Title

Geospatial data in pediatric asthma in the United States: a scoping review protocol.

Journal

JBI Evidence Synthesis, 20(11)

Authors

Cushing, Anna

Khan, Masrur

Kysh, Lynn

et al.

Publication Date

2022-11-01

DOI

10.11124/JBIES-21-00284

Peer reviewed

HHS Public Access

Author manuscript

JBI Evid Synth. Author manuscript; available in PMC 2023 November 01.

Published in final edited form as:

JBI Evid Synth. ; 20(11): 2790–2798. doi:10.11124/JBIES-21-00284.

Geospatial data in pediatric asthma in the United States: a scoping review protocol

Anna M. Cushing[1,*], **Masrur A. Khan**[2,*], **Lynn Kysh**[3], **Whitney S. Brakefield**[4,5], **Nariman Ammar**[5], **Danica B. Liberman**[1,6], **John Wilson**[7], **Arash Shaban-Nejad**[5], **Juan Espinoza**[2,6]

[1]Division of Emergency and Transport Medicine, Children's Hospital Los Angeles, Los Angeles, CA, United States

[2]Department of Pediatrics, Children's Hospital Los Angeles, Los Angeles, CA, United States

[3]Institute for Nursing and Interprofessional Research, Children's Hospital Los Angeles, Los Angeles, CA, United States

[4]Bredesen Center for Data Science and Engineering, University of Tennessee, Knoxville, TN, United States

[5]Oak Ridge National Laboratory Center for Biomedical Informatics, Department of Pediatrics, College of Medicine, University of Tennessee Health Science Center, Memphis, TN, United States

[6]Department of Pediatrics, Keck School of Medicine, University of Southern California, Los Angeles, CA, United States

[7]Spatial Sciences Institute, Dornsife College of Letters, Arts and Sciences, University of Southern California, Los Angeles, CA, United States

Abstract

Objective: The objective of this scoping review is to identify and describe the literature on the use of geospatial data in pediatric asthma research.

Introduction: Asthma is one of the most common pediatric chronic diseases in the United States, disproportionately affecting low-income patients. Asthma exacerbations may be triggered by local environmental factors, such as air pollution or exposure to indoor allergens. Geographic information systems are increasingly recognized as tools that use geospatial data to enhance understanding of the link between environmental exposure, social determinants of health, and clinical outcomes. Geospatial data in pediatric asthma may help inform risk factors for asthma severity, and guide targeted clinical and social interventions.

Corresponding author: Juan Espinoza, MD, jespinoza@chla.usc.edu.

*AMC and MAK are co-first authors and contributed equally to this work.

Author contributions

AMC conceptualized the study design, participated in the design of the search strategy, and drafted and revised the manuscript. MAK participated in study design and drafted and revised the manuscript. LK designed the search strategy, and drafted and revised the manuscript. WSB, NA, DBL, JW, and ASN assisted in study and search strategy design and revised the manuscript. JE conceptualized the study design, oversaw design of the search strategy, and revised the manuscript.

Conflicts of interest

The authors declare no conflicts of interest.

Inclusion criteria: This review will consider studies that utilize geospatial data in the evaluation of pediatric patients with asthma, ages 2 to 18 years, in the United States. Mixed samples of adults and children will also be considered. Geospatial data will include any external non-clinical geographic-based data source that uses a patient's environment or context.

Methods: The following databases will be searched: PubMed, Embase, Cochrane CENTRAL, CINAHL, ERIC, Web of Science, and IEEE. Gray literature will be searched in DBLP, the US Environmental Protection Agency, Google Scholar, Google search, and a hand search of recent abstracts from relevant conferences. Articles published in English, Spanish, and French from 2010 to the present will be included. Study screening and selection will be performed independently by two reviewers. Data extraction will be performed by a trained research team member following pilot testing.

