


Aligning Partners in Pediatric Health: Using Geographical Information Systems to Plan Community Coalitions

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Abstract

Introduction: Compared with adults, children have higher emergency department (ED) utilization for asthma exacerbation. While community coalitions have been shown to prevent ED visits for asthma, there is little guidance on where to best implement these efforts. Geographical information systems (GIS) technology can help in the selection and coordination of potential coalition partners. This report proposes a model to be used by clinicians and child health equity advocates to strategize high-impact community health interventions. The aims were to identify the clusters of ED utilization for pediatric asthma, evaluate sociodemographic features of the population within the clusters, and identify potential primary care and school community partners. **Methods:** This model uses ED visit data from 450 nonmilitary California hospitals in 2012. We obtained ZIP code–level counts and rates for patients younger than 18 years discharged with a diagnosis code of 493 for asthma conditions from the California Office of Statewide Health Planning and Development’s Open Portal. We applied GIS spatial analysis techniques to identify statistically significant cluster for pediatric asthma ED utilization. We then locate the candidate community partners within these clusters. **Results:** There were 181 720 ED visits for asthma for all age groups in 2012 with 70 127 visits for children younger than 18 years. The top 3 geographic clusters for ED utilization rates were located in Fresno, Inglewood, and Richmond City, respectively. Spatial analysis maps illustrate the schools located within 0.5– and 1-mile radii of primary care clinics and provide a visual and statistical description of the population within the clusters. **Conclusion:** This study demonstrates a model to help clinicians understand how GIS can aid in the selection and creation of coalition building. This is a potentially powerful tool in the addressing child health disparities.

Keywords

emergency visits, pediatrics, primary care, spatial analysis, community partnership, GIS, geographical information system, asthma, coalition, underserved communities

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Introduction

Compared with adults, children have proportionally higher asthma prevalence and emergency department (ED) utilization for asthma exacerbations,¹ making asthma an important chronic pediatric condition. Acute asthma exacerbations consistently rank as one of the most common reasons for pediatric ED visits.² Yet despite initiatives to reduce the prevalence of childhood asthma, ED visits for pediatric asthma increased between 12% and 18% in California from 2001 to 2012.^{3,4}

Decreasing the burden of asthma calls for a comprehensive community health approach. Asthma is a complex disease affected by genetics, environmental and social factors, thus the strategies aimed at decreasing its burden must be

multifaceted. Community coalitions that include local primary care centers and school health programs have been shown to reduce ED asthma visits.^{5–11} Primary care tactics that involve case management and in-home environmental remediation^{5,6,8} as well as, clinical asthma plans at school-based health centers can reduce asthma morbidity and decrease both ED visits and admissions.^{12–15} While

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these strategies can affect pediatric asthma health, there is little guidance on selecting the best location to implement these efforts.

Geographical information systems (GIS) technology can aid in the selection and coordination of potential community partners by examining patterns in ED utilization and determine locations with significant health disparities. While there are studies that employ GIS to depict child health inequities or clinical and community health resources, there is a paucity of literature that employs GIS technology to leverage all these elements together.¹⁶⁻¹⁹ This report proposes a model to be used by clinicians and child health equity advocates to strategize high-impact community health interventions. It is novel in its overall goal to demonstrate how GIS tools can integrate health care data and public databases to identify community partners to form health coalitions. The aims of this investigation were to identify the clusters of ED utilization for pediatric asthma, evaluate sociodemographic features of the population within the clusters, and identify potential primary care and school partners to create prevention programs.

Methods

Data Sources

The California Health and Human Services Open Data Portal provides data on patient visits to 450 nonmilitary EDs in California. We obtained 2012 ZIP code-level summarized counts and rates for patients younger than 18 years discharged with International Classification of Disease 9th revision code 493 for asthma conditions. Primary care office locations and the areas designated by the federal government as primary care shortages in 2010 were obtained through the Office of Statewide Health Planning and Development (OSHPD). School locations were provided through ArcGIS as a layer sourced from the California Spatial Data Clearinghouse. For simplicity of demonstration, the top 3 clusters were used for the model. ZIP codes identified within these clusters were matched to sociodemographic information obtained from the 2008-2012 American Community Survey summary file.

