NEJM Catalyst | Innovations in Care Delivery

CASE STUDY

Pediatric Asthma Surveillance System (PASS): Community-Facing Disease Monitoring for Health Equity

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Vol. 5 No. 8 | August 2024

DOI: 10.1056/CAT.24.0121

The partnership between health care delivery systems and public health entities is essential in improving community health equity in a synergistic manner. One key challenge is creating a common data source to assess community risk and support actionable insights for collective impact interventions. Through a partnership between Parkland Health (Parkland), Dallas County Health and Human Services (DCHHS), and the Parkland Center for Clinical Innovation, the Pediatric Asthma Surveillance System (PASS) was built as a community-facing dashboard with involvement from the local community, leveraging AI/machine learning techniques and social and clinical risk insights to predict pediatric asthma risk, identify risk drivers, and map risk disparities at the zip-code and census-tract level. PASS serves as a *single source of truth* to support community collaboration to collectively improve pediatric asthma outcomes equity. PASS uncovers microgeographic disparities in asthma risk and risk factors that were not previously readily available. For instance, contiguous census tracts have distinct asthma risk profiles requiring different clinical, public health, and social services strategies for improvement. PASS is leveraged by health care delivery systems, public health entities, and social services organizations to design and coordinate efforts in high-risk communities. The key to replicating PASS for other communities or chronic diseases (e.g., diabetes/hypertension) is a robust cross-sectoral partnership, advanced expertise in social determinants of health and clinical data analyses, community education, and a simplified, intuitive, and accessible dashboard. PASS is both the product of and a catalyst for a

synergistic partnership between a health care delivery system (Parkland) and a public health entity (DCHHS).

KEY TAKEAWAYS

- » Combining clinical and social information to build a community-level asthma surveillance system is feasible and can lead to unexpected, actionable community vulnerability insights.
- » Important data reside in disparate data sources, diverse formats, and inconsistent standards, requiring expertise to creatively summarize and produce meaningful data.
- » Existing community partnerships and early engagement of key stakeholders are crucial to ensure that the surveillance system is valuable, accessible, and useful.

The Challenge

The necessity and benefits of a robust partnership between health care delivery systems and public health systems became pronounced during the Covid-19 pandemic, as illustrated by the collaboration between Parkland Health (Parkland), which is Dallas County's safety-net health system, and Dallas County Health and Human Services (DCHHS), which yielded a synergistic scaling of pandemic-related emergency response in both health care delivery and public health functions.[1] Prior to the pandemic, the 2019 Dallas County Community Health Needs Assessment (CHNA) performed by Parkland and DCHHS identified pediatric asthma as a key driver of pediatric morbidity and mortality, reconfirmed by the 2022 CHNA showing stark disparities in asthma burden across zip codes (Figure 1).[2,3]

Based on that information, in May 2020, Parkland and DCHHS launched a CHNA implementation plan, together with the Parkland Center for Clinical Innovation (PCCI) — which is an independent North Texas nonprofit research, data analytics, and innovation hub that was spun out of Parkland in 2012 — as well as federally qualified health centers and community-based organizations (CBOs). The implementation plan was designed to address the inequitable pediatric asthma disparities predominantly affecting racial and ethnic minorities and socioeconomically disadvantaged children, by improving asthma morbidity in the targeted zip codes through a robust partnership among the participating safety-net providers. Part of the implementation challenge was the need for granular, precise, timely, and actionable data insights at the microgeographic level (beyond zip codes) to guide coordinated cross-systems collaborations.

