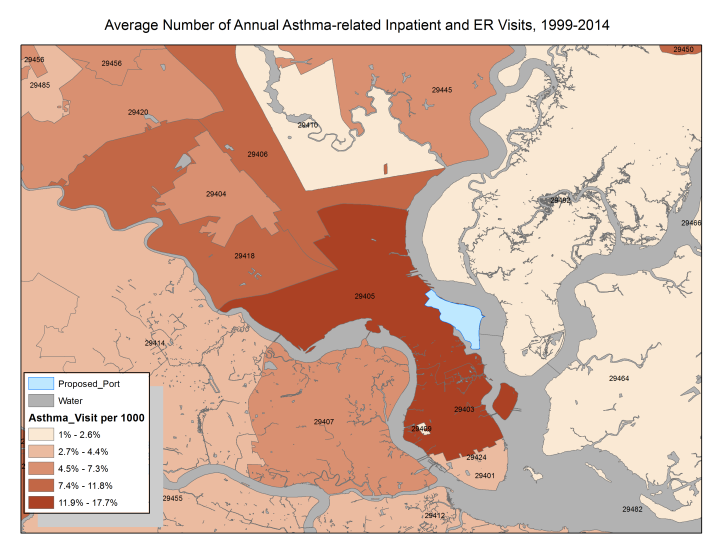
**Background**

Port-related activities have a profound impact on the air pollution within communities which they are located due to emissions from ships, trucks and dock vehicles. Environmental justice research has shown that goods movement impacts of ports impact communities of color and poor populations disproportionately. Yet, very few health studies have ever been performed in such goods movement communities. There is a significant need for more research regarding public health impacts of ports on nearby neighborhood residents.

In 2019, a new marine container terminal will open in North Charleston. This facility will add 1.4 million more containers each year, essentially doubling the Port of Charleston's volume. This expansion will likely cause a disproportionate increase in exposure to hazardous air pollution among overburdened communities near the port. For the past nine years and with NIH support (1R21ES017950-01 and 3R21ES017950-01S1), our unique community-university partnership has been working together to perform a baseline/pre-expansion assessment of environmental pollution, exposure disparities, and public health in economically distressed communities in the Charleston region impacted by goods movement and other local industrial activity before the Charleston port expansion. This partnership, known as the Charleston Area Pollution Prevention Partnership (CAPs), has been using community-based participatory research (CBPR) and the US EPA Collaborative Problem-Solving (CPS) modelto build community capacity for understanding and addressing local exposures to environmental stressors.Together, we have studied ambient levels of particulate matter (PM10 and PM2.5) in our communities; community perception of environmental quality, asthma triggers, public health, and cancer risks, and distribution of pathogenic and salutogenic infrastructure before the port expansion. Through CAPs, our communities have identified research priorities to reduce the differential burden of air pollution on our communities both currently and in the future after the port expands. Furthermore, our communities have expressed concerns about exposure to particulate matter and other asthma triggers for vulnerable groups (e.g. asthmatics) and the need for tools that will help increase community knowledge to avoid such exposures. We have a unique and innovative community-university partnership which positions our partnership to study the impact of port expansion related pollution exposures and health effects that can be applied to similar port communities across the country.

We will perform three quasi-experimental (pre/post) intervention studies using the CBPR framework from our previous work. These will include: 1) community air monitoring team training, 2) port expansion-related community air monitoring, and 3) environmental health literacy interventions within and across partner neighborhoods. In essence, we will train community members to monitor air pollution, then have them perform such monitoring before/after the port expansion, and then lastly train both asthmatic and non-asthmatic community members on the use of our innovative environmental health literacy (EHL) tools to minimize their own personal exposures and related health risks.