Spatial Data Preparation

We mapped age-adjusted ED visit rates by patient ZIP code using ArcGIS 10.2.1 and performed a spatial scan statistic in Satscan to assess the geographic distribution of ED utilization. The primary goal of the scan statistic is to identify the collection of rates least consistent with the null hypothesis, which states the ED visits for asthma are randomly distributed in geographic space and the expected

rates are proportional to the population at risk. The scan statistic uses a circular window of varying sizes as it moves methodically across all locations in the study area calculating the likelihood ratio to provide a measure of how unlikely it would be to encounter the observed excess of cases. A cluster with $P < .05$ was considered to be statistically significant. The statistic performed 999 simulations and reported nonoverlapping clusters. This model only considered Gini clusters. We then characterized the demographic, social, and economic attributes of the cluster population. Last, we identified candidate partners by identifying schools located within 0.5- and 1-mile radii of the primary care centers.

Results

There were 181 720 ED visits for asthma for all age groups in 2012 with 70 127 visits for children younger than 18 years. The median ED visit rate across 971 reporting ZIP codes was 67 per 10 000 children younger than 18 years (95% CI 73.2-78.8 per 10 000). Spatial analysis revealed the top geographic clusters for ED utilization rates were located in Fresno, Inglewood, and Richmond City (Figure 1). The likelihood ratios (LLRs) were 486.3, 387.8, and 230.6, respectively; all 3 clusters had $P < .001$ (Table 1a). Populations within these clusters demonstrated high rates of unemployment and families living in poverty. In Fresno and Inglewood clusters, the population was largely Hispanic, 59.5% and 53.2%, respectively, while 22.1% of the population in Richmond City cluster were African American. Children across all clusters had high rates of insurance coverage with most children participating in public insurance (Table 1b). More than 75% of the geographic areas within Fresno and Inglewood clusters were identified as a primary care shortage area (Supplemental Figure). Schools and households located within a half-mile and a one-mile radius of a primary care clinic are depicted for each of the 3 clusters in Figure 2a-c.

Discussion

The purpose of this article was to increase the literature base in GIS applications in the planning of community coalitions. GIS has been essential to industries in business, marketing, and environmental assessments, but its adoption into health care has been relatively slow in comparison.²⁰ Its application has typically been limited to display health utilization or disease data and illustrating the locations of service provision.^{18,21,22} In the medical literature, it is seldom used to display these elements together on the same map.²³ Our project uniquely combines pediatric health utilization data and primary care centers with the location of potential coalition partners all on one map. This technique thus

