Using Complex, Multi-Sectoral Data in a Needs Assessment to Inform Future Strategies in Childhood Asthma Management

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Abstract

The purpose of this needs assessment was to study the current state of asthma management in high-risk children in Houston, Texas to inform a theory-based approach to improving asthma management. The mixed-method assessment included multi-sectoral survey, quantitative, and geospatial data that address a range of social and community factors in family, community, home, and medical contexts. Houston Emergency Medical Services (EMS) provided ambulance-treated asthma data mapped by geographic area to identify where childhood asthma management was weakest. Texas Children's Health Plan (TCHP) provided medication compliance rates and counts of children by zip code that TCHP considered high-risk according to claims data. Houston Independent School District (HISD) provided school nurse survey results from schools with high-rates of ambulance-treated asthma attacks regarding local barriers to asthma management. Elementary schools with children at highest risk were identified by overlaying the EMS data, TCHP data, and HISD school zone boundaries. Survey results from the high-rate schools indicate the priority challenges to childhood asthma management, including lack of resources, lack of communication, lack of knowledge of triggers, and inadequate time for quality care from providers. By weaving together EMS, TCHP, and HISD data, the needs assessment informed a socio-ecological view of gaps in high-risk childhood asthma management and control, specifically where and what to target. An assessment approach with multi-sectoral data, geospatial mapping, nurse input, current systems of care, education, and funding helped focus planning on a practical approach to asthma control solutions for high-risk children.

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Asthma in children is an important public health issue in the United States and within the city of Houston. An estimated 6.1 million children suffer from asthma nationwide, with approximately 13.8 million missed school days per year attributed to the disease for children between the ages of 5 and 17 years (Centers for Disease Control and Prevention [CDC], 2015, 2018).

In Houston, the fourth largest city in the nation, an estimated quarter of the city's 2.2 million families have children between 5 and 17 years of age (American Housing Survey [AHS], 2015; City of Houston, 2019). Over 90,000 families (14.2%) have children diagnosed with asthma, and over 21,0000 of these families (23.8%) have visited the emergency room in the past 12 months due to the child's asthma (AHS, 2015). Houston has multiple factors that impact the

risk of children suffering from asthma, including environmental factors (e.g., indoor and outdoor air pollutants), weather (e.g., extreme heat, humidity), and disproportionate poverty among African American and Hispanic populations (Clements et al., 2006; Marsha, Sain, Heaton, Monaghan, & Wilhelmi, 2018; Mayor's Task Force on the Health Effects of Air Pollution, 2006; Raun, Ensor, Campos, & Persse, 2015; Zhang, Chen, & Begley, 2015).

In this needs assessment, children at high risk of an asthma attack were identified by multiple factors, including medication compliance and use of ambulance treatment for an asthma attack. The population of children at high risk of an asthma attack in Houston is racially disproportionate, consisting of 73% African American and 20% Hispanic children (Raun et al., 2015). Sixteen percent of families in census tracts with the highest rates of children at high risk of an asthma attack earned less than $10,000 per year, and 30% had less than a high school degree (Raun et al., 2015). These findings for Houston coincide with national-level statistics that show high-risk asthma is linked with race, poverty, and levels of education (CDC, 2011; Forno & Celedón, 2012; Volerman, Chin, & Press, 2017).

Given the scope of the asthma problem, several Houston institutions made efforts to better understand and address the needs of the city's children at high risk of an asthma attack. Local efforts to address childhood asthma management were in place. However, there was no centered coordination following a collaborative cross-sector approach to leverage a more comprehensive method to identify and address home, community, and medical policies and practices that support high-risk children. In collaboration with Rice University and the City of Houston Health Department, three main players worked to maximize local-level cross-sector data to better assess needs of children at high risk of asthma attacks. These three players, the City of Houston Emergency Medical Services (EMS), Texas Children's Health Plan (TCHP), and Houston Independent School District (HISD), decided to share childhood asthma-related data to inform the development of a more coordinated and targeted strategy to promote asthma management and control in high-risk populations across Houston.

