ASSESSING REGULATORY COMPLIANCE AND COMMUNITY AIR POLLUTION IMPACTS OF CRUDE OIL BY RAIL TRANSPORT IN BALTIMORE CITY, MARYLAND

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16. Abstract Increased fracking since 2011 has resulted in the transport of crude oil by rail (CBR) to refineries and ports across the United States. Previous derailments of trains transporting CBR have resulted in dozens of deaths and polluted air, soil, and waterways. A derailment of a train carrying crude oil in Baltimore, Maryland, could adversely impact roughly 165,000 residents. This project sought to deliver an evidence-based characterization of CBR within Baltimore City. Specifically, the researchers (a) characterized the periodicity and regulatory compliance of CBR train transit; (b) determined the temporal relation between CBR train traffic and volatile organic compound emissions at residential sites proximal to CBR corridors; and (c) developed lessons learned and best practices suitable for other U.S. communities affected by CBR. This affordable, efficient, and adaptable protocol to understand CBR patterns can supplement the efforts of Baltimore City activists and promote community health and self-determination across the United States.		

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Executive Summary

Problem Statement

Advances in unconventional oil extraction processes, increases in oil prices, and railway flexibility have spurred increases in the volume of crude oil being transported via railway. Explosions related to crude oil by rail (CBR) traffic derailments kill nearby residents and contaminate soil and local waterways, highlighting rail transit as a public health concern. The threat of large explosions causes concern for Baltimore City, Maryland, residents about the rail transport of hazardous chemicals near their homes and schools. In many cities, including Baltimore, rail lines are disproportionately located in low-income and African-American communities, making related risks an environmental justice concern. Previous public information requests have been met with silence from rail transport companies, leaving local residents frustrated and seeking methods to answer questions themselves. The lack of available data has even led to calls by Baltimore City elected officials for more information about the local health impacts of CBR. Research is needed to fill these knowledge gaps.

Technical Objectives

The objective of this project was to advance policy change by contributing rigorous evidence to fill knowledge gaps about the impact of CBR on pollutant emissions. In partnership with local residents and community organizations, the research team conducted a pilot investigation to answer community-identified questions related to CBR. For this study, the researchers set the following goals: (a) characterize the periodicity and regulatory compliance of CBR train transit through Baltimore City; (b) determine the temporal relationship between CBR train traffic and volatile organic compounds (VOCs) emissions at residential, recreational, faith-based, business, and/or other sites proximal to CBR corridors; and (c) develop lessons learned and best practices suitable for other U.S. communities affected by CBR. These goals were completed through a series of five different tasks:

- Study recruitment.
- Data collection.
- Systematic literature review.
- Data analysis.
- Synthesis and distribution of study findings and results.

The research team tested equipment and conducted site visits along major rail corridors in Baltimore City to identify potential community locations where real-time deer cameras, VOC monitoring instruments, and noise dosimeters could be located. These site visits resulted in the identification of several ideal data collection locations with optimal distances for camera image resolution and capture of source-relevant pollutants, such as within 100 ft of CBR tracks, and with an unobstructed view of the tracks during the daytime and nighttime. The researchers worked to identify hazardous material placards and characterize these CBR components utilizing motion-sensing, night-vision image capture by deer cameras and pollutant (noise and air) monitors to record passing trains. The researchers recorded the frequency, speed, and regulatory compliance characteristics of CBR tank cars at multiple sites proximal to rail lines within Baltimore City. Through this pilot study, the researchers solidified a community-based participatory research partnership with Clean Water Action and Chesapeake Climate Action Network, who have active policy campaigns to reduce CBR throughout Baltimore City and, on a larger scale, the United States.

Key Findings

The researchers recorded passing trains for several weeks and examined rail traffic, noise, and VOCs with collocated monitoring devices. Data collected at the study sites in Westport and Mount Vernon indicated an increased transport of all hazardous materials at night, as well as an increased speed of train cars. On average, there were 22.4 more train cars passing during the night than the day ($p < .033$). Additionally, there were on average 11.4 more DOT-111 black cylindrical cars that passed during the night than the day ($p < .0001$). When trains were absent, the average noise (decibel [dB]) measurement over this 24-hour period ranged from 60–65 dB. With trains present, the highest measurement exceeded 100 dB. However, recorded VOC measures did not correspond with passing trains.

Through a systematic literature review, the researchers identified 17 reviewed publications on current CBR public health policies, which fell under three categories: chronic exposure, acute exposure, and risk management and mitigation. Consensus that acute derailments pose potential harm to human life was reached, but the publications were inconclusive in their risk assessment and presentation of chronic exposure pathways.