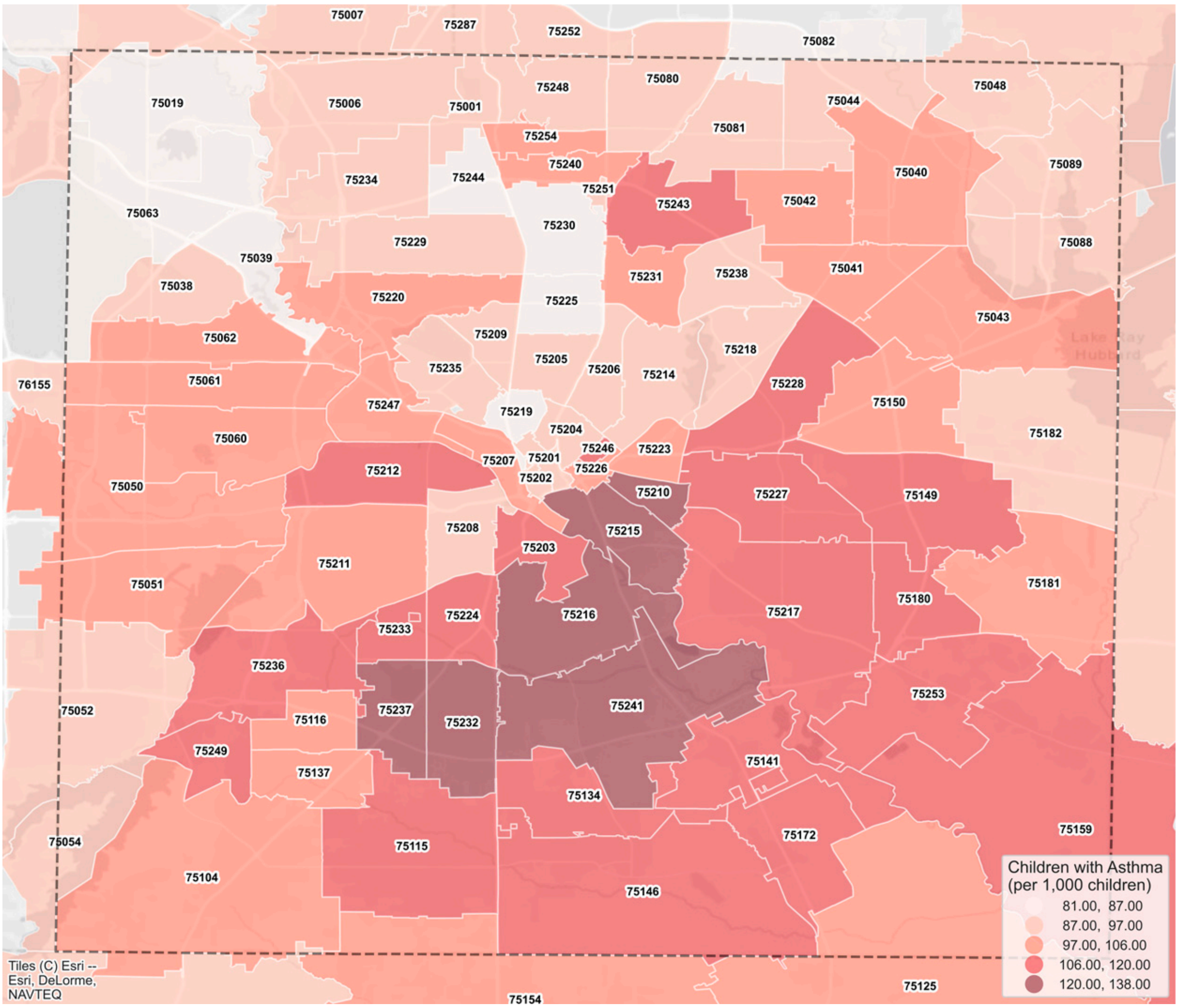
The Goal

In June 2022, Parkland, PCCI, and DCHHS leaders recognized that having a common data source would enhance community partnerships and make interventions more data driven and effective at improving community health; they began collaborating to develop the Pediatric Asthma Surveillance System (PASS), which would launch in December 2022. PASS is a community-facing, dynamic

FIGURE 1

Pediatric Asthma Population in Dallas County, 2018–2020

Pediatric asthma is prevalent in south and southeast Dallas County. Pockets of high prevalence also can be seen in western and eastern regions. Southern zip codes with high pediatric asthma prevalence are among the most socially disadvantaged in Dallas County. The key refers to the number of pediatric patients with a diagnosis of asthma per 1,000 children within the zip code outlined.



Source: Parkland Center for Clinical Innovation analysis of data from PLACES, the U.S. Centers for Disease Control and Prevention, https://www.cdc.gov/places; and the Dallas-Fort Worth Hospital Council Foundation dataset, https://dfwhcfoundation.org/

dashboard leveraging AI and machine learning to build a zip-code– and census-tract–level predictive model incorporating clinical and social risk insights to identify communities at high risk for poor asthma outcomes, quantify key risk drivers, and support community-wide coordinated interventions. (There are 529 census tracts in Dallas County; a census tract generally has visible, identifiable boundaries and a population between 1,200 and 8,000, with an optimal size of 4,000.[4]) To ensure its broad use as a *single source of truth* across stakeholders, PASS was designed to be simple, intuitive, actionable, and easily digestible by laypeople and experts alike.

The Execution

Clinical providers, community health advocates, and public health specialists were involved in the full PASS life cycle, from design to deployment. Clinical and public health providers were instrumental in identifying relevant clinical and nonmedical variables for inclusion into the model. They also assisted with reviewing and refining the model prediction to ensure that the direction of the association between predictors and outcomes made sense. Community health advocates with roots in — and in-depth knowledge of — Dallas County communities supported the design of the user-friendly dashboard and validated PASS results based on their community experience. The execution included two key stages: construction and deployment of the PASS.