Prior to this work, data were not shared, and each institution approached management of children at high risk of an asthma attack separately. While all provided self-management education on trigger avoidance and proper use of medication, HISD was not aware of information the other two players had that would assist the school nurses in supporting the children. For example, knowing that medication compliance was an issue, or that a school was located in a high-rate region for ambulance-treated asthma attacks, would alert the nurse and the school district to focus on increased compliance to reduce asthma-related emergencies. This paper outlines the needs assessment methods and the use of cross-sector data from these three Houston players to inform the development of an appropriate multi-strategy approach to addressing children's asthma management.

Methods

The needs assessment was based on three sources of aggregated, de-identified data to assess where children are most in need of increased support in asthma management and the barriers to that management. The three individual datasets are described below, followed by the method used for integration. The Rice University Institutional Review Board approved all data collection procedures.

Emergency Medical Services (EMS)

The City of Houston EMS responds to close to 300,000 calls each year and has extensive response call data (Houston Fire Department, 2018). Previously published research examined Houston's EMS call database on ambulance-treated asthma attacks from 2004 to 2013 for children ages 5 to 18 located in HISD school zones (Raun et al., 2017). Data were aggregated by HISD school zones at elementary, middle, and high school levels. Schools with rates in the upper quartile of ambulance-treated asthma attacks were considered "high-rate." School zones that were in the lower three quartiles of ambulance-treated asthma attacks were defined as "other."

Statistics of demographics and HISD data for the high-rate and other zones were calculated. HISD data included nurse presence, percentage of economically disadvantaged students, and students at risk for dropping out of school. HISD defines "at risk" by several characteristics, including English language proficiency, state test scores, and failure to advance grade levels consistently (Raun et al., 2017).

Texas Children's Health Plan (TCHP)

TCHP is the largest Medicaid (STAR) and Children's Health Insurance Program (CHIP) provider in Houston, covering many students enrolled in HISD. TCHP's widespread coverage, with almost 350,000 children enrolled as members in Houston and surrounding areas, is representative of other insurers in Houston (Farber, Silveira, Vicere, Kothari, & Giardino, 2017). For the needs assessment, data were used from a TCHP analysis of de-identified 2014 Medicaid and 2015 CHIP children who had been diagnosed with asthma in Houston. Analysis of 2015 Medicaid data was not supplied to this needs assessment, but is thought to be consistent with 2015 Medicaid data. The analysis contained medication management statistics, survey question responses of asthma symptoms and effects on the child's activities, and the child's asthma risk rating. TCHP determined the asthma risk rating by several factors, including medication compliance, primary care provider visits, emergency room visits, and hospitalizations due to asthma. In this analysis, a child is considered compliant when their medication prescription is filled and used correctly 75% of the time (National Heart, Lung, and Blood Institute [NHLBI], 2012). Children with high TCHP asthma risk ratings were considered to be high-risk asthma members. TCHP provided aggregated medication compliance data and counts of high-risk members by zip code.

Houston Independent School District (HISD)

HISD is the largest school district in Texas and the seventh largest in the nation, consisting of 284 schools, including 159 elementary, 38 middle, and 38 high schools (HISD, 2018). Almost 75% of the 216,106 students enrolled were considered socioeconomically disadvantaged (HISD, 2018). This needs assessment aimed to use survey responses from school nurses serving elementary schools due to higher current asthma prevalence in children aged 5 to 9 years when compared to other children's age groups (CDC, 2013). Specifically, the survey consisted of responses from HISD elementary school nurses working in the high-rate school zones identified with the EMS data (zones with rates in the upper quartile of ambulance-treated asthma attacks) to prioritize the barriers to asthma management and control.

There were 41 elementary schools designated as high-rate, of which three had no school nurse and four had only part-time nurses. According to HISD nurse management, these nurses were predominantly African American and female (only one male nurse); all had at least a bachelor's degree in nursing (BSN); their experience levels varied from one year to over 25 years of working as a school nurse; and seven of these nurses had documented asthma training.

The survey questions, developed by HISD nurse management, explored barriers and gaps in four main care coordination areas of childhood asthma management: Family, Community, Home, and Medical. The Family area considered the child's family or guardians involved in their care. The Community area considered the child's school environment. The Home area considered the child's primary residence environment. The Medical area considered medical professionals involved in a child's asthma care, including primary care physicians and insurance providers. Four questions were then developed asking participants in the survey to rank identified barriers in each care coordination area, with no repetition of rankings (i.e., for each care coordination area, a '1' could not be assigned to more than one barrier listed). Each question had a free text box available so that the school nurse could provide additional details or barriers they perceived as contributing to poor childhood asthma management in the associated care coordination area.