Keywords

asthma; geospatial; GIS; pediatrics

Introduction

Asthma is one of the most common pediatric chronic diseases, affecting more than 5 million children in the United States.[1] In 2018 alone, children with asthma exacerbations accounted for nearly 770,000 emergency department visits and more than 74,000 inpatient hospitalizations nationally.[2] Asthma disproportionately affects children of color, those who live in urban environments, and those from a lower socioeconomic status.[1,3] There are also disparities in terms of the quality of asthma care available and access to appropriate asthma medications.[4]

As we acquire more knowledge of the extent of disparities in asthma prevalence and outcomes, researchers and clinicians are increasingly interested in examining the interaction between environmental and social determinants of health and asthma. Such associations are particularly important in children. The onset of asthma is typically during childhood, and pediatric patients are uniquely vulnerable to asthma-related morbidity compared with adults.[5,6] Patients from underserved and high-poverty communities are at higher risk of severe asthma outcomes and are more likely to visit the emergency department for asthma.[7,8] Environmental exposures, including indoor and outdoor air quality and allergens (eg, cockroaches, rodents), are independently associated with worse asthma morbidity.[7,9,10] Importantly, these factors are closely linked, with patients from a lower socioeconomic status having higher rates of exposure to environmental triggers.[11,12]

A geographic information system (GIS) is a powerful tool that generates geospatial data that can be combined with health data to detect the relationships and patterns between a patient’s environment and their health. It can allow for spatial analysis of disease, associating and stratifying risk factors, health service planning, or new health technology development.[13,14] Geographic information systems have historically been used primarily in ecological and cross-sectional studies to understand the geographic distribution of diseases. In recent years, the focus has shifted toward understanding geospatial variation in health outcomes.[13,15,16] Other applications of a GIS include identifying service gaps and unmet community needs

to improve resource allocation,[17] spatially mapping environmental factors such as childhood lead exposure,[18] and analyzing neighborhood risk factors for poor outcomes, including perinatal morbidity.[19] With improvements in electronic medical records and the ability to connect clinical and geospatial data directly, there are increasing opportunities to utilize a GIS directly in clinical environments to perform risk stratification and develop real-time interventions.[20,21] The ability of a GIS to combine different types of data based on geography allow them to provide a more complete picture of the complex interplay between health, environmental factors, and social determinants.

A GIS is particularly well-suited for use in pediatric asthma research because of the strong effect of socioeconomic and environmental factors on asthma outcomes.[22] Examples in the literature of geospatial data in pediatric asthma include the relationship between asthma and public housing,[23] the association between low-income and public health insurance and asthma prevalence,[24] the relationship between neighborhood violence and asthma morbidity,[25] and the link between environmental factors, including road density and air pollution, with asthma exacerbations.[26,27] Geographic clustering of patients with asthma can be useful in creating risk-stratification models and targeting community interventions.[28-30] However, the current extent of the literature addressing geospatial data in pediatric asthma is not yet known. A GIS is a technical and software-driven field that is evolving quickly. As such, a scoping review is needed to describe the most current literature available, which can be used to inform future directions for research and integration of geospatial data into clinical decision-making and clinical practice.[31]

One unique aspect of geospatial data is their highly contextual nature that depend on the political and administrative organization of geographic regions. Geospatial systems are often deployed at the national or sub-national (eg, states, cities) level, and the available data can range widely both in terms of geographic granularity and variables collected. Although systems for spatial mapping and analysis are global, and the intent to use data to improve patient outcomes is shared, the variables depend on the country. To address this issue, we will focus on one country, the United States, so that the articles reviewed will share similar variables and levels of granularity. This review can then be used to generate a framework of classes or domains, which can be expanded and enriched with variables from other regions, as we work toward developing a more global understanding of GIS use in pediatric asthma.

A preliminary search of PROSPERO, MEDLINE, the Cochrane Database of Systematic Reviews, and *JBI Evidence Synthesis* was conducted and only one previous scoping review was found on the topic of geospatial data in asthma.[32] The identified review was not specific to pediatric asthma and was limited to articles found in medical literature databases, whereas the review we propose will also include geography, geographic information science, informatics, and gray literature sources. No other current or in-progress scoping reviews or systematic reviews on the topic were identified.

This scoping review aims to map the available literature on the use of geospatial data in pediatric asthma within the United States. The specific objectives of the scoping review are to:

i. Determine the type and amount of currently published literature using geospatial data in pediatric asthma research and care

ii. Describe the characteristics of the existing literature on the subject, including data types, outcomes studied, analytic approaches, and applications.

Review question

What are the study characteristics, data types, and applications of geospatial data in pediatric asthma in the United States?