> *"Part of the implementation challenge was the need for granular, precise, timely, and actionable data insights at the microgeographic level (beyond zip codes) to guide coordinated cross-systems collaborations."*

PASS Construction

PASS has two major components: (1) an index to capture pediatric asthma vulnerability at the census-tract or zip-code level incorporating clinical, environmental, and social risk factors at a microgeographic level; and (2) a community-facing, intuitive dashboard to display the vulnerability index along with actionable risk factors and key community characteristics.

The Pediatric Asthma Vulnerability Index

Using historical data (2018–2022), PCCI developed and validated a statistical model triggered by monthly data pulls to predict census-tract–level incidence of pediatric asthma ED visits (EDVs) and hospitalizations within 90 days among children 6 months to 17 years of age. We used diverse data sources to collate the necessary clinical, social, and environmental data, including the U.S. Centers for Disease Control and Prevention's PLACES, Parkland's electronic health records, health claims data from the Dallas-Fort Worth Hospital Council Foundation (DFWHCF, a North Texas membership organization that serves, in part, as a data aggregator), Housing and Transportation Affordability Index data from the Center for Neighborhood Technology (CNT), 2019 American Community Survey (ACS) data from the U.S. Census Bureau, and outdoor air quality data from OpenWeather.

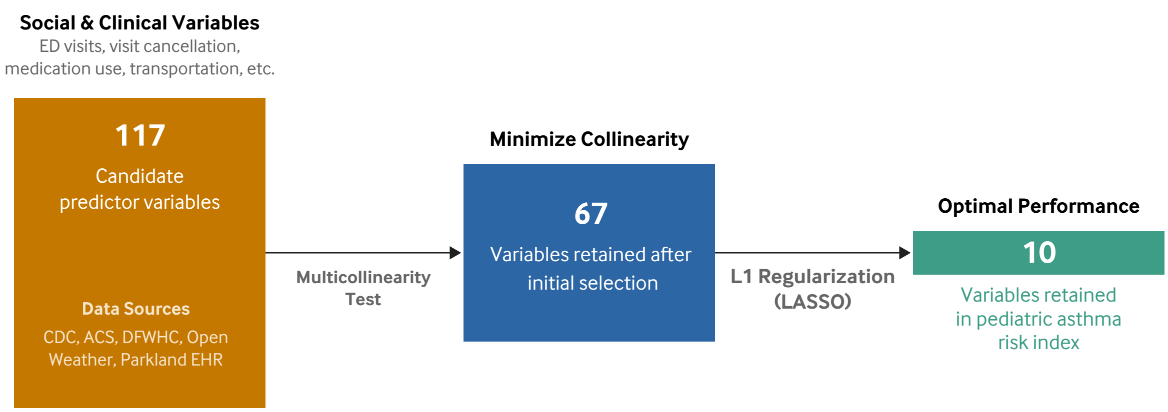
The value of these varied sources includes, for example, from the ACS, features related to food, housing, transportation, and family structure; from OpenWeather, features related to air quality and different gas and dust content; from the U.S. Centers for Disease Control and Prevention, features related to chronic disease prevalence and mental health; from DFWHCF, features related to clinical utilization; and from Parkland, features related to clinical utilization and medication prescription. Even though the resulting list of 117 features was not comprehensive of all possible features, it provided good coverage of different domains related to the patients' (and their families') homes, neighborhoods, and air they breathe. Next, we calculated the multicollinearity between these features and removed the highly multicollinear ones from the dataset, decreasing the number of features to 67. Finally, we further decreased the number of features to 10 by applying L1 regularization (LASSO [Least Absolute Shrinkage and Selection Operator regression]) on the feature set (Figure 2).

Unlike other vulnerability indices like the Area Deprivation Index, Social Vulnerability Index, or Environmental Justice Index, PASS is focused specifically on asthma-related vulnerabilities for pediatric populations. The model has clinical drivers (total controllers prescribed, fewer than two relievers prescribed, EDVs, chronic obstructive pulmonary disease prevalence) and social drivers (Black or African American proportion, Hispanic proportion, number of automobiles in the household), as well as environmental features (air quality), which also separates PASS from other vulnerability indices.

FIGURE 2

Selecting and Refining the Relevant Features to Monitor Pediatric Asthma Risk

The original 117 candidate variables were provided from various data sources in the development of the Pediatric Asthma Surveillance System tool. To minimize collinearity, this collection was reduced to 67 candidate variables using bivariate analyses as well as variance inflation factor analysis. Finally, to support optimal performance of the dashboard, a final streamlined set of 10 variables was selected, using L1 regularization (LASSO), to serve as the model risk predictors for the Pediatric Asthma Vulnerability Index.