The survey was sent to the high-rate elementary school nurses. The responses of those that consented to participate were recorded anonymously. Simple analysis of frequencies and percentages of the responses was performed to gain insight into the prioritization of these barriers and gaps. Free text boxes were individually combed through to pull out any additional gaps that could provide further insight.

Geospatial Mapping Process

The locations of children at high-risk of an asthma attack were spatially identified by overlaying data from the different sources using ESRI ArcGIS Desktop 10.3. First, the EMS high-rate zones were represented on the map using hatching. Next, the TCHP high-risk member counts were used to calculate zip code rates per 100,000 children. The zip code counts were divided by the zip code population of children 18 and under, according to the 2010 U.S. Census. The rates were mapped using the inverse distance weighting tool in ArcGIS (ArcGIS Desktop, 2019). The locations of the elementary schools that were in the fourth quartile of ambulance-treated asthma attack rates were represented on the map by black circle symbols. Schools located in both the high-rate EMS and the high-rate TCHP regions were considered to be locations to target interventions. This information, coupled with the barriers prioritized from the school nurse survey, provided the basis to inform future strategies in childhood asthma management.

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Results

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Emergency Medical Services (EMS)

Table 1 shows a breakdown of school-level characteristics of 1,826 ambulance-treated asthma attacks in Houston from 2004 to 2013 (Raun et al., 2017). This table shows selected statistics stratified by school type (elementary, middle, and high schools) and by school zone rate for ambulance-treated attacks (high-rate and other). The mean rate was 56.6 per 100,000 children for ambulance-treated asthma attacks across the high-rate schools in HISD. For other schools,

the mean rate was 17.3 per 100,000 children. This analysis showed that 85% to 100% of HISD schools (coded high-rate and other) had 50% or greater of the student population that is considered economically disadvantaged. On average, 90% of high-rate schools had more than 50% of the student population considered economically disadvantaged. Almost all high-rate schools were considered to have 50% or more of their student populations to be at-risk. Additionally, high-rate school zones were less likely to have a full-time school nurse on staff than other school zones.

Table 1

Comparing School Zone Characteristics Between High-rate Zones and Other Zones

	Elementary School Zones		Middle School Zones		High School Zones	
	High-Rate	Other	High-Rate	Other	High-Rate	Other
Mean rate per 100,000 children (standard deviation)	58 (34.7)	11 (7.1)	57 (18.5)	18 (10.4)	55 (4.9)	23 (10.7)
Number of school zones	41	123	9	28	5	18
Percentage of schools with full-time nurse	78	87	56	86	100	100
Percentage of schools with economically disadvantaged students above 50%	93	85	100	89	100	89
Percentage of schools with at-risk students above 50%	98	87	100	82	100	94

Texas Children's Health Plan (TCHP)

The analysis of TCHP data showed that 53,988 children enrolled in TCHP were diagnosed with asthma in Houston, accounting for 15% of TCHP members. Table 2 shows medication compliance rates for 50% and 75% levels for CHIP and STAR child members of TCHP. The analysis of CHIP data indicated that only 26.7% of children 5 to 11 years of age and 17.2% of children 12 to 18 years of age had medication compliance of 75% or greater. The analysis of STAR data indicated that only 19.0% of children 5 to 11 years of age and 18.0% of children 12 to 18 years of age had medication compliance of 75% or greater.

Table 2

Medical Compliance Rates for TCHP Members on CHIP and STAR Programs

Age Group (in years)	Medication Compliance	CHIP	STAR
5 – 11	50%	54.8%	48.4%
	75%	26.7%	19.0%
12 – 18	50%	46.9%	42.7%
	75%	17.2%	18.0%

Houston Independent School District (HISD)

Thirty-nine percent of elementary school nurses in designated high-rate schools consented to participating in the survey. The results in Table 3 are reported in terms of the percentage of nurses ranking a barrier as the main priority by each care coordination area. Survey results from the high-risk schools indicate the priority barrier to childhood asthma management, including lack of resources in Family (43.7%), lack of communication in Community (37.5%), lack of knowledge of triggers in Home (43.7%), and inadequate time for quality care from providers in Medical (50%).