Inclusion criteria

Participants

This review will consider studies that include children ages 2 to 18 years of age with a diagnosis of asthma. Mixed samples of adults and children with asthma will also be considered. Studies that use any diagnosis of asthma regardless of disease severity, controller medication usage, or presence of other comorbidities will be included. Studies that pertain only to other non-asthma respiratory diseases will be excluded. Studies in which all participants are younger than 2 years of age will be excluded because of the challenge of accurately diagnosing asthma in young children, and the clinical overlap with other non-asthma respiratory diagnoses, such as bronchiolitis.[33] Studies in which the participants do not have a diagnosis of asthma or in which all study participants are 19 years or older will also be excluded.

Concept

We will consider studies in which geospatial data are used. We define this as any external non-clinical geographic-based data source that uses a patient's environment or context, including government agency data, census data, community-level socioeconomic data, or environmental data. We will include all sources of geospatial data, such as the US Census Bureau, the US Environmental Protection Agency, the Centers for Disease Control and Prevention, and the US Department of Housing and Urban Development. Studies that examine electronic health record or personal patient data without any connection to geographic-based data sources will be excluded. We will consider studies that use all types of geographic-based data applications, including clustering of disease or disease outcomes, the relationship between geospatial data and clinical outcomes, and development of new composite indices.

Context

We will include studies that take place in the United States or US territories in any clinical or non-clinical setting. Studies that have a mixed national and international sample will be included. Studies that take place exclusively outside of the United States and US territories will be excluded because of the highly contextual nature of social determinants of health and the available geospatial data.

Types of sources

This scoping review will consider all study designs, including quantitative, qualitative, and mixed methods analyses; editorials; commentaries; and quality improvement studies. In addition, primary literature citations from systematic and scoping reviews will be considered.

Methods

The proposed scoping review will be conducted in accordance with the JBI methodology for scoping reviews.[34]

Search strategy

The search strategy will aim to locate both published and unpublished primary studies and reviews. A medical librarian (LK) created PubMed (National Library of Medicine) and Embase (Elsevier) search strategies using a combination of controlled vocabularies (Medical Subject Headings [MeSH] and Excerpta Medica Database Subject Headings [EMTREE]) and keywords for the concepts of GIS or geospatial data, pediatrics, and asthma. Team members reviewed the strategies and results to edit and improve the search strategy. With approval of the team, the librarian will create customized search strategies using controlled vocabularies (when available) and keywords in the remaining pre-identified databases. See Appendix I for the PubMed (NLM) search details. The search strategy, including all identified keywords and index terms, will be adapted for each included information source. The reference lists of articles included in the review will be screened for additional papers.

Articles published in English, Spanish, and French from 2010 to the present will be included, as these are the languages used by the reviewers. Due to the rapidly changing nature of geospatial data and its reliance on new technologies and methods, we will include only studies that are published in 2010 or later to capture modern data elements and data types. This is in line with the newer availability of data sources in pediatric asthma including the American Community Survey (2005-) and the Child Opportunity Index, which is based on the 2010 census.

We will search and report the search strategies so that they can be replicated for the following literature databases: PubMed (National Library of Medicine), Embase (Elsevier), Cochrane CENTRAL (Wiley), CINAHL (EBSCO), ERIC (EBSCO), Web of Science (Clarivate), and IEEE Xplore.

We will search gray literature in the following sources: DBLP (computer science bibliography website), the US Environmental Protection Agency, the first 200 citations in Google Scholar, and the first five pages of results in a Google search. We will also perform hand searches of the most recent two years of abstracts from the following conferences when available: American Academy of Pediatrics ; American Academy of Allergy, Asthma, and Immunology; American Thoracic Society; Chest; American Medical Informatics Association; Health Information Management Systems Society; Pediatric Academic Societies; ACM SIGSPATIAL Advances in Geographic Information Systems;

American Association of Geographers; University Consortium for Geographic Information Science; and medRXiv.

Study/source of evidence selection

Following the search, all identified records will be collated and uploaded into EndNote X9 (Clarivate Analytics, PA, USA) and duplicates removed. Prior to starting the review process, we will perform pilot testing, which will consist of independent review of 40 abstracts by each research team member who is participating in article review. The team will then meet and discuss the pilot-tested abstracts to ensure a consensus understanding of the inclusion and exclusion criteria. Following pilot testing, titles and abstracts will be imported into Covidence (Veritas Health Innovation, Melbourne, Australia), an online systematic review management system. Each reference will be independently reviewed for eligibility by two members of the research team, and any disagreements will be resolved by a third reviewer. All potentially eligible references will be uploaded in full into Covidence for the second phase of review.