South Carolina Department of Health and Environmental Control (SCDHEC) used saturation monitors in several of our communities to provide preliminary information for representative, longer term sampler siting in the Charleston Neck area. Our analysis of the saturation data show that PM levels range from 2 to 28 µg/m3 across four communities (Accabee, Union Heights, Chicora-Cherokee, and Howard Heights). In general, PM2.5 levels were highest in Union Heights. PM2.5 was highest in September and lowest in December. The saturation study was followed up by a study to measure PM2.5 and PM10 using the Thermo Scientific Dichotomous Sequential Air Sampler Partisol-Plus 2025-D, which can collect samples of fine (PM2.5) and coarse ambient PM (PM2.5). Sampling occurred from July 2012 to July 2013. During this study, the Charleston Community Research to Action Board (CCRAB) helped to develop the air pollution study design, the monitoring plan, and selected the monitoring locations. In addition, community members were trained to exchanged old and new filters in the partisols and helped to analyze the data in winter 2012. Results show marked variations in the mean 24-hour PM2.5 and PM10 levels in the study communities. For example, the range of mean PM2.5 concentrations collected in Accabee (3.6µg/m3 - 12.3µg/m3) was similar to the concentrations found in Rosemont (3.2µg/m3 - 12.9µg/m3). However, these concentrations were much lower than the range of mean PM2.5 concentrations measured at the Gethsemane community center in Union Heights (4.1µg/m3 - 15.2µg/m3). The higher values obtained in Gethsemane may be due to the proximity of the station to heavier traffic and the port. Despite the differences in mean PM2.5 concentrations in each community, most of the levels were still lower than those collected at the FAA monitoring station (0.35µg/m3 - 17µg/m3) and none of the average PM2.5 values exceeded the 24-hour NAAQS (35µg/m3). These results allow us to build a larger study to understand spatiotemporal variation of PM2.5 before the Port of Charleston expands in 2019.

Research has shown that urban areas with poorer air quality generally experience higher asthma morbidity than areas with better air quality. In order to assess the burden of emergency room visits attributed to asthma, we map the standardized morbidity ratio (SMR) of observed vs. expected pediatric (children aged 5 to 17 years) asthma-related emergency room visits for the years 2009-2014 (Figure). Expected visits for each zip code were calculated by projecting the South Carolina average ER visit rate onto the underlying child population of each zip code. These results clearly show that our study area falls within a zip code with an SMR = 2.71, a measure that indicates asthma-related ER visits are nearly three times higher than expected for the state. 

**Research Strategy and Methods**

To address Specific Aim #1, we will answer the following research questions: (Q1) Was Environmental Health (EH) literacy of participants increased after training? (Q2) Was knowledge and capacity of residents to use air monitoring equipment increased after training?

Engaging communities impacted by environmental justice in scientific research is an important way to increase their EH literacy and capacity to reduce exposures and improve health outcomes. In our communities, some residents have been trained to use stationary federal reference method (FRM) monitors that have provided useful baseline data on PM2.5 and PM10 levels. However, this data is limited in its spatial coverage and does not represent exposure at the neighborhood or personal levels. Training residents as citizen scientists can help expand EH literacy across communities and provide the foundation for a more expansive spatially-resolved community-based monitoring network using low-cost sensors before the new port terminal opens.

Community members will be directly involved in the implementation of the community engagement and public health action plans particularly education, outreach, and data collection activities.

CCRAB will have bi-monthly in person meetings to discuss issues related to the proposed project. The research team and CCRAB will have bi-weekly conference calls to discuss project updates. In addition, there will be internal communication activities to ensure community leaders, board members, and partners are aware and understand what is occurring with CCRAB and project-related activities. These activities include the CCRAB workgroups to help with environmental education efforts; a Google Calendar, to ensure that all activities, projects, and events are featured on a yearly calendar that can be electronically distributed; Microsoft Project 2013 to enhance the ability of project staff and volunteers to collaborate on project objectives via an electronic platform; and bi-weekly calls for constituent neighborhoods to have bidirectional communication with CCRAB and the research team.

CCRAB aims to drive efforts to improve air quality in the region particularly for neighborhoods impacted by goods movement activity and the port expansion in Charleston through pollution reduction strategies in partnership with local government, SCDHEC, and the SC State Port Authority. In addition, CCRAB aims to empower residents to become more engaged in local environmental decision-making so they can contribute to the revitalization of their communities. CCRAB will communicate its purpose, objectives, and progress to local residents. These activities will include: a quarterly newsletter, annual progress reports, LAMC office functioning as an information repository, press releases, community project publications (brochures, white papers, articles, powerpoints, etc.), flyers, door-to-door campaigning, monthly community update meetings, community workshops on various environmental health topics, Annual Day of Neighborly Needs and Health Fair, CCRAB website, and increased social media presence.