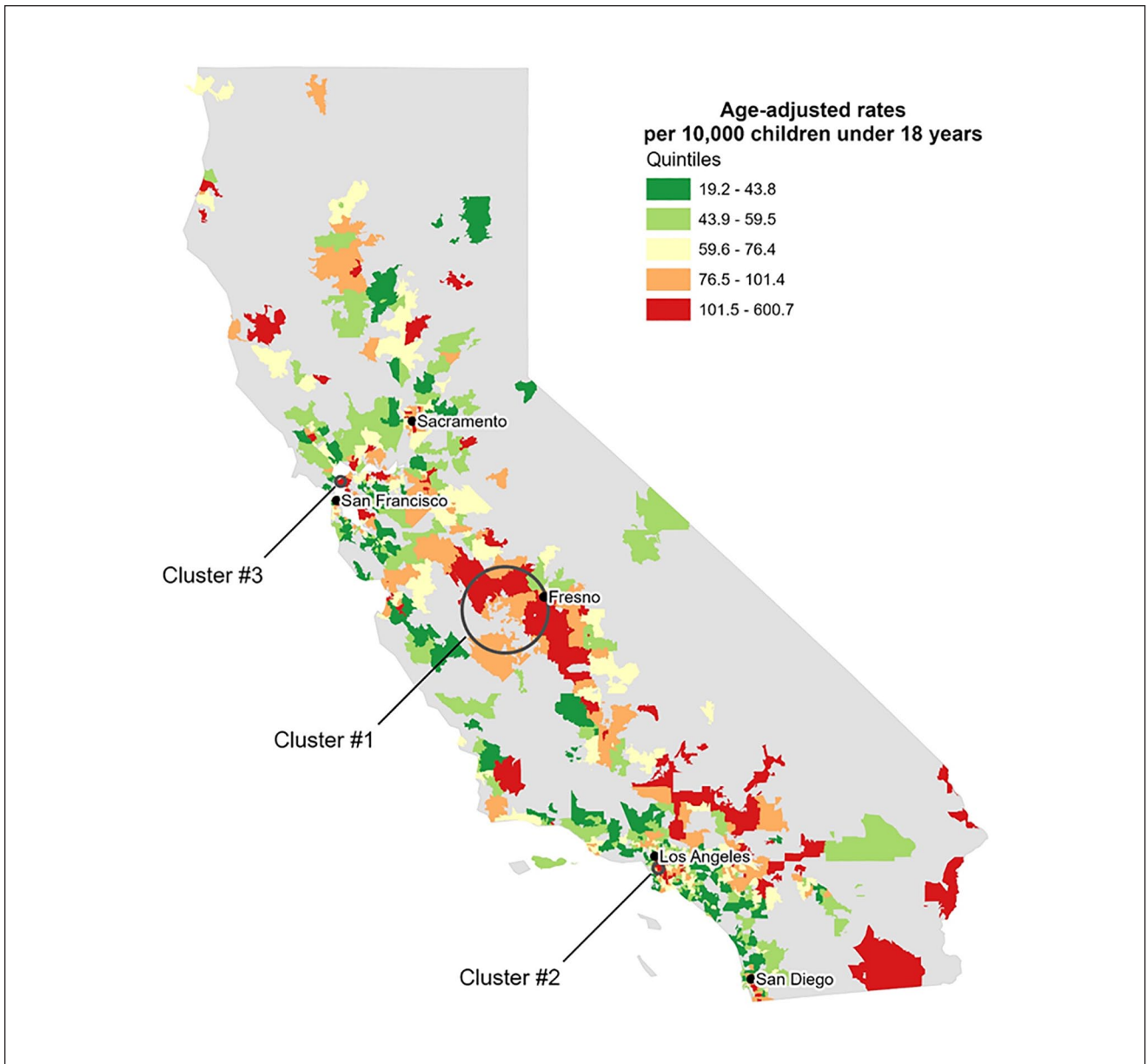


Figure 1. California asthma emergency department (ED) visits by ZIP code, 2012. Three clusters for pediatric ED utilization rates for asthma were located in Fresno, south of Los Angeles, and north of San Francisco.

becomes an important tool for clinicians and local organizations who desire form community-based partnerships to address health disparities.^{24,25}

GIS has provided greater understanding of child health issues ranging from gun violence, pediatric poisoning, to vaccination rates.^{19,26-28} One of the most impactful application of GIS in child health has been in its role in blood lead level screening. Researchers compiled surveillance data and information on the built environment to assess children’s risk for lead poisoning.

These efforts have resulted in geographically targeted, specific intervention measures to reduce children’s exposure to lead.^{17,29,30}

Understanding where health disparities exist is an important first steps in developing strong community coalitions. While traditional statistical methods seek the central tendency of the data without regard to geography, spatial analysis is different as it takes location into account to identify the outliers of data. This aspect makes it a powerful tool for improving health equity. Moreover,

Table 1. Population demographics for top three clusters of pediatric ED utilization rates for asthma in 2012.