The full text of selected citations will be assessed in detail against the inclusion criteria by two independent reviewers. Reasons for exclusion of full-text papers that do not meet the inclusion criteria will be recorded and reported in the scoping review. Citations for articles that are excluded on the basis of language will be included as an appendix. The results of the search will be reported in full in the final scoping review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.[35]

Data extraction

Manuscript data will be extracted and uploaded into a Google form by the reviewers. Pilot testing will be performed by all reviewers prior to data extraction, which will consist of independent data charting of 10 articles. Changes and clarifications to the data extraction tool will be made based on research team feedback from the pilot testing. Data extraction will then be performed for each manuscript by a trained research team member. The data extracted will include specific details about the provenance, study methodology, patient demographics (including personal socioeconomic status), asthma-related factors and outcomes (including asthma severity and health care utilization), and geospatial data elements relevant to the review question. Appendix II contains the data that we intend to extract for this review. The data extraction tool will be modified and revised as necessary during the process of extracting data from each included paper. Any modifications will be detailed in the full scoping review. The authors of primary studies will be contacted for clarification or missing information when needed.

Data analysis and presentation

The research team will utilize the data extracted from included manuscripts to examine frequencies and percentages of data categories and to understand the geospatial data types and characteristics as well as the applications of these data in pediatric asthma. We expect that our approach combining a broad search of known databases and gray literature will lead to an enhanced understanding of the existing literature using geospatial data in pediatric asthma. Our review will provide future researchers with information on existing data, gaps

in research, and areas in need of future exploration. We hope this will guide researchers and clinicians alike toward increasing the use of geospatial data in pediatric asthma risk stratification and targeting interventions toward the most vulnerable patients.

Funding

This work was supported by grants UL1TR001855 and UL1TR000130 from the National Center for Advancing Translational Science (NCATS) of the US National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Appendix I: Search strategy

Database name: PubMed **Database vendor: National Library of Medicine** **Database coverage: 1946 – present** **Date last searched: July 28, 2021**		
PCC	**Search string**	**Records retrieved**
Population	(Infant[Mesh] OR Child[Mesh] OR Adolescent[Mesh] OR Pediatrics[Mesh] OR Hospitals, Pediatric[Mesh] OR Schools[Mesh:NoExp] OR infan* OR newborn OR baby OR babies OR nursery OR toddler OR "pre school*" OR preschool* OR child* OR kid OR kids OR juvenile OR youth OR youngster OR boy OR boys OR girl OR girls OR kindergarten* OR "elementary school*" OR "grade school*" OR "primary school*" OR preadolescen* OR "pre adolescen*" OR preteen* OR "middle school*" OR adolescen* OR teen* OR "high school*" OR pediatric* OR paediatric*)	6,034,689
Concept	(Asthma[Mesh] OR Anti-Asthmatic Agents[Mesh] OR asthma OR asthmatic OR asthmaticus)	213,663
Context	("Geographic Information Systems"[Mesh] OR Spatial Analysis[Mesh] OR Geography, Medical[Mesh] OR GIS OR ((geographic OR geographical OR geographically OR global) AND (information OR informations OR informational OR positioning OR regression OR regressions OR "space time")) OR ((spatial OR spacial OR spatio-temporal OR spatiotemporal OR "spatial temporal" OR "space time") AND (analysis OR analyses OR interpolation OR interpolations OR dependency OR dependencies OR autocorrelat* OR auto-correlat* OR regression OR regressions OR cluster*)) OR "kernel density" OR ((geographic OR geographically OR dasymetric OR choropleth) AND (mapping OR mappings)) OR geographic cartography OR geocoding OR georeferencing OR "medical geography" OR "health geography" OR geomedicine OR geostatistic* OR nosogeograph* OR "medical toPography" OR (predict* AND model* AND (geograph* OR spatial* OR geospatial*)) OR ArcGIS OR ESRI OR BatchGeo OR QGIS eSpatial)	428,327
Population AND Concept AND Context		1528
Date filter	("2010"[Date - Entry] : "3000"[Date - Entry])	**1174**