Successful community scientist trainees will collaborate with academic scientists to implement a community-based PM2.5 air monitoring plan across our study area designed to perform two air monitoring tasks: 1) establish fixed sites for longer-term air monitoring in each neighborhood, and 2) perform snapshot sampling using low cost air monitors within communities to address local pollution concerns (e.g., pollutant trends along primary commuter routes, near roadways, residences, etc.). With these results, residents will be able to better understand PM2.5 levels at two spatial scales: inter-neighborhood and intra-neighborhood. The primary focus of our longer term air monitoring campaign is to address (Q3) - What are the longer-term trends for PM2.5 levels in my community before and after the port terminal has opened?The intent is to establish representative measurements for baseline understanding of trends in PM2.5 across our study area and to establish a network that can be used by the community to address future air quality concerns. While each neighborhood in our study area likely experiences similar meteorology, differences in traffic volume, local source emissions, and varying degrees of regional deposition and transport may contribute to differences in local air quality. To explore these differences, we propose to establish monitoring sites for each neighborhood (n=6) that are designed for long-term real-time monitoring of PM2.5. Neighborhood monitor locations will be determined by community input. Also, best practices for deploying air monitors at the neighborhood scale will be applied to ensure data quality. To address (Q4) - When and where are potential air pollution exposures to PM2.5 the highest/lowest in our community before and after the new port terminal has opened? We will useparticipatory monitoring that will deploy larger numbers of handheld mobile sensors (n=10/neighborhood) to assess air quality within our study area. This will include ‘snapshot’ monitoring of four target areas not usually addressed by traditional air monitoring: 1) frequent commuter routes; 2) near-roadway gradients; 3) near-source gradients; and 4) residential outdoor air pollution. This approach offers a unique opportunity to address community concerns and to improve understanding air pollution gradients at smaller spatial scales. Results are anticipated to increase community capacity to avoid air pollution exposure by increasing community knowledge on air quality and support qualitative assessments of the air citizens breathe on a day-to-day basis.

We will answer the following questions: (Q5) - Was EH literacy increased by using our GIS tools? (Q6) - Did knowledge about air pollution levels through real-time PM2.5 mapping improve health protection decisions and reduce air pollution exposure particularly for vulnerable residents (e.g., asthmatics)? to access the EH of community participants.

By training these individuals in the use of our PPGIS online mapping tool called EJRADAR and EH Literacy strategies, we may promote a greater understanding of the relationship between the distribution of environmental health hazards such as port-related activities and traffic, air quality, and their individual health. This training may stimulate individuals to act based on their understanding of these environmental risks leading to more self-efficacy and control in their ability to protect their own health while also contributing to the community’s capacity to reduce exposures across all groups and be more engaged in local environmental decision-making.

The EJRADAR online mapping tool will be expanded to include a mobile app for both Android and Apple platform. In this app, the user can upload photos, see real-time data on ABM and NAM PM2.5 readings, report asthma attacks, and provide other information about environmental hazards or risks. This information will be uploaded to a GIS server in Amazon Elastic Compute Cloud and also housed on the LAMC server. The Apache http server will host website and web services in Amazon Cloud. The data will be managed in PostgreSQL database with PostGIS plugin to support spatial data storage and queries. HTML5, PHP, Javascript and OpenLayers will be used to visualize the data on Google map. The photo and other large size files will be stored on Google Drive, which can be used by the web server in Amazon. All data collected across study neighborhoods will be summarized and made accessible through tables or maps in the EJRADAR app.