Table 1a	Fresno cluster	Inglewood cluster	Richmond cluster	
Cluster rank	1	2	3	
P	<.001	<.001	<.001	
Observed cases	2646	2540	743	
Expected cases	1361	1394	301	
Relative risk	2.0	1.9	2.5	
Area in primary care shortage	75.9%	77.4%	8.5%	
Number of primary care clinics	43	25	8	
Number of school districts	17	3	1	

Table 1b	Fresno Cluster	Inglewood Cluster	Richmond Cluster	California
Total population	521 861	608 958	142 130	37 325 068
Male, %	50.2	47.7	49.0	49.7
Non-Hispanic white, %	23.9	4.0	18.5	40.1
Non-Hispanic black or African American, %	5.5	38.6	22.1	5.8
American Indian and Alaska Native alone, %	0.4	0.2	0.3	0.4
Asian alone, %	8.6	2.0	15.6	13.0
Native Hawaiian and Other Pacific Islander alone, %	0.1	0.3	0.3	0.4
Other race alone, %	0.2	0.4	0.3	0.2
Two or more races, %	1.8	1.4	2.5	2.5
Hispanic or Latino, %	59.5	53.2	40.4	37.6
Less than high school diploma, %	34.5	33.6	24.1	19.0
High school dropout rate, %	8.9	7.1	8.7	4.8
Unemployment, %	14.3	12.9	13.0	11.0
Families living below poverty level, %	24.8	24.0	14.5	11.5
Younger than 18 years with health insurance, %	91.2	86.9	87.7	91.2
Public insurance coverage, %	69.9	64.6	53.9	37.55

this method can also provide measures by which coalitions might gauge their impact. In this case, data on ED asthma visits could be compared before and after implementing interventions.

Limitations

This investigation has important limitations. The 2012 health care utilization data used here may not be useful in forming present-day coalitions; however, the methods demonstrated here could be applied to do so. Additionally, California's OSHPD provides public information regarding California's health care infrastructure. This robust database may not be available in other states. This model might advocate for similar investments in such data infrastructure to improve overall health equity. Our model does not incorporate qualitative methods to ensure successful community collaboratives.^{22,31,32} Qualitative methods are recommended to further develop the understanding of health care access and provision²⁰ and to validate the geospatial model.³³

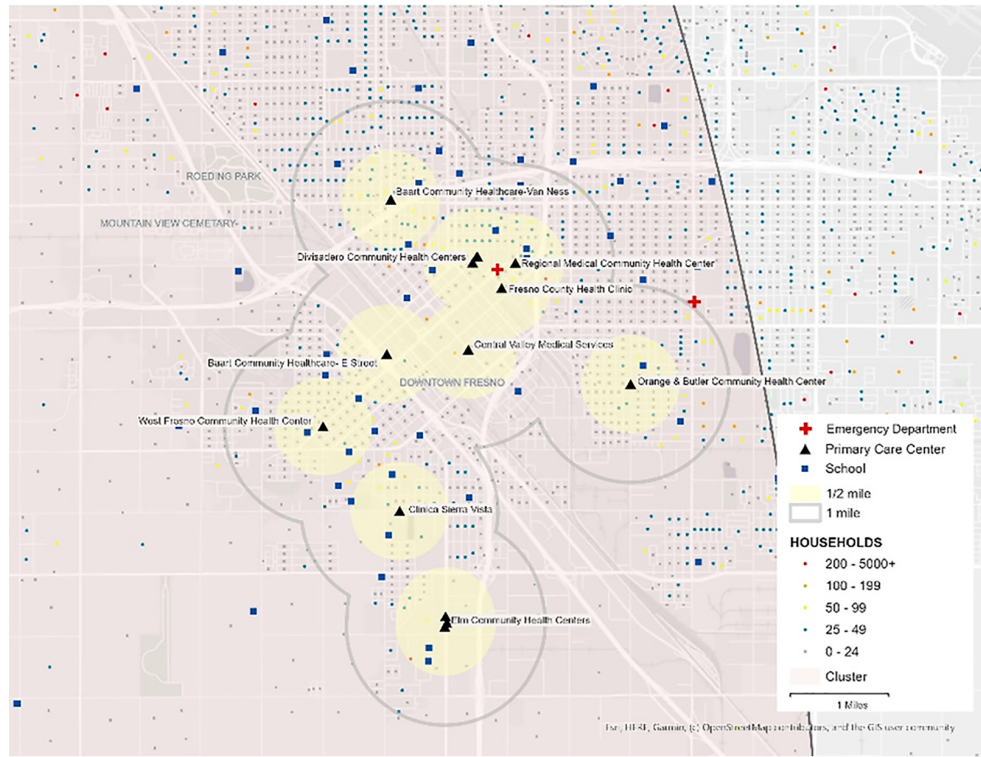
In terms of cluster identification, there exist several spatial analysis techniques with no single technique