ACS = American Community Survey, CDC = U.S. Centers for Disease Control and Prevention, DFWHCF = Dallas-Fort Worth Hospital Council Foundation, EHR = electronic health record, LASSO = Least Absolute Shrinkage and Selection Operator regression.
Source: The authors

Beginning with 117 candidate variables including known asthma risk factors (e.g., past EDVs, medication use, and secondhand smoking exposure) and known social determinants of health (e.g., transportation needs, food insecurity, and access to insurance), we constructed the model using a hierarchical approach to first predict weekly county-level incidence rates of asthma-related EDVs or hospitalizations, then estimate census-tract–level incidence rates. The differences between census-tract–level and county-level incidence rates were normalized to create the Pediatric Asthma Vulnerability Index. Normalization allows for a direct comparison of pediatric asthma risk across geographies without the confounding effect of seasonal variations and population size differences. The predictive model showed good performance on hold-out set, with an adjusted R-squared of 55.5%. (For demographics-related studies, R-squared values of 0.3–0.4 are considered good. In this project, our model shows what we are predicting as a positive signal is significantly higher than the noise.) Ten (of 117) candidate predictors were retained in the model, spanning the continuum of clinical and social risk, from medication use patterns and health services utilization, to transportation needs and sociodemographic characteristics (Table 1).

Table 1. List of Model Risk Predictors and Nonmodel Risk Predictors

Predictors	Value
Model Risk Predictors	
<2 Relievers Prescribed in Last 90 days	+
Proportion of Female Population Ages 15 to 17 Years	–
Proportion of Female Population Ages 18 to 19 Years	–
Air Quality ($PM_{2.5}$)	+
Automobiles per Household	–
Proportion of Black (non-Hispanic) Population	+
COPD Prevalence	+
Emergency Department Visits in Last 90 days	+
Proportion of Hispanic Population	+
Total Controllers Prescribed in Last 365 days	–
Nonmodel Risk Predictors	
Health Insurance Coverage in Ages <19 Years	+
Affordable Housing and Transport	–
Depression Population	+
Food Insecurity	+
Median Household Income	–
Single-Parent Household	+
Smoking Population	+

Known clinical and nonclinical factors that affect asthma ED visit risk are incorporated into the risk model, including recent history of ED visits and access to transportation. Other factors also known to impact asthma (e.g., exposure to secondhand smoking or access to insurance) are not retained in the model, yet they can add to our understanding of community-level asthma risk. Including these nonmodel variables into the Pediatric Asthma Surveillance System provides, beyond the calculated risk index, additional explanatory insights that can be leveraged to support the community strategy to curb asthma risk. A positive value (+) indicates a risk factor, whereas a negative value (–) indicates a risk protector. $PM_{2.5}$ = fine inhalable particulate matter with diameters 2.5 micrometers and smaller; COPD = chronic obstructive pulmonary disease. Source: Parkland Center for Clinical Innovation analysis of data from multiple public and private data sources

> *“Clinical providers, community health advocates, and public health specialists were involved in the full Pediatric Asthma Surveillance System life cycle, from design to deployment.”*

Using stakeholders’ expert input, seven additional variables (not retained in the model) were identified as important for display on the PASS dashboard (but not included in the index) because they had a strong correlation with pediatric asthma vulnerability and provided actionable insights to support synergistic cross-sectoral collaboration. Examples of these nonmodel risk factors include adult smoking, caregiver depression, and lack of insurance (Table 1). Predictors’ values were normalized between (–1 and 1), with positive values indicating risk factors and negative values indicating risk protectors; values farther from 0 indicate a higher magnitude of risk, and values closer to 0, a lower magnitude of risk.

The Dashboard

The vulnerability index and predictor values were divided into risk quintiles (Very High, High, Moderate, Low, Very Low risk) for ease of representation on dashboards and maps, and were incorporated into a community-facing, interactive dashboard displaying asthma risk insights at the census-tract and zip-code level (Figure 3).

PASS is deployed in Power BI (a Microsoft interactive data visualization software product), is accessible on the DCHHS Asthma Control Program, and is updated monthly. (The updating is partially automated, with full automation planned; however, human involvement will be maintained to monitor the pipeline, data integrity, and any drift related to population change.) A color-coded map occupies the center of the dashboard, whereas risk predictors are displayed on the side by order of magnitude, and sociodemographic parameters are displayed below, highlighting racial, ethnic, and other community characteristics important for program design and strategy. An impact score is calculated for each variable using the variable’s weighted coefficient in the vulnerability index (or in bivariate analyses for nonmodel variables), and its relative value in a specific geography is normalized at the Dallas County level. The impact score tells us the absolute contribution of each variable to pediatric asthma vulnerability that is comparable between geographies.