Additionally, several nurses utilized the free text box at the end of each care coordination area question to provide other barriers not listed. For the Family area, nurses elaborated on: the lack of insurance; the family being reactive (as opposed to proactive) about their child's health; the family's beliefs that an inhaler is not necessary at school; and the caregiver's unwillingness or inability to create a trigger-free environment (e.g., caregivers smoking in the presence of their child even if aware the action exacerbates their child's asthma). For the Community area, nurses noted: the need for asthma education for school nurses; the concern that not all schools have full-time nurses; the lack of resources for immigrant students; and the family's misconception that the child does not need an inhaler at school because he does not readily use one at home. For the Home area, nurses emphasized: the lack of resources or knowledge about triggers and trigger reduction; the lack of knowledge or willingness of caregivers to quit smoking; the inability to keep the house clean and clothes washed; the fear of immigration status; and the caregiver's lack of transportation to the provider's office or to school. For the Medical area, nurses added: the lack of follow-up care; and the lack of insurance or finances for co-payments.

Integrating Cross-Sector Data

The map (Figure 1) shows where TCHP high-risk (heat map) regions were aligned with EMS high-rate school zones (hatch markings) of ambulance-treated asthma attacks. The map shows the 41 high-rate elementary schools with the 19 highest rate schools, based on EMS and TCHP data, identified and coded as priority intervention schools.

Table 3

Response Percentages by Care Coordination Areas from School Nurse Survey

	Identified Barrier (prioritized)	Nurse Response Percentage
Family	Lack of resources	43.7%
	Family functioning	31.3%
	Education	18.8%
	Culture	6.2%
	Communication	37.5%
Community	Facility	37.5%
	Medication	18.8%
	Miscellaneous	6.2%
	Lack of knowledge to identify/remove triggers	43.7%
Home	Lack of resources to make changes	25.0%
	Triggers	18.8%
	Miscellaneous	12.5%
Medical	Time for quality care	50.0%
	Education	37.5%
	Miscommunication	12.5%

Discussion

The needs assessment indicates that geospatial mapping of the different data sources was key in highlighting regions in Houston where children with asthma have poorer asthma management and potentially less coordination of care. By using this multi-sectoral data analysis and geospatial mapping approach, areas of asthma management disparities were more easily identified. Together with this information of where to target interventions, the nurse survey put the current asthma management situation in context and provided a preliminary framework for areas where care coordination could improve. This survey indicated an acknowledgment that both school nurses and families often lack the resources and capacity to make changes in medical care management and how schools and communities may impact a child's care.

To address this lack of resources, developing strategies in Houston would take not just an understanding of the needs, but an understanding of who is affected and how to strengthen the institutions that support children and their families. A potential solution may include a commitment to building a sustainable, equitable system of asthma management into existing payment, coordination, and support structures, as supported in part by Gomez, Reddy, Dixon, Wilson, and Jacobs (2017) and Kattan et al. (2005), in terms of medication compliance and trigger reduction education.