identified as the gold standard. While the spatial scan technique is widely accepted, one might choose to apply an additional spatial technique to confirm cluster identification. Moreover, the spatial scan technique presumes clusters are circular; if there are gaps within the cluster, this technique will not demonstrate it. Despite these limitations, the spatial scan statistic can be applied to any disease process to generate information vital to improving health in local communities. Because the model only analyzed data from a single calendar year, to ensure these clusters persist over time, further iterations would include ED visit data over several years.

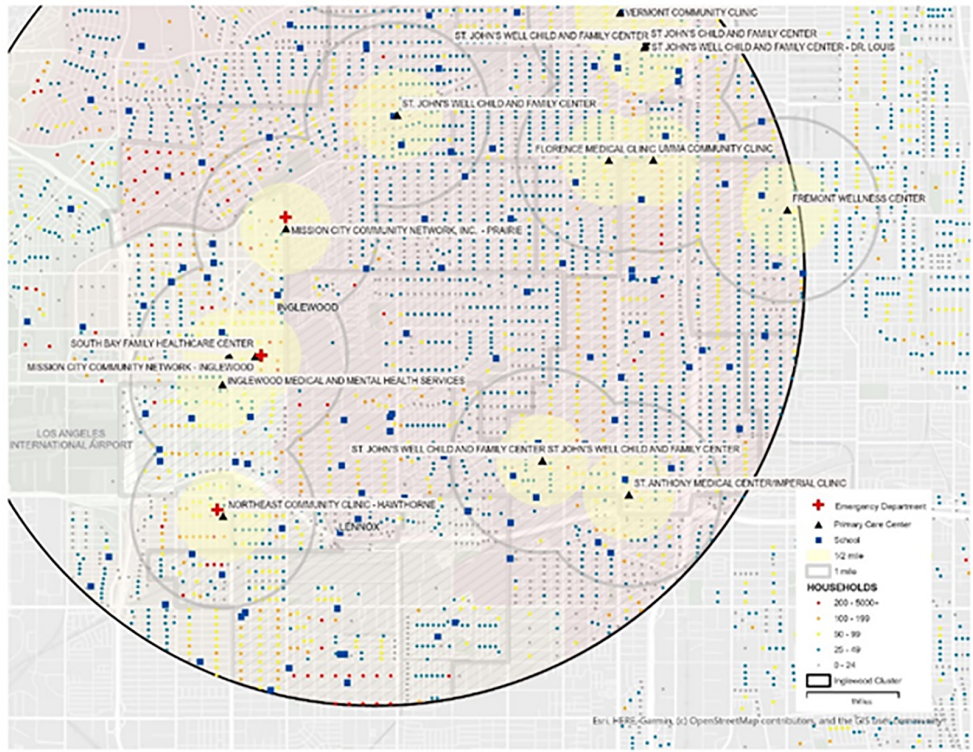
This model was limited to primary care and schools as community partners. Other potential candidates could include and are not limited to local youth athletic clubs, faith-based organizations and even local businesses.

Conclusion

This study demonstrates a model to help clinicians understand how GIS can aid in the selection and creation of coalition building. This is a potentially powerful tool in the addressing child health disparities.