Users can drill down from the vulnerability index view to specific indicator/predictor views, navigate from the zip-code to the census-tract view, and select specific geographies to further analyze disparities and actionable insights. A simplified glossary is included, along with links to original data sources and a data refresh time stamp, for full transparency to drive community trust and adoption.

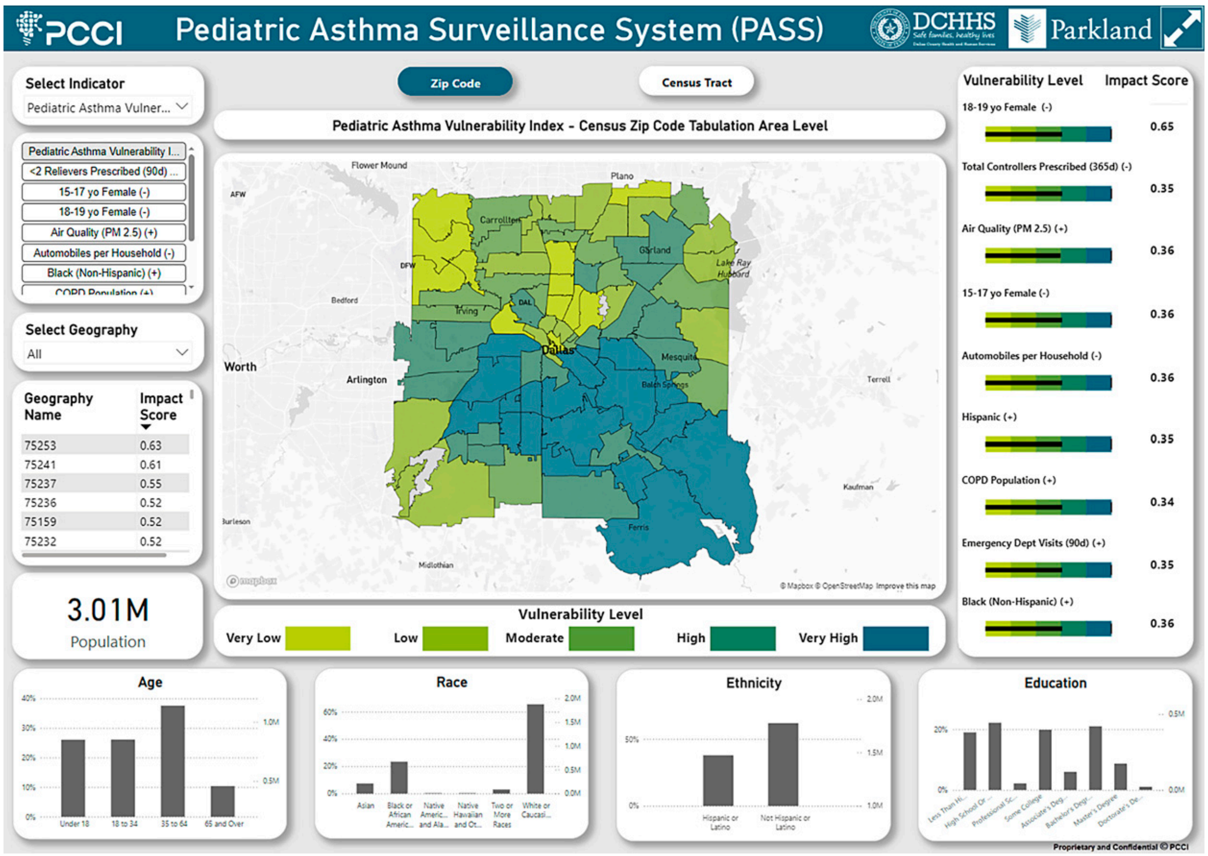
PASS Deployment

PASS was deployed on December 31, 2022. A key rollout component was community awareness dissemination, stakeholder training (emphasizing a *train-the-trainer* approach), and active community

FIGURE 3

Pediatric Asthma Surveillance System (PASS) Dashboard, User Interface

PASS displays a map of geographic-level pediatric asthma vulnerability at the census-tract or zip-code level, along with a list of risk drivers and sociodemographic characteristics of the population. For each risk driver, a normalized impact score is calculated and displayed that measures the magnitude of the risk driver's contribution to the vulnerability index and is comparable across risk drivers/variables.