Appendix II: Data extraction table

Domain	**Item**	**Description**
Provenance	Type	Published article (peer-reviewed or not), conference (poster, podium, abstract), book chapter, thesis/dissertation
	Article subtype	Research, quality improvement, editorial, evidence-based practice project, clinical commentary, literature/narrative review, systematic review or meta-analysis, guidelines
	Title	Listed title
	Year	Publication date, unless not available, then e-publication date
	First author name	Last name, first name, middle initial
	Senior author name	Last name, first name, middle initial

Domain	Item	Description
	Author discipline (first/last)	Engineering, pharmacy, nursing, psychology, social work, rehab, physician (pediatric), physician (non-pediatric), academic research, social sciences, behavioral sciences, trainee/student
	Sector (all)	Industry, university, community hospital, academic medical center, other community organization (reflects employment of all authors)
	Sector primary	Industry, university, community hospital, academic medical center, other community organization (first author)
	Interdisciplinary?	2 categories represented across all authors
	Institution	First author home institution
	Funding (type)	Government, non-government organization, corporate, academic, other, none
	Funding (source)	Name of funder
Study methodology	Registry-driven versus clinical study-driven	Registry: used patients from an existing dataset vs. a clinical study that enrolled patients in a specific setting
	Setting	Inpatient, home, school, community (non-medical), community (medical), ED/urgent care, academic center/hospital
	Number of sites (number of sources contributing patients to registry or number of study sites)	Actual number
	Sample size	Actual number
	Research question category	Health care utilization, disease prevalence, economic burden of disease, symptom control, morbidity and mortality, prevention
	Research design (category)	Observational, experimental, non-research
	Analysis type	Spatial analysis of disease, spatial analysis of health service planning, public health, health technologies and tools
	Application	Disease mapping, association with outcome, risk stratification, predictive model, drive clinical intervention, other
	Research design	Retrospective, prospective observational, randomized controlled trial, quality improvement, cost analysis, qualitative, non-research
	Outcome type	Cost analysis, healthcare utilization, symptom score, QoL, mortality
	Outcome data source	Survey, interview, medical records review, claims data
Population	Age	By groups: preschool child (2-5), school age child (6-12), adolescents (13-18), adults (18+)
	Race/ethnicity	All categories in study according to their demographics
	Sex	As reported
	Language (spoken by participants, as described in eligibility criteria or participant demographics)	Spanish, English, other
	Insurance type (as described in eligibility criteria or participant demographics)	Public, private, no insurance
	Limited English proficiency	Percent reported, not reported
	Personal social determinants of health variables	Did the study evaluate personal/patient social determinant factors? If so, which ones: health and health care, education, economic stability, social and community context, neighborhood and built environment, named indices, other

Domain	Item	Description
Asthma	Asthma severity (as described in eligibility criteria or participant demographics)	Intermittent, mild persistent, moderate persistent, severe persistent, persistent (not specified)
	Hospitalization	Did this study look at hospitalization outcomes? If so, which ones? Number of hospitalizations, LOS, readmission, other
	ED/urgent care visits	Did this study look at ED/urgent care outcomes? If so, which? Number of visits, rate of admission, return visit, LOS, other
	ICU admissions	Did this study look at ICU outcomes? If so, which ones? Number of admissions, LOS, morbidity, mortality, other
	Cost variables	Did this study look at cost? If so, which variable: medications, provider fees, hospital/facility fees, family expenses, other
	Cost	Did this study include cost analysis? If so, how: claims data, modeled data, self-reported data, provider billing data, other
	Missed school days	Did this study track missed school days? Yes/No
	Quality of life	Did this study assess QoL? If so, how? patient/parent/provider QoL, health-related QoL
	Pulmonary function	Did this study measure pulmonary function? If so which components: peak flow, FEV_1, FEV_1/FVC, FVC, $FEF_{25-75\%}$
Geographic information system	Time dimension	Cross-section, longitudinal, seasonal, 5-year average, real-time, 10-year average, other
	Space dimension (ie, spatial units)	Zip code, city, county, state, census division, core based statistical area, census tract, census block group, census block, non-standard unit, other
	Data sources	10-year Census, American Community Survey, Air Quality System, Environmental Protection Agency, California EnviroScreen, US Department of Agriculture, Department of Housing and Urban Development, state or local health department, American Healthy Homes Survey, American Housing Survey, National Ambulatory Medical Care Survey, National Health Interview Survey, other
	Data types	Average, peak, minimum, imputed, other
	Geospatial variable domains	Health and health care, education, economic stability, social and community context, neighborhood and built environment, named indices, other
	New index development	Did the authors develop or propose a new index?