The three sources of data each had strong information, but they had not had the opportunity to integrate the data and coordinate the needs in a way that would impact high-risk children with asthma in Houston. TCHP had a strong system for measuring medication
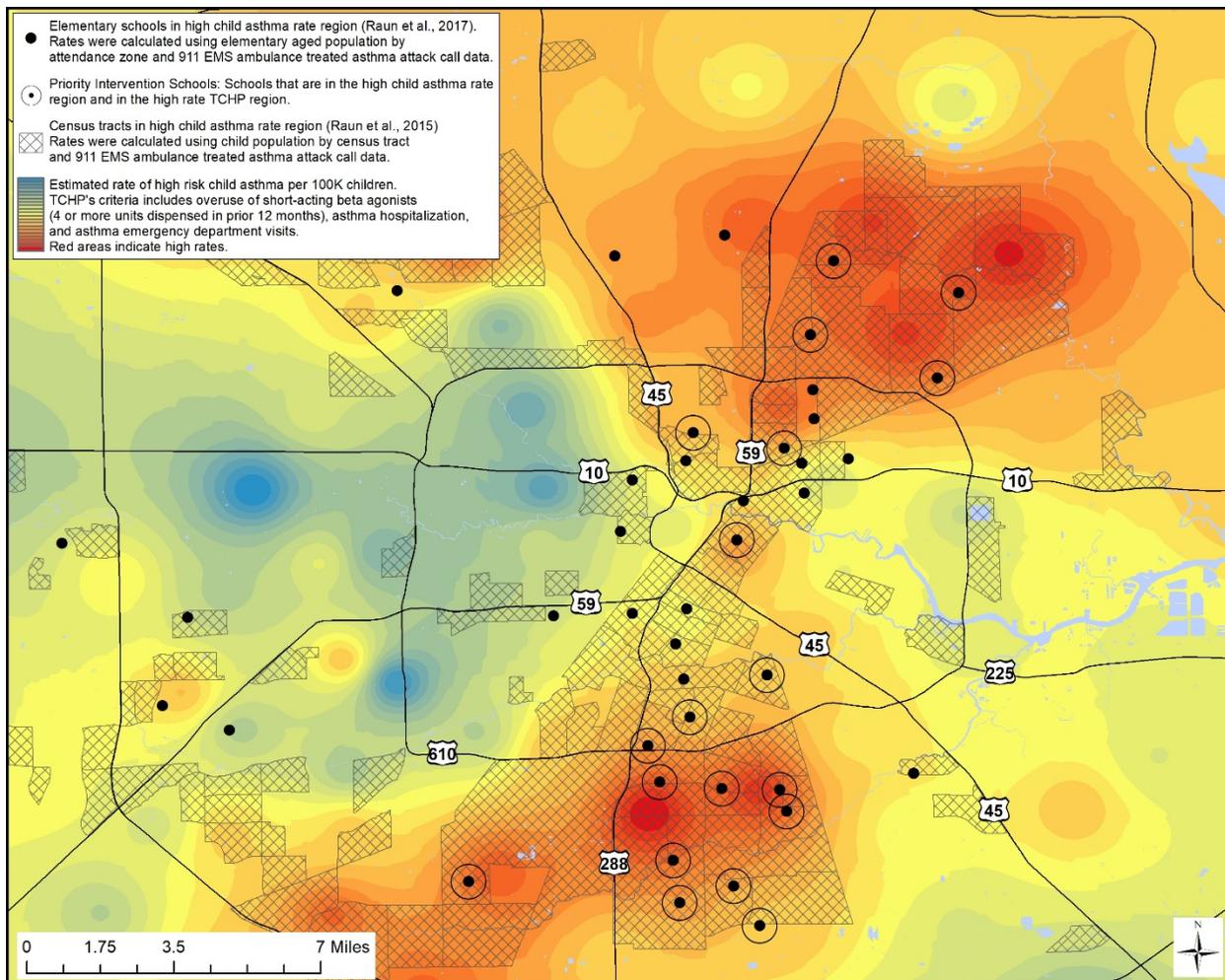
Figure 1. Map of EMS, TCHP, and HISD data combined.

compliance and for tracking hospitalizations and intermittent care, but no ongoing means of regularly working with children and families. EMS had strong data on high-risk asthma events and their locations, but no means of guiding care management. HISD had a system of school nurses with a focus on asthma and regular education and interaction with children and families, but few abilities to communicate with medical care providers to learn information on asthma hospitalizations or lapses in coordination of care. The needs assessment, by using multi-sectoral data, was able to provide an overarching framework for better coordination of care.

The framework would propose the possibility of the school nurse as a central figure who can act as point person between all sectors in asthma management, especially for high-risk regions and school zones identified by the geospatial mapping. Potentially, an improved system could facilitate the ability of the school nurse to serve as the central coordinator for asthma management and ultimately reduce emergency department visits and hospitalizations due to asthma by: encouraging families to make and maintain appointments with providers; ensuring families attend doctor appointments on time; providing asthma medication, as needed, at school; completing Asthma Action Plans; and maintaining strong communication with families and providers so that all are aware of asthma education needs and asthma-related events or attacks (American Academy of Pediatrics [AAP], 2016; Levy, Heffner, Stewart, & Beeman, 2006).