Source: Parkland Center for Clinical Innovation analysis of data from multiple public and private data sources.

engagement for feedback. We hosted six community training sessions with more than 15 organizations attending (e.g., school systems, after-school programs, health care and social service providers, county health personnel, and city environmental advocacy and corporate responsibility leaders). Stakeholders identified use cases ranging from advocacy for environmental-friendly city policies, to targeted smoking cessation programs, to data-driven partnerships for community-benefit programs. PASS was marketed across social and traditional media platforms, and within about 12 months (January 1, 2023–January 15, 2024), it had generated about 12,000 impressions on social media and 3,463 website views (up to 4,530 website views by June 2024), indicating community engagement and interest. We also included a built-in feedback mechanism for user questions, comments, or requests.

> *“For instance, if a child with poorly controlled asthma lives in a census tract with a high prevalence of smokers and low controller medication use, the clinical provider might initiate caregiver education about secondhand smoking and medication adherence, whereas public health entities might address access to medication and smoking cessation programming at the community level.”*

Metrics

Insights

PASS-generated data confirms CHNA findings that communities in southeast Dallas County bear the brunt of pediatric asthma vulnerability. However, PASS’s census-tract–level data identify pockets of vulnerability throughout the county. PASS also uncovers stark differences in vulnerability between neighboring communities as illustrated in Figure 4, which shows two contiguous census tracts, one *High Risk* and the other *Low Risk*, with differences in population characteristics, medication use, and other leading risk factors, which would warrant different strategies for clinical, social, and public health interventions.

PASS data broadens the visibility for those in health care delivery systems and public health entities by enabling a holistic picture of individual and community vulnerability by supplementing information accessible by either system alone. Using PASS, each system’s strengths and expertise can be coordinated to collectively improve pediatric asthma equity countywide. For instance, if a child with poorly controlled asthma lives in a census tract with a high prevalence of smokers and low controller medication use, the clinical provider might initiate caregiver education about secondhand smoking and medication adherence, whereas public health entities might address access to medication and smoking cessation programming at the community level.