ED, emergency department; FEF25-75, forced expiratory flow at 25%-75% of vital capacity; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; ICU, intensive care unit; LOS, length of stay; QoL, quality of life

References

1. Centers for Disease Control and Prevention. Most recent national asthma data [internet]. Asthma: data, statistics, and surveillance. 2021 [cited 2021 Jun 21]. Available from: https://www.cdc.gov/asthma/most_recent_national_asthma_data.htm.
2. Centers for Disease Control and Prevention. Asthma-related healthcare use [internet]. Asthma: data, statistics, and surveillance. 2021 [cited 2021 Jun 21]. Available from: https://www.cdc.gov/asthma/national-surveillance-data/healthcare-use.htm.
3. Stingone JA, Ramirez OF, Svensson K, Claudio L. Prevalence, demographics, and health outcomes of comorbid asthma and overweight in urban children. J Asthma. 2011;48(9):876–85. [PubMed: 21958346]
4. Williams DR, Sternthal M, Wright RJ. Social determinants: taking the social context of asthma seriously. Pediatrics. 2009;123(Suppl 3):S174–84. [PubMed: 19221161]
5. Federico MJ, McFarlane AE, Szefler SJ, Abrams EM. The impact of social determinants of health on children with asthma. J Allergy Clin Immunol Pract. 2020;8(6):1808–14. [PubMed: 32294541]

6. Gelfand EW. Pediatric asthma: a different disease. Proc Am Thorac Soc. 2009;6(3):278–82. [PubMed: 19387030]
7. Babin SM, Burkom HS, Holtry RS, Tabernero NR, Stokes LD, Davies-Cole JO, et al. Pediatric patient asthma-related emergency department visits and admissions in Washington, DC, from 2001-2004, and associations with air quality, socio-economic status and age group. Environ Heal A Glob Access Sci Source. 2007;6:9.
8. Claudio L, Stingone JA, Godbold J. Prevalence of childhood asthma in urban communities: the impact of ethnicity and income. Ann Epidemiol. 2006;16(5):322–40.
9. Breysse PN, Diette GB, Matsui EC, Butz AM, Hansel NN, McCormack MC. Indoor air pollution and asthma in children. Proc Am Thorac Soc. 2010;7(2):102–6. [PubMed: 20427579]
10. Sheehan WJ, Permaul P, Petty CR, Coull BA, Baxi SN, Gaffin JM, et al. Association between allergen exposure in inner-city schools and asthma morbidity among students. JAMA Pediatr. 2017;171(1):31–8. [PubMed: 27893060]
11. Jabre NA, Keet CA, McCormack M, Peng R, Balcer-Whaley S, Matsui EC. Material hardship and indoor allergen exposure among low-income, urban, minority children with persistent asthma. J Community Health. 2020;45(5):1017–26. [PubMed: 32377967]
12. Goodman JE, Loftus CT, Liu X, Zu K. Impact of respiratory infections, outdoor pollen, and socioeconomic status on associations between air pollutants and pediatric asthma hospital admissions. PLoS One. 2017;12(7):e0180522. [PubMed: 28719626]
13. Lyseen AK, Nøhr C, Sørensen EM, Gudes O, Geraghty EM, Shaw NT, et al. A review and framework for categorizing current research and development in health related geographical information systems (GIS) studies. Yearb Med Inform. 2014;9:110–24. [PubMed: 25123730]
14. Wilson JP. Connecting population, health and place with geospatial tools and data. In: Berrigan D, Berger N, editors. Geospatial Approaches to Energy Balance and Breast Cancer. Engergy Balance and Cancer, volume 15. Springer; 2019:3–27.
15. Jarup L. Health and environment information systems for exposure and disease mapping, and risk assessment. Environ Health Perspect. 2004;112(9):995–7. [PubMed: 15198919]
16. Walsh SJ, Gilchrist A. Geographical clustering of mortality from systemic lupus erythematosus in the United States: contributions of poverty, Hispanic ethnicity and solar radiation. Lupus. 2006;15(10):662–70. [PubMed: 17120593]
17. Walker SC, Hurvitz PM, Leith J, Rodriguez FI, Endler GC. Evidence-based program service deserts: a geographic information systems (GIS) approach to identifying service gaps for state-level implementation planning. Adm Policy Ment Heal. 2016;43(6):850–60.
18. Akkus C, Ozdenerol E. Exploring childhood lead exposure through GIS: a review of the recent literature. Int J Environ Res Public Health. 2014;11(6):6314–34. [PubMed: 24945189]
19. Suplee PD, Bloch JR, Hillier A, Herbert T. Using geographic information systems to visualize relationships between perinatal outcomes and neighborhood characteristics when planning community interventions. J Obstet Gynecol Neonatal Nurs. 2018;47(2):158–72.
20. Soares N, Dewalle J, Marsh B. Utilizing patient geographic information system data to plan telemedicine service locations. J Am Med Informatics Assoc. 2017;24(5):891–6.
21. Spratt SE, Batch BC, Davis LP, Dunham AA, Easterling M, Feinglos MN, et al. Methods and initial findings from the Durham Diabetes Coalition: integrating geospatial health technology and community interventions to reduce death and disability. J Clin Transl Endocrinol. 2015;2(1):26–36. [PubMed: 29159106]
22. Wright R, Subramanian S. Advancing a multilevel framework for epidemiologic research on asthma disparities. Chest. 2007;132(5 Suppl):757S–769S. [PubMed: 17998340]
23. Northridge J, Ramirez OF, Stingone JA, Claudio L. The role of housing type and housing quality in urban children with asthma. J Urban Heal. 2010;87(2):211–24.
24. Vo P, Bair-Merritt M, Camargo CA, Eisenberg S, Long W. Individual factors, neighborhood social context and asthma at age 5 years. J Asthma. 2017;54(3):265–72. [PubMed: 27485524]
25. Beck AF, Huang B, Ryan PH, Sandel MT, Chen C, Kahn RS. Areas with high rates of police-reported violent crime have higher rates of childhood asthma morbidity. J Pediatr. 2016;173:175–182.e1. [PubMed: 26960918]