In year 3, two EJRADAR training sessions will occur in each CCRAB neighborhood (n=6). An EJRADAR training manual developed by CCRAB leadership will be used to provide information to trainees on how to effectively use EJRADAR to map hazard and pollution data. The research team has used the manual for previous trainings. It has trained over 125 individuals (residents, students, advocates) across eight sessions from 2014-2016 at research retreats and community summits. Technical assistance will be provided on an as-needed basis for trainees. During these sessions, researchers will conduct observational assessments to explore initial knowledge levels, receptivity toward training, and uptake of instructional guidance to inform self-efficacy. Individual participant interviews will be conducted following training sessions to seek perceptions of the training and individuals’ self-efficacy in adoption of the tools.

Building on the prior work of CCRAB through Project Excellence and Dr. Nichols’ work with teen health literacy, specific training modules will be developed to address health literacy, EH literacy, and asthma self-management for participants and community members. Modules will include: 1) An overview of asthma; 2) Asthma medication and adherence including appropriate use of inhalers; 3) Environmental triggers; 4) Accessing health information; and 5) Resource availability to manage asthma. CCRAB will guide the development of module content and trainees will be interviewed for feedback on content, delivery approaches, and recommendations for further community dissemination.

We expect to see: 1) a statistically significant change in the knowledge about environmental health issues and skills related to the use of EJRADAR in the results of the pre- and post-tests for both adults and youth; 2) increase in self-efficacy due to EJRADAR and EHL training.; and 3) changes in exposure behavior for youth and adult participants. Due to their training and daily use of EJRADAR, we also expect to see a reduction in the number of asthma attacks for EJRADAR users who currently have asthma.

**Citizen Science Air Monitoring Training Plan**

Researchers will work with CCRAB staff to recruit participants for this proposed study. Through Project Excellence, CCRAB staff have engaged youth from the community through summer camps on environmental justice and health issues. The study will be presented at neighborhood association meetings and at informal meetings at churches and other sites to inform residents about opportunities to participate in the study. Study materials will be distributed at these meetings to potential participants interested in PM exposure, air quality, environmental justice, and community revitalization. Residents will be asked to call the CCRAB office for additional information. Residents will receive incentives for participating in different phases of the project to recruit and retain participants.

The research team will work with CCRAB staff to train residents to act as citizen scientists following approaches used in a previously funded NIEHS study. These citizen scientists will receive training from project staff and Dr. John Pearce, a MUSC air pollution scientist, will assist with training activities and maintenance of air quality monitoring equipment.

To participate in the training program, a participant must be at least 12 years old, have lived in the targeted neighborhoods for at least one year, does not smoke, able to read and speak English, healthy enough to participate in field exercises and to perform field monitoring, and expressed an interest in learning more about air pollution and environmental health issues on the intake survey.

The team will develop a citizen science training guide. The guide will include modules on the field equipment. Each module will include specifications on each instrument: monitoring technique (i.e., continuous, light scatter), accuracy, sampling range, specificity, start-up procedures, deployment, calibration, limit of detection (LOD), energy source, data download process, etc. This guide will be developed via a series of discussions with CCRAB, the community advisory board (CAB) for this proposed project. The training guide will explain how the equipment works in terms that various groups, including those with less than HS education, below the age of 18, and over the age of 65 can comprehend. Guides will be pilot tested by CCRAB members.

The research team will focus the training modules in four key areas of field monitoring: 1) frequent commuter routes, 2) near-roadway gradients, 3) near-source gradients, and 4) residential outdoor pollution. In regards to frequent commuter routes, citizen scientists will receive training in how to recognize roadways that are primary commuter routes, perform vehicle counts following the DOT protocol, and measure PM levels appropriately at various locations along high traffic routes vs low traffic routes during morning, evening rush hour and non-rush hour time points. In regards to near roadway monitoring, citizen scientists will learn how to monitor at various distances from roadways using a transect or grid approach, understand the physics of pollution decay, and learn about plume movements and peak exposures. In regards to the near source gradients, residents will learn about how the height of stacks impacts emissions and pollution concentrations at different distances from the stacks, influence of meteorological parameters on near source gradients, and how to use transects, grids, and other approaches to sample near stationary pollution sources. Additionally, citizen scientists will receive training on how to effectively monitor PM levels at the residential level. Participants will learn about positioning sensors in locations that will provide a good measure of air pollution without obstruction from trees and other physical barriers and without the negative influence of other pollution sources such as exhaust from indoor cooking or nearby vehicles.