(a)



(b)

Figure 2. (continued)

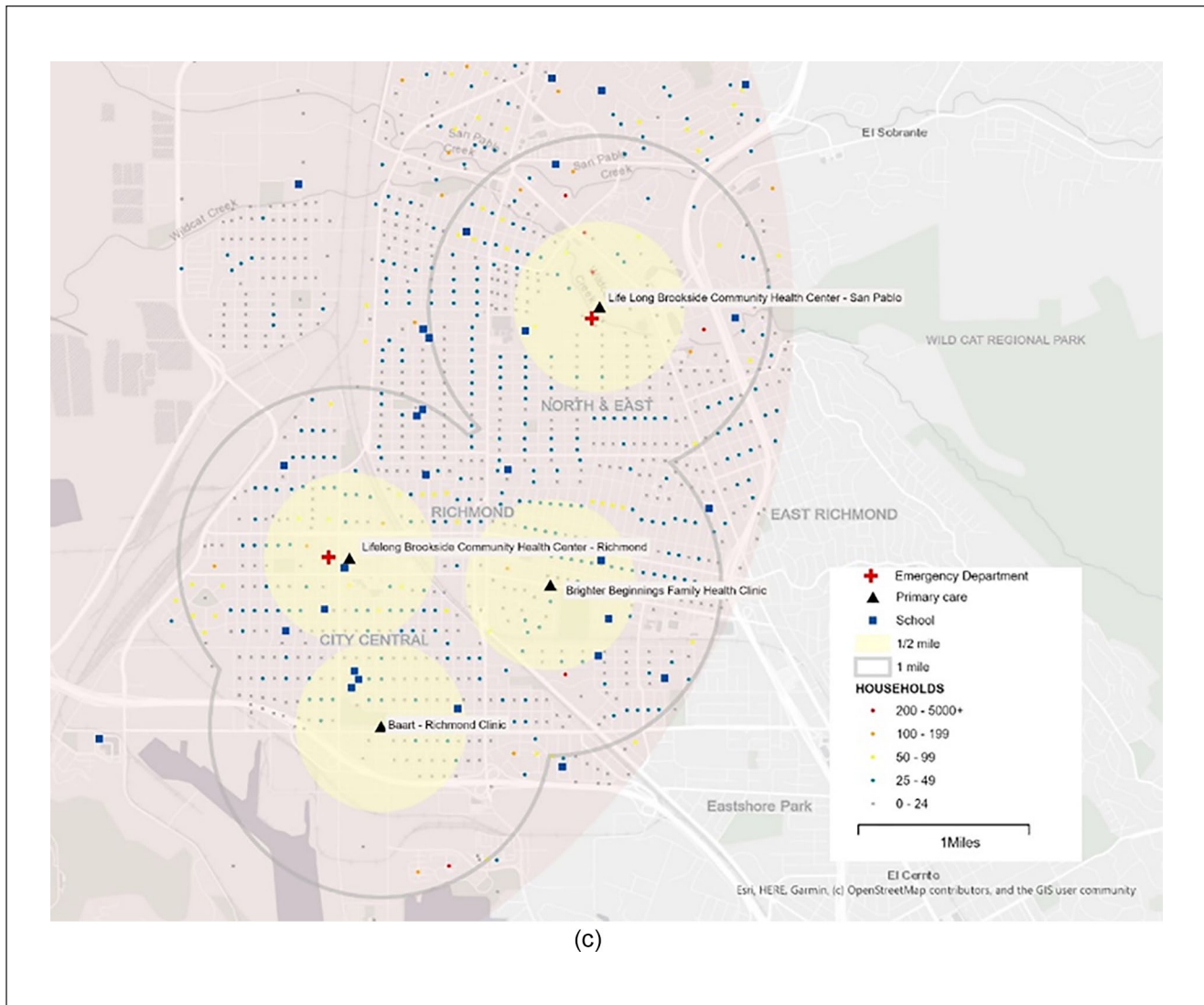


Figure 2. (a) Fresno cluster. (b) Inglewood cluster. (c) Richmond cluster.

Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

References

1. Akinbami LJ, Moorman JE, Bailey C, et al. Trends in asthma prevalence, health care use, and mortality in the United States, 2001-2010. *NCHS Data Brief*. 2012;(94):1-8.
2. Weir LM, Hao Y, Owens P, Washington R. *Overview of Children in the Emergency Department, 2010*. HCUP Statistical Brief #157. Agency for Healthcare Research and Quality; 2013. Accessed June 22, 2020. <http://www.hcup-us.ahrq.gov/reports/statbriefs/sb157.pdf>
3. Nath JB, Hsia RY. Children's emergency department use for asthma, 2001-2010. *Acad Pediatr*. 2015;15:225-230. doi:10.1016/j.acap.2014.10.011
4. Ostrov BF. Despite efforts, ER visits spike in California kids with asthma. *Kaiser Health News*. Published May 24, 2015. Accessed March 28, 2017. <https://ww2.kqed.org/>

- stateofhealth/2015/05/24/despite-efforts-er-visits-spike-in-california-kids-with-asthma/
5. Woods ER, Bhaumik U, Sommer SJ, et al. Community Asthma Initiative: evaluation of a quality improvement program for comprehensive asthma care. *Pediatrics*. 2012;129:465-472. doi:10.1542/peds.2010-3472
 6. Woods ER, Bhaumik U, Sommer SJ, et al. Community Asthma Initiative to improve health outcomes and reduce disparities among children with asthma. *MMWR Suppl*. 2016;65:11-20. doi:10.15585/mmwr.su6501a4
 7. Carcel CM, Amaro S, Sowa F, Morphew T, Galant SP. The impact of home visits on retention in a low-income school based mobile asthma clinic. *J Allergy Clin Immunol*. 2007;119(suppl 1):S80. doi:10.1016/j.jaci.2006.11.339
 8. Brown AS, Disler S, Burns L, et al. Family and home asthma services across the controlling asthma in American cities project. *J Urban Health*. 2011;88(suppl 1):100-112. doi:10.1007/s11524-010-9472-2
 9. Crocker DD, Kinyota S, Dumitru GG, et al. Effectiveness of home-based, multi-trigger, multicomponent interventions with an environmental focus for reducing asthma morbidity: a community guide systematic review. *Am J Prev Med*. 2011;41(2 suppl 1):S5-S32. doi:10.1016/j.amepre.2011.05.012
 10. Cloutier MM, Wakefield DB. Translation of a pediatric asthma-management program into a community in Connecticut. *Pediatrics*. 2011;127:11-18. doi:10.1542/peds.2010-1943
 11. Liao O, Morphew T, Amaro S, Galant SP. The Breathmobile™: a novel comprehensive school-based mobile asthma care clinic for urban underprivileged children. *J Sch Health*. 2006;76:313-319. doi:10.1111/j.1746-1561.2006.00119.x
 12. Cicutto L, Gleason M, Szeffler SJ. Establishing school-centered asthma programs. *J Allergy Clin Immunol*. 2014;134:1223-1230. doi:10.1016/j.jaci.2014.10.004
 13. Guo JJ, Jang R, Keller KN, McCracken AL, Pan W, Cluxton RJ. Impact of school-based health centers on children with asthma. *J Adolesc Health*. 2005;37:266-274. doi:10.1016/j.jadohealth.2004.09.006
 14. Huffaker M, Phipatanakul W. Introducing an environmental assessment and intervention program in inner-city schools. *J Allergy Clin Immunol*. 2014;134:1232-1237. doi:10.1016/j.jaci.2014.09.010
 15. Simoneau T, Langton CR, Kuo CL, et al. A school nurse-led asthma program reduces absences: evaluation of easy breathing for schools. *Acad Pediatr*. 2020;20:73-80. doi:10.1016/j.acap.2019.07.007
 16. Taveras EM, Marshall R, Sharifi M, et al. Connect for health: design of a clinical-community childhood obesity intervention testing best practices of positive outliers. *Contemp Clin Trials*. 2015;45(pt B):287-295. doi:10.1016/j.cct.2015.09.022