From the analysis of TCHP data, improvements could be made in asthma medication compliance. A school nurse could communicate with parents or guardians and the child's primary care provider (and specialists) to ensure the child has an Asthma Action Plan. The school nurse could offer continuing education to the child and the family about the proper use of medication and the importance of keeping prescriptions filled to avoid asthma-related emergencies. TCHP data should be continuously monitored to see if medication compliance is improving for the identified high-risk members. With better medication compliance, a reduction in ambulance-treated asthma attacks could potentially occur, allowing ambulance resources to focus attention on other non-preventable health emergencies (Raun et al., 2015).

The school nurses, in coordination with personnel from other institutions (e.g., the City of Houston Health Department), could help assess a child's home environment. A home visit to identify possible asthma triggers could provide a better understanding of the child's overall asthma management system. A school nurse, coordinating with community health workers, could potentially provide additional education about triggers and their remedies. Because the families of high-risk children often lack resources, the coordination with already established remediation and education programs could help provide the missing resources and, furthermore, build trusting relationships between the family and its community. Partnering with health plans (e.g., TCHP) could provide educational resources, ongoing communication with the insurance provider, and use of media messages to deliver asthma education to families. With continued coordination with the city's government, efforts could be made to provide easier public transportation for families to maintain doctor's appointments, perhaps by giving complimentary tokens or passes. These coordination efforts could also provide opportunities to inspect and resolve triggers in the home with assistance from local and federal organizations (e.g., the EPA).

Further, the integration of these data sources has already assisted informing current and future pediatric asthma programs at the City of Houston Health Department. For example, this analysis assisted in the identification and prioritization of home trigger reduction kits for high-risk children with asthma in Houston and will inform the future scheduling of a mobile unit program that will visit schools in HISD to evaluate and educate children about their asthma. Similar cross-sector data analysis of other cities and communities could advise local policies and efforts to improve asthma management in children.

One limitation to this approach was that it only considered the perspective of the systems involved and did not seek the perspectives of the patient or caregivers directly; school nurses, instead of the families themselves, provided insight into the everyday barriers the families face in their child's asthma management. This limitation is likely not substantial because the elementary school nurse is involved with the care of the high-risk child with asthma and is aware of the barriers to care through daily interactions with the child and family (AAP, 2016). Another limitation may be the relatively low response rate (39%) to the high-rate school nurse survey. However, the responses received were in overall accordance with one another, with most nurses agreeing on the top barriers for each care coordination area, suggesting that similar results may be found with a higher response rate.

Implications for Health Behavior Research

Figure 2 is based on a socio-ecological approach to health behavior and shows the school nurse at the center with a ring surrounding showing the four care coordination areas (Golden & Earp, 2012). The next ring shows what improvements can be made with increased
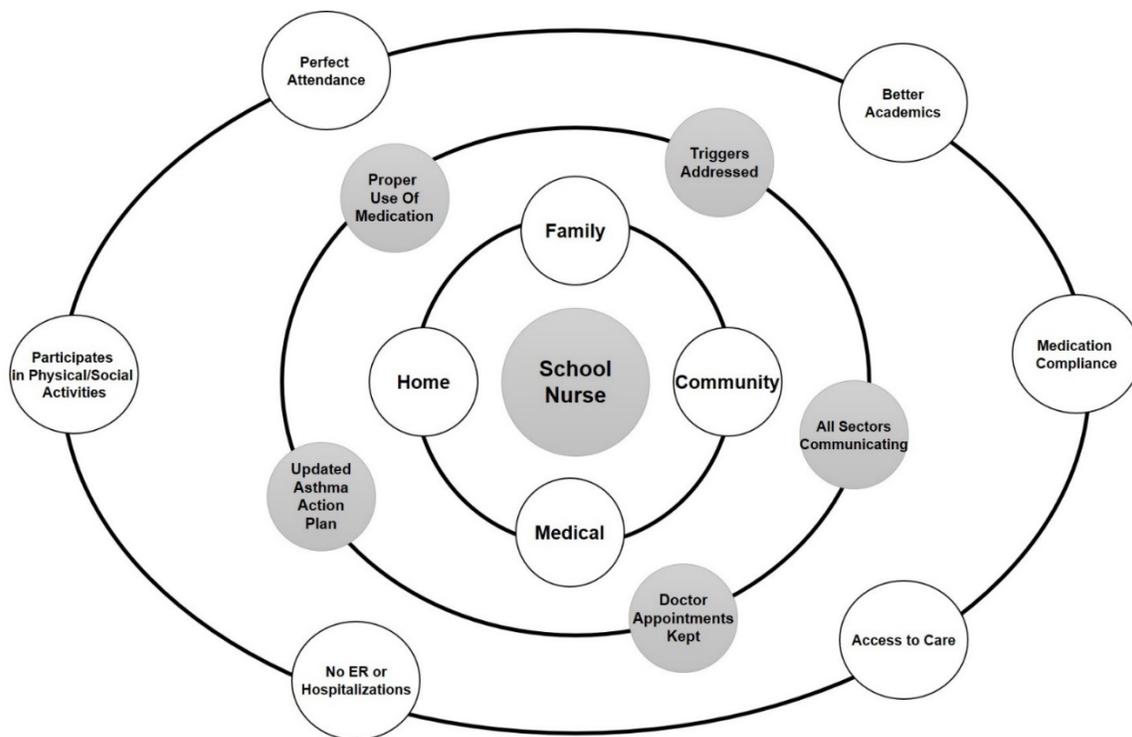
Figure 2. Proposed multi-sectoral strategy with school nurse as center of care coordination.

