43.4%)	0.78	90 (58.4%)	80 (51.9%)	0.25	186 (48.7%)	179 (46.9%)	0.61
Rescue Med. Usage (Yes)	90 (39.5%)	69 (30.3%)	0.04	68 (44.2%)	61 (39.6%)	0.42	158 (41.4%)	130 (34.0%)	0.04
Daytime Disruption (Yes)	54 (23.7%)	49 (21.5%)	0.58	59 (38.3%)	44 (28.6%)	0.07	113 (29.6%)	93 (24.3%)	0.10
Nighttime Disruption (Yes)	50 (21.9%)	46 (20.2%)	0.65	53 (34.4%)	40 (26.0%)	0.11	103 (27.0%)	86 (22.5%)	0.15
Activity Disruption (Yes)	43 (18.9%)	40 (17.5%)	0.72	31 (20.1%)	29 (18.8%)	0.77	74 (19.4%)	69 (18.1%)	0.64

Comparisons are performed using the Chi-Square test and Kruskal Wallis test for discrete and continuous variables, respectively

Table 4: Change from Enrollment to Follow-up in Clinical Outcomes for Building Bridges Students

	Denver N=228		Hartford N=154		Total N=382		
	Enrollment	Follow-Up	Enrollment	Follow-Up	Enrollment	Follow-Up	p-value
Outcome							
SABA Use >2 Times/Week [% (n/N)]	31.5 (57/181)	19.3 (33/171)	43.9 (43/98)	29.7 (27/91)	35.8 (100/279)	22.9 (60/262)	<.01
ACT/cACT Score [Mean (S.E.)]	19.8 (0.3)	21.0 (0.3)	19.2 (0.4)	21.4 (0.4)	19.5 (0.2)	21.1 (0.2)	<.01
Asthma Control Test <=19 [% (n/N)]	37.9 (83/219)	28.1 (50/178)	49.7 (75/151)	29.9 (40/134)	42.7 (158/370)	28.8 (90/312)	<.01
ACT/cACT MCID>=3 at Follow-Up [% (n/N)]		34.3 (61/178)		41.7 (55/132)		37.4 (116/310)	

A generalized mixed model was performed to estimate the mean and standard error (SE) for continuous data. A binomial mixed model was used for binary data.