***Recruitment***

We will recruit 45 residents per each CCRAB neighborhood (n=6) including 10 adults and 10 youth/neighborhood currently with asthma (as defined by the CDC). Total recruitment will be 270 residents.

**Air Monitoring Equipment**

We propose to assess PM2.5 levels by employing two separate low-cost sensors. PM2.5 concentrations will be monitored continuously in each neighborhood using the Met One Neighborhood Air Monitor (NAM) (Grants Pass, Oregon). The NAM is a relatively low cost PM2.5 sensor that continually monitors air quality and makes data available immediately via wireless communication. The NAM measures PM2.5 using a forward light scatter laser Nephelometer (sensitivity of 1 ug/m3; range: 0 to 100,000 ug/m3). Secondly, we plan to conductparticipatory air monitoring using Airbeam monitors (ABMs) (Habitat Map, Brooklyn, New York), low cost sensors designed for citizen science. ABMs are nephlometers that use a light scattering method to measure PM2.5 via Bluetooth. ABM measurements can be communicated approximately once a second to smartphone via a mobile phone app and sent to a host website (AirCasting). We plan to use this funding to purchase 270 Airbeam monitors for our study.

**Instrument Field Testing**

Field testing of instruments in year 1 of the project will occur. Trainees will be shown how to operate the ABMs and the NAMs in the field. They will be shown a series of operations and monitoring tasks such as instrument start up, deployment and downloading the data following the standard operating procedures (SOP) outlined in the community-based air monitoring plan. Each trainee will be expected to repeat procedures in the field and will be graded on the knowledge about the instrument, time taken to complete tasks, and proficiency of completing the tasks for each specific instrument.

**Data Management***.*

Data will be collected by the NAMs and the ABMs at sub-hourly intervals and will be continuously streamed using the manufacturer provided website hosts (NAM: https://grovestreams.com/; ABM: <http://aircasting.org/>). To improve data quality, we plan to access data from these servers and transfer it to a server hosted by CCRAB for data review, validation, and archiving. Raw data will then be processed for reporting and further analyses following guidelines for continuous data reporting. This will involve quality control procedures to remove outliers and summarize complete data over 15-min, 1-h, and 24-h intervals. Next, processed data will be adjusted to improve comparability to FEMs by applying instrument specific calibration models using data collected during our collocated monitoring assessments. Real-time data processing will take place in the R Statistical Computing environment and processed data will be made available for further analyses and uploaded to EJRADAR for reporting to the public.

***Data Communication***.

Real-time data will be made available on EJRADAR. Our system will be designed to process and report data in 15-min intervals on the website. We will also develop annual reports that will summarize trends in air quality across study communities with guidance from CCRAB. Within these reports, we will provide information on patterns of particulate matter in an effort to identify times and areas of peak concentrations as well as valleys to help EJRADAR users modify their behaviors to reduce exposure risks.

Summary reports on major findings will be provided at dissemination meetings following. Using the established CPS workgroups, local partners will work with research team members to develop presentations on PM exposure and present exposure maps developed using EJRADAR that will be presented to local residents at churches, barber and beauty shops, bus terminals, and convenience stores. CCRAB leadership will use CPS action workgroup to develop a policy plan; leverage on-going relationships with local stakeholders; present briefs to policymakers that explore key findings on variation in PM2.5 levels, and make recommendations on pollution-reduction strategies important to the community

**Expected Results and Outcomes**

We expect to provide community members access to real-time data that can be used to minimize exposure risks and over the long term by increasing their knowledge of air quality, a benefit that better positions them to handle current and future air quality issues including asthmatics. We expect to find heterogeneous air pollution levels across CCRAB neighborhoods, with differing pollution trends occurring within each neighborhood. Neighborhood level monitors will provide important information that can be used to establish trends between each neighborhood. Snapshot monitoring using low cost monitors will provide data that can address issues related to individual level exposure. Collectively, this information will be a powerful tool for enhancing decision making to reduce the burden of poor air quality on goods movement communities. Our results will provide data that can be useful for neighborhood comparison, near source screening, EH literacy, and personal health protections.

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