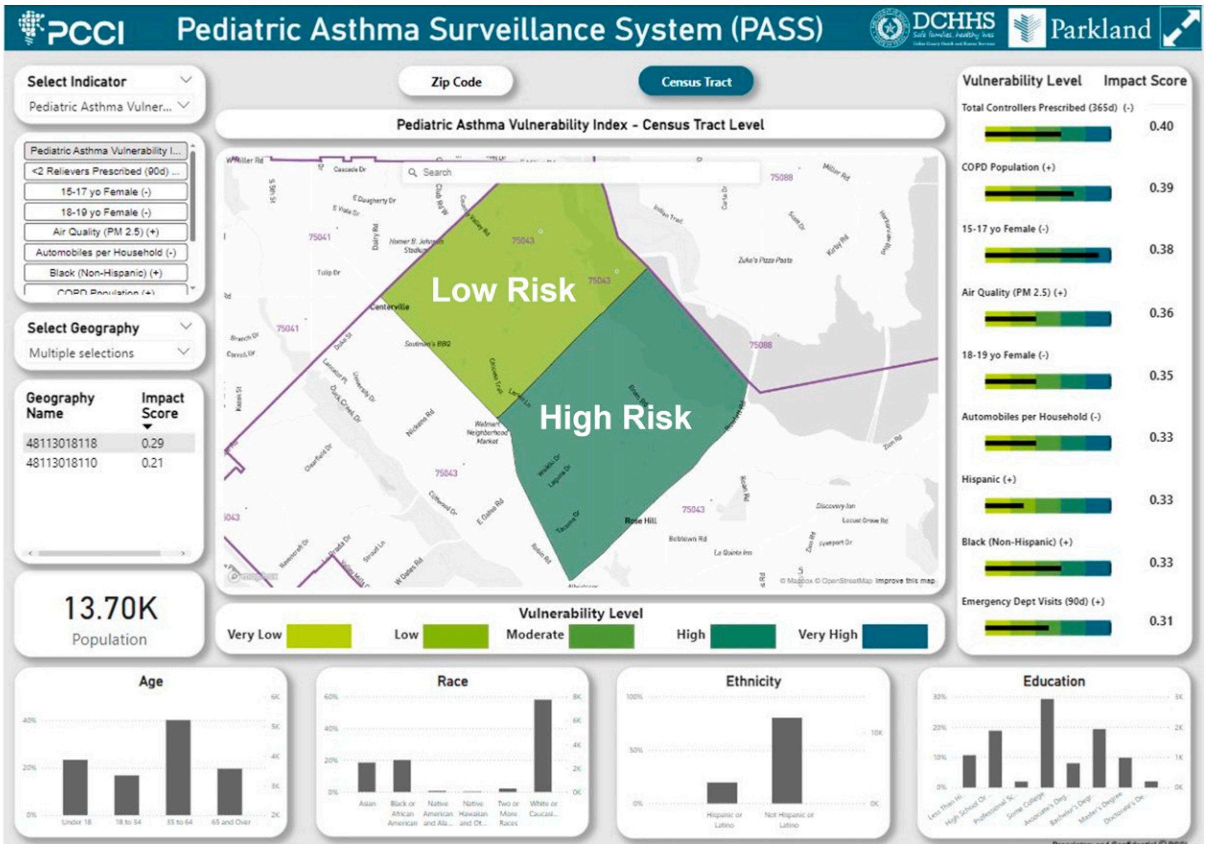
Community Impact

With PASS, health care delivery systems like Parkland can seamlessly identify its existing patients with asthma who live in high-risk census tracts and design targeted outreach efforts tailored to community-specific risk factors (e.g., asthma education, literacy barriers, health care coverage needs, and environmental risk factors). Parkland currently uses PASS to guide patient referrals for DCHHS virtual home visits for asthma medication education in neighborhoods where this risk factor is prevalent. PASS also enlightens clinical providers with information on patients’ microecosystems, including possible social challenges or home environment challenges, a usual blind spot for health care delivery systems. For instance, by identifying transportation barriers as a risk factor in a community, health care providers can creatively combine in-person, phone, and virtual visits to effectively reach high-risk patients in

FIGURE 4

Two Contiguous Census Tracts with Different Levels of Vulnerability

Two contiguous zip codes are identified with different pediatric asthma risk profiles that would allow users to design interventions tailored to each community. Zip-code–level risk stratification would miss these granular findings, whereas a census-tract–level map highlights them.



Source: Parkland Center for Clinical Innovation analysis of data from multiple public and private data sources

those communities. Parkland plans on leveraging PASS to develop partnerships for school-based interventions tailored to the specific needs of students living in high-risk neighborhoods. Finally, building on the pediatric asthma model, Parkland and DCHHS plan to replicate the same framework for a diabetes and hypertension surveillance system, two conditions identified through CHNA as key drivers of adult morbidity and mortality countywide.

Given limited investments in public health infrastructures, PASS offers an alternative mechanism to share resources such as IT, data analytics, and clinical and public health expertise across local public health entities. More importantly, PASS strengthens public health entities' capacity to plan, design, and deploy programs because they now have a single source of truth for pediatric asthma as a robust data source. As with clinical providers, PASS addresses public health entities' data blind spots with information about community-level patterns of health services utilization, medication adherence, and care engagement, which, combined with social risk data, can support the design and implementation of effective public health interventions. For example, while addressing traditional public health issues such as housing quality and smoking cessation, county health teams can leverage PASS data to supplement interventions with asthma medication adherence assessment and education, address barriers to care (e.g., pharmacy deserts), and design culturally appropriate interventions tailored to the most vulnerable communities. Public health entities also can use PASS to develop strategic partnerships with local CBOs, and DCHHS plans to leverage PASS to identify sites for county-funded community farms to alleviate the burden of food insecurity that impacts pediatric asthma outcomes.

“ *We actively monitor the model output for data drift and retrain the model when it starts deteriorating.”*

Furthermore, PASS has been used by CBOs, schools, and local news agencies to achieve their missions and is used by pediatric residents at University of Texas Southwestern Medical School to design and implement an advocacy project to address asthma disparities in target high-risk Dallas neighborhoods.

Next Steps

To enhance the value of the PASS system, we will be engaging the community to understand their use of PASS and how it impacts their activities and missions so that we can collaborate to monitor trends in health asthma outcomes that might be explained by the community activities supported by PASS. For example, community users suggested modifications to the dashboard to make the risk indicators display easy to understand by adding signs in addition to colors; in response, the dashboard was modified to (1) include signs (+/–) next to each risk driver to indicate their impact on asthma, and (2) to add a caption to PASS to explain what the signs meant.

Also, since the deployment of the surveillance system, DCHHS and other collaborating organizations have actively outreached patients in the high-risk areas. These interventions may cause changes in ED utilization, which will then change the dynamics of the dataset we trained the initial model on. Hence, we actively monitor the model output for data drift and retrain the model when it starts deteriorating. When building the model, we utilized 2010 shapefiles for census tracts and the 2019 ACS 5-year dataset. Since then, ACS has updated the census tract borders due to significant population changes inside Dallas County. Updating the shapefiles and the ACS features for retraining will also help improve the model performance.