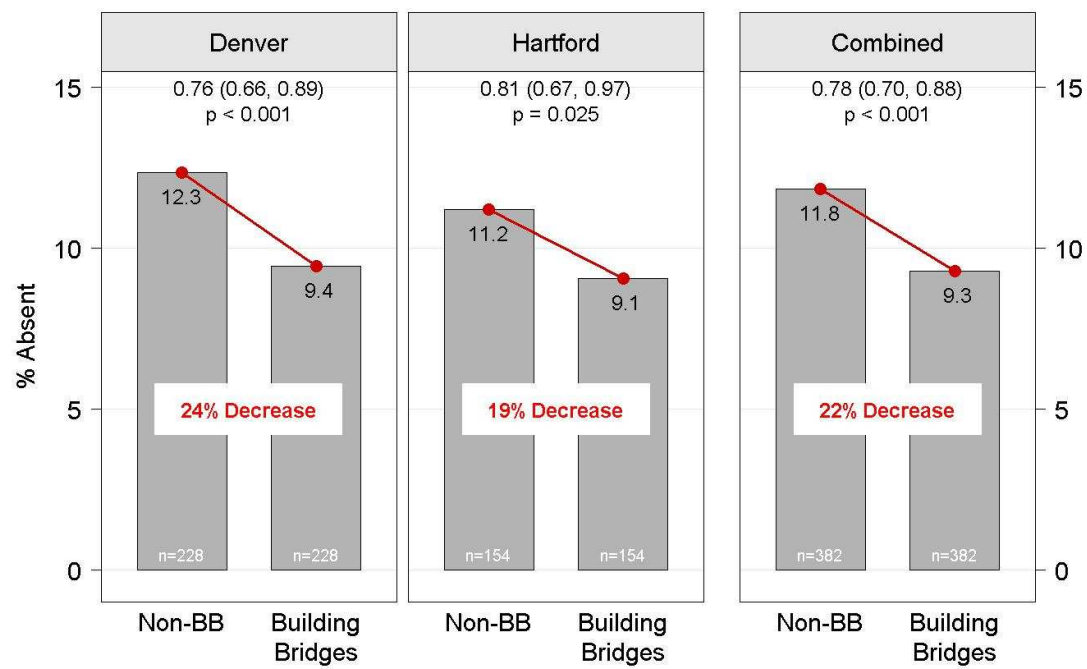


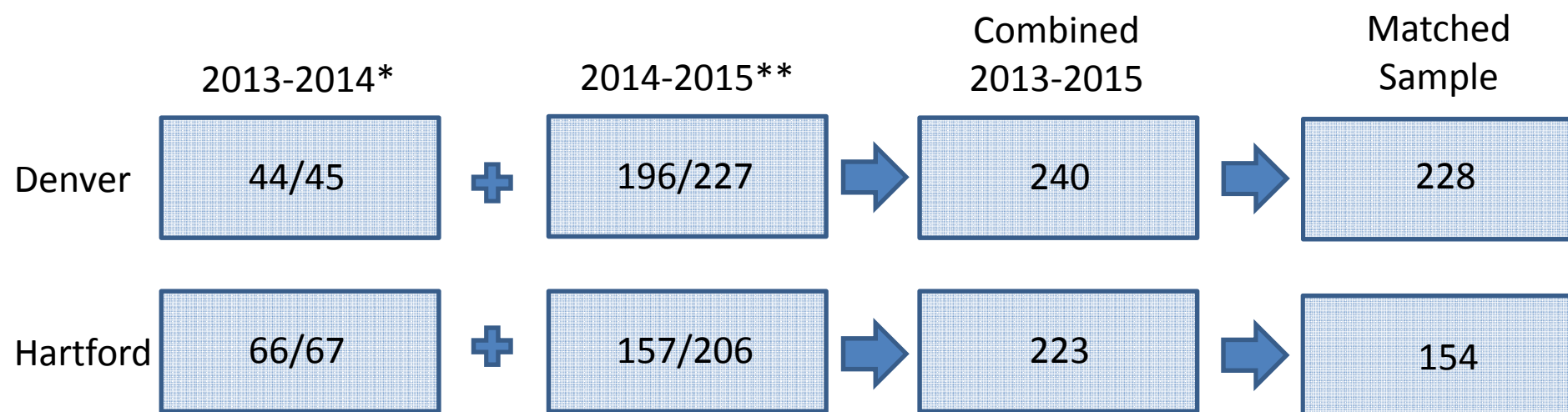
**Table E1: Demographics and Baseline Asthma Morbidity of the Denver and Hartford School Children
Statistical Matches vs Non-Matches**

	Denver		p-value	Hartford		p-value
	Matches N=228	Non-Matches N=12		Matches N=154	Non-Matches N=69	
Gender (Male)	146 (64.0%)	10 (83.3%)	0.1720	90 (58.4%)	27 (39.1%)	0.0100
Grade			0.5860			0.2800
PK	15 (6.6%)	0 (0.0%)		8 (5.2%)	1 (1.4%)	
K	30 (13.2%)	2 (16.7%)		16 (10.4%)	11 (15.9%)	
1	26 (11.4%)	1 (8.3%)		33 (21.4%)	10 (14.5%)	
2	31 (13.6%)	3 (25.0%)		29 (18.8%)	7 (10.1%)	
3	35 (15.4%)	2 (16.7%)		17 (11.0%)	10 (14.5%)	
4	34 (14.9%)	4 (33.3%)		20 (13.0%)	11 (15.9%)	
5	21 (9.2%)	0 (0.0%)		11 (7.1%)	4 (5.8%)	
6	15 (6.6%)	0 (0.0%)		9 (5.8%)	7 (10.1%)	
7	11 (4.8%)	0 (0.0%)		7 (4.5%)	3 (4.3%)	
8	10 (4.4%)	0 (0.0%)		4 (2.6%)	5 (7.2%)	
Race/Ethnicity			0.4760			0.6800
Hispanic/Latino	156 (68.4%)	7 (58.3%)		107 (69.5%)	52 (75.4%)	
Black/African American	41 (18.0%)	4 (33.3%)		38 (24.7%)	12 (17.4%)	
White	16 (7.0%)	0 (0.0%)		7 (4.5%)	4 (5.8%)	
Other	15 (6.6%)	1 (8.3%)		2 (1.3%)	1 (1.4%)	
ER/Urgent Care Visit (Yes)	86 (37.7%)	6 (50.0%)	0.3940	87 (56.5%)	45 (65.2%)	0.2200
Hospitalized (Yes)	50 (21.9%)	2 (16.7%)	0.6660	29 (19.0%)	18 (26.1%)	0.2300
Steroid Usage (Yes)	96 (42.1%)	9 (75.0%)	0.0250	88 (57.9%)	35 (53.0%)	0.5100
Rescue Med. Usage (Yes)	90 (39.5%)	4 (33.3%)	0.6710	68 (44.2%)	38 (55.9%)	0.1100
Daytime Disruption (Yes)	54 (23.7%)	0 (0.0%)	0.0550	59 (38.6%)	35 (51.5%)	0.0700
Nighttime Disruption (Yes)	50 (21.9%)	2 (16.7%)	0.6660	53 (34.6%)	40 (58.8%)	<.0001
Activity Disruption (Yes)	43 (18.9%)	1 (8.3%)	0.3580	31 (20.3%)	29 (43.3%)	<.0001

Comparisons are done using the Fisher's Exact, Chi-Square test and Kruskal Wallis test for discrete and continuous variables, respectively

Number of students enrolled by school year		
	Denver	Hartford
2013-2014	45	67
2014-2015	227	206

Flow of students from enrollment to matched analysis:



*Numerator represents students with analyzable, non-missing data.

**Students' data who were enrolled in both school years have been removed from the 2014-2015 school year.

1 **Figure E1.** Summary diagram of the number of students enrolled over the first two years
2 and then subsequent selection for the matching program based on school, grade, sex,
3 ethnicity, program eligibility, asthma severity and program year.

4