coordination between the four areas with the school nurse encouraging open communication between Family, Community, Home, and Medical care coordination areas. The outside ring shows the potential benefits for the child in implementing the proposed, more equitable strategy for improving asthma management.

This school nurse-centered strategy in child asthma management could provide a practical systems approach to improving Houston's childhood asthma management problem by focusing interventions on strengthening multi-sector approaches at the individual and the societal level for high-risk children and high-rate regions. Allowing coordination between some of Houston's main health institutions and encouraging open communication between a child's Family, Community, Home, and Medical care coordination areas could create a more ideal system in asthma management for children most at risk. This strategy could focus on high-risk children and their families, who currently do not have the power or resources themselves to change their behaviors to lead healthier lives. These high-risk children could benefit from the coordination among a wide range of systems that target support for families' capacity to improve their child's health.

With an increase in coordination in a high-risk child's asthma management system and community-based guidance from a school nurse, this multi-sectoral assessment and its resulting multi-sectoral strategy could improve asthma outcomes and lead to improvements in other areas of the child's life. Based on current evidence, the high-risk child could miss fewer days of school (Jacobsen, Meeder, & Voskuil, 2016; Hsu, Qin, Beavers, & Mirabelli, 2016; Telljohann, Dake, & Price, 2004; Levy et al., 2006). Missing less school could possibly lead to the children

performing better academically and to lower school dropout rates, which is associated with other negative outcomes, such as violence and unemployment (AAP, 2016; Basch, 2011; Balfanz & Byrnes, 2012). A high-risk child could participate more regularly in daily physical activities like exercise, sports, and socializing with friends, potentially improving self-esteem and mental health (Hughes, 2014). Increased medication compliance and access to care could lessen emergency room visits and hospitalizations due to asthma attacks. Using complex multi-sectoral data and a multi-sectoral strategy has ramifications in addressing health equity in childhood asthma management and in strengthening the approaches to addressing health behavior.

Discussion Questions

1. Given the needs assessment, the findings suggest the child's school nurse should act as the center of coordination to address health equity and improve childhood asthma management and control in high-risk children and areas. However, given that the survey indicated a disconnect between the school nurse and the child's primary care provider, what methods or strategies could improve data sharing (child's electronic medical record) between clinics and school nurses (given formal HIPAA-complying agreements are established)? How are these best built around current organizational-level needs and how could the Health Information Exchange (HIE) at local levels support these efforts?
2. The multi-sectoral needs assessment used three data sources (emergency, insurance, and school) to inform a strategy to mitigate health equity in childhood asthma management. Are there any other untapped data sources or systems that could be analyzed to address barriers identified and enhance strategies to improve health practices in high-risk children?

Acknowledgments

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