Hurdles

Data Challenges

The primary challenge of building a cross-sectoral, comprehensive disease surveillance system like PASS is gathering the necessary clinical, public health, and social needs data because they are stored in disparate systems, use different data standards, and are aggregated at different granularity levels. It is challenging to identify appropriate data sources and then validate and process data into suitable formats for analysis. Moreover, specialized expertise is required to select appropriate analytical techniques to summarize and synthesize the data into insightful, validated information. For PASS, we leveraged PCCI's data expertise to identify 25 data sources, of which seven were selected based on the format and granularity offered. We used creative analytical techniques (e.g., factor analyses combined with clinician insights) to build the vulnerability index. Given the high mobility of safety-net patients across health systems, we obtained data from DFWHCF to track asthma EDVs and hospitalizations countywide for model building and validation. However, we have yet to identify a reliable data source for indoor allergens exposure, a key data point for asthma risk analysis. Regarding concerns related to data integration processes and governance, we had the advantage of leveraging existing relationships that had broken such cross-systems hurdles. We also have expertise in data aggregation following HIPAA (Health Insurance Portability and Accountability Act) rules to avoid displaying protected health information in a dashboard that many can see.

> *"We obtained data from Dallas-Fort Worth Hospital Council Foundation to track asthma ED visits and hospitalizations countywide for model building and validation. However, we have yet to identify a reliable data source for indoor allergens exposure, a key data point for asthma risk analysis."*

Partnership Challenges

Cross-sectoral partnerships are essential to support a comprehensive surveillance system such as PASS. Engaged partners are more likely to guide the development of a meaningful platform and leverage it for interventions and strategic collaborations. Health care delivery systems and public health entities have different — although complementary — functions, which can create barriers to integration due to perceived differences in goals and purposes or concerns for one system overtaking another. A partnership leveraging each system's unique expertise leads to synergistic outcomes, beyond what either system could achieve separately. In this case, we leveraged the long-standing functional partnership between Parkland and DCHHS to build and deploy PASS. Partnership with PCCI helped accelerate the data analytics process and ease the data acquisition and analytics learning curve. Finally, we leveraged long-standing partnerships with CBOs to ensure community dissemination and uptake.

The Team

This collaborative effort brought together a multidisciplinary team of professionals. Parkland's community health and clinical leadership brought the health system's perspective. DCHHS leadership and expertise ensured public health relevance. PCCI's team of clinicians, data scientists and engineers, technology specialists, and program managers led data analysis and dashboard deployment.

Where to Start

To replicate the PASS (or similar surveillance systems), it is essential to leverage cross-systems partnerships between health care delivery, public health, social services, and data analytics organizations. Once this core team is assembled:

- Start with local, regional, and national datasets for health and social determinants of health data, clinical data from local health systems and health information exchanges, social data from local CBOs, and environmental data.
- Engage partners early and incorporate their input across the project life cycle to create a sense of ownership.
- Make the dashboard simple, intuitive, actionable, and transparent to drive community engagement.
- Build robust monitoring parameters to evaluate its community engagement, health equity impact, and convening capacity.
- Educate the community and continuously gather feedback for improvement.

In terms of funding, the first-time implementation of PASS was built in part using grant funds. We expect subsequent implementations to be less expensive because they would primarily entail some refinement and updates to the existing PASS blueprint, including data use agreements, risk prediction models, and community engagement strategies.

Health care delivery systems can leverage PASS to support population health strategies and programming, and, for charitable health systems, PASS can guide the design and implementation of mandated community-benefit plans including CHNA. For frontline clinical providers, PASS provides insights into patients' microenvironments. For instance, for a child with poorly controlled asthma, PASS assists health care providers with identifying potential risk factors, such as secondhand smoking or poor medication adherence, which might not be forthcoming from caregiver reports yet would help shape clinical decision-making, including treatment plans, educational interventions, and referrals.

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Acknowledgments

We gratefully acknowledge the contributions of Dr. Fred Cerise, Jessica Hernandez, Dr. Donna Persaud, and Grace Mathew at Parkland; Woldu Ameneshoa at Dallas County Health and Human Services; and Arun Nethi, Venkatraghavan Sundaram, Ashley Steele, and Elizabeth Powell at Parkland Center for Clinical Innovation, whose dedicated efforts helped make this project and/or article possible.

Disclosures: Yolande Pengetnze, Teresita Oaks, Yusuf Talha Tamer, Thomas Roderick, Jason Allen, Hannah Ligon, Lance Rather, Cesar Termulo, Phil Huang, and Steve Miff have nothing to disclose. This work is funded in part by Lyda Hill Philanthropies.

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