26. Bozigar M, Lawson A, Pearce J, King K, Svendsen E. A geographic identifier assignment algorithm with Bayesian variable selection to identify neighborhood factors associated with emergency department visit disparities for asthma. Int J Health Geogr. 2020;19(1):9. [PubMed: 32188481]
27. Brandt S, Perez L, Künzli N, Lurmann F, Wilson J, Pastor M, et al. Cost of near-roadway and regional air pollution-attributable childhood asthma in Los Angeles County. J Allergy Clin Immunol. 2014;134(5).
28. Nguyen MB. Aligning partners in pediatric health: using geographical information systems to plan community coalitions. J Prim Care Community Heal. 2020;11:1–7.
29. Beck AF, Huang B, Wheeler K, Lawson NR, Kahn RS, Riley CL. The Child Opportunity Index and Disparities in pediatric asthma hospitalizations across one Ohio metropolitan area, 2011-2013. J Pediatr. 2017;190:200–6. [PubMed: 29144247]
30. Shin EK, Mahajan R, Akbilgic O, Shaban-Nejad A. Sociomarkers and biomarkers: predictive modeling in identifying pediatric asthma patients at risk of hospital revisits. NPJ Digit Med. 2018;1(1):1–5. [PubMed: 31304287]
31. Lewinter KE, Hudson SM, Kysh L, Lara M, Betz CL, Espinoza J. Reconsidering reviews: the role of scoping reviews in digital medicine and pediatrics. NPJ Digit Med. 2020;3(1):158. [PubMed: 33303889]
32. Samuels-Kalow ME, Camargo CA. The use of geographic data to improve asthma care delivery and population health. Clin Chest Med. 2019;40(1):209–25. [PubMed: 30691713]
33. Redddel HK, Bacharier LB, Bateman ED, Brightling CE, Brusselle GG, Buhl R, et al. Global Initiative for Asthma Strategy 2021: executive summary and rational for key changes. Eur Respir J. 2021;59(1):1202730.
34. Peters M, Godfrey C, McInerney P, Munn Z, Trico A, Khalil H. Chapter 11: Scoping reviews. In: Aromatis E, Munn Z, editors. JBI Manual for Evidence Synthesis [internet]. Adelaide: JBI; 2020 [cited 2021 Jun 21]. Available from: https://synthesismanual.jbi.global.
35. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. [PubMed: 33782057]