 17. Vaidyanathan A, Staley F, Shire J, et al. Screening for lead poisoning: a geospatial approach to determine testing of children in at-risk neighborhoods. *J Pediatr*. 2009;154:409-414. doi:10.1016/j.jpeds.2008.09.027
 18. Teach SJ, Guagliardo MF, Crain EF, et al. Spatial accessibility of primary care pediatric services in an urban environment: association with asthma management and outcome. *Pediatrics*. 2006;117(4 pt 2):S78-S85. doi:10.1542/peds.2005-2000E
 19. Fu LY, Cowan N, McLaren R, Engstrom R, Teach SJ. Spatial accessibility to providers and vaccination compliance among children with Medicaid. *Pediatrics*. 2009;124:1579-1586. doi:10.1542/peds.2009-0233
 20. Shaw NT. Geographical Information Systems and Health: current state and future directions. *Healthc Inform Res*. 2012;18:88-96. doi:10.4258/hir.2012.18.2.88
 21. Mudd AE, Michael YL, Melly S, Moore K, Diez-Roux A, Forrest CB. Spatial accessibility to pediatric primary care in Philadelphia: an area-level cross sectional analysis. *Int J Equity Health*. 2019;18:76. doi:10.1186/s12939-019-0962-x
 22. McLafferty SL. GIS and health care. *Annu Rev Public Health*. 2003;24:25-42. doi:10.1146/annurev.publhealth.24.012902.141012
 23. Dubowitz T, Williams M, Steiner ED, et al. Using Geographic Information Systems to match local health needs with public health services and programs. *Am J Public Health*. 2011;101:1664-1665. doi:10.2105/AJPH.2011.300195
 24. Topmiller M, Jacquez F, Vissman AT, Raleigh K, Miller-Francis J. Partnering with youth to map their neighborhood environments: a multi-layered GIS approach. *Fam Community Health*. 2015;38:66-76. doi:10.1097/FCH.0000000000000050
 25. Israel BA, Parker EA, Rowe Z, et al. Community-based participatory research: lessons learned from the centers for children's environmental health and disease prevention research. *Environ Health Perspect*. 2005;113:1463-1471. doi:10.1289/ehp.7675
 26. Bayouth L, Lukens-Bull K, Gurien L, Tepas JJ, Crandall M. Twenty years of pediatric gunshot wounds in our community: have we made a difference? *J Pediatr Surg*. 2019;54:160-164. doi:10.1016/j.jpedsurg.2018.10.003
 27. Lieu TA, Ray GT, Klein NP, Chung C, Kulldorff M. Geographic clusters in underimmunization and vaccine refusal. *Pediatrics*. 2015;135:280-289. doi:10.1542/peds.2014-2715
 28. Nguyen MB, Pizon AF, Branas CC, Fabio A. Regional variations in pediatric medication exposure: spatial analysis of poison center utilization in Western Pennsylvania. *Clin Toxicol (Phila)*. 2016;54:47-52. doi:10.3109/15563650.2015.1113543
 29. Akkus C, Ozdenerol E. Exploring childhood lead exposure through GIS: a review of the recent literature. *Int J Environ Res Public Health*. 2014;11:6314-6334. doi:10.3390/ijerph110606314
 30. Centers for Disease Control and Prevention. Screening young children for lead poisoning: guidance for state and local public health officials. Accessed April 28, 2013. <http://www.cdc.gov/nceh/lead/publications/screening.htm>
 31. Dyck I. Using qualitative methods in medical geography: deconstructive moments in a subdiscipline? *Prof Geogr*. 1999;51:243-253. doi:10.1111/0033-0124.00161
 32. Cutchin MP. Qualitative explorations in health geography: using pragmatism and related concepts as guides. *Prof Geogr*. 1999;51:265-274. doi:10.1111/0033-0124.00163
 33. Dulin MF, Ludden TM, Tapp H, et al. Using Geographic Information Systems (GIS) to understand a community's primary care needs. *J Am Board Fam Med*. 2010;23:13-21. doi:10.3122/jabfm.2010.01.090135