Project Impacts

Findings from this investigation were able to improve communities' understanding of the periodicity and regulatory compliance of CBR transit in their neighborhoods. Through discussions with community groups and environmental organizations, the researchers were able to improve the best practices of the CBR monitoring methodology, which can be synthesized for use in other U.S. communities proximal to heavy CBR transit corridors. This research will serve as a vehicle to develop a model that can be expanded to partnerships that Clean Water Action and Chesapeake Climate Action Network have formed with other U.S. communities impacted by CBR transit. Sharing of the data with residents and elected officials, in addition to the scientific community, has increased awareness of CBR transit and continued conversations about reducing exposure. During the project period, the coalition was able to band together, attending city council meetings and providing scientific evidence on CBR transit, thereby contributing to the passing of Zoning Bill 17-0150—Prohibiting Crude Oil Terminals in Baltimore City.

With approaches developed during this investigation, communities will be able to continue to advocate for other policies, such as the electrification of freight traffic (e.g., the ongoing Solutionary Rail campaign), greater local rail protections around schools, health interventions for residents living near rail lines, city regulations on allowable noise from rail operators and industrial sites, training for disaster and emergency response, etc. Additionally, trained community members will be able to use similar research methods to investigate the air quality impact of diesel engine buses by monitoring air quality on busy bus routes and match spikes in air pollution with buses passing and advocate for cleaner-burning buses such as hybrid and fully electric transit buses. Ultimately, this project provided an affordable, efficient, and adaptable protocol by which communities throughout the United States can understand CBR and other transit patterns.

Acknowledgments

Many individuals, groups, and organizations helped further the charge for more information on crude oil by rail in Baltimore City, Maryland. Those below contributed considerable efforts toward the project's advancement.

- Baltimore community members and organizations:
  - Keisha Allen, Baltimore resident.
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  - Mount Winans Community Association.
  - Westport Neighborhood Association.
  - Taylor Smith-Hams, Health Communities Campaign Organizer, Chesapeake Climate Action Network.
  - Jennifer Kunze, Maryland Program Organizer, Clean Water Action.
  - Crude Awakening Network.
  - Yinka Bode-George, Program Manager, Maryland Environmental Health Network.
  - Hugh Pocock, Coordinator of Sustainability and Social Practice, Maryland Institute College of Art.
  - All Baltimore residents, workers, and public health supporters in the fight against crude oil by rail.

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  - Drew Cantor, Johns Hopkins Bloomberg School of Public Health.
  - Emma Cogan, Johns Hopkins Bloomberg School of Public Health.
  - Irena Gorski, Johns Hopkins Bloomberg School of Public Health.
  - Rachel Viqueira, Johns Hopkins Bloomberg School of Public Health.

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Background and Introduction

Increases in hydraulic fracturing, or fracking, in the Bakken Shale region of the United States have resulted in the transport of enormous volumes of crude oil by rail (CBR) across the country to refineries and ports along both the east and west coasts. Oil train traffic in the United States increased by 5,100 percent between 2008 and 2014 (*1*). Neglected rail infrastructure coupled with CBR presents a major public health concern (*2*). Additionally, the train cars used to transport much of the crude oil, DOT-111s, are particularly prone to derailment and have been implicated in multiple large-scale explosions that have damaged communities and killed dozens of people (*3*–*7*). Previous derailments have resulted in horrific explosions, such as the derailment that occurred in 2013 in Lac-Mégantic, Canada, killing 47 residents and contaminating 558,000 tons of soil and local waterways.

Baltimore City, Maryland, has been a hub for CBR transport throughout the fracking boom due to its central location along the eastern shoreline and service as a transfer station along Chesapeake Bay. Millions of gallons of crude oil have been shipped through Baltimore between 2014 and 2016 (*8,9*). Crude-oil-associated health issues have plagued Baltimore since the 1950s (*9*). Baltimore City residents have expressed concerns related to CBR for two primary reasons: (a) roughly 165,000 residents live within a 1-mi radius of a CBR corridor, which is the impact zone for an acute derailment disaster and/or explosion; and (b) CBR tank cars lose between 2 to 5 percent of their total content volume between origin and final destination, potentially causing elevated residential exposures to volatile organic compounds (VOCs) that are associated with elevated rates of asthma and chronic illnesses (*10,10*) and are also carcinogenic. Concerned residents of Baltimore City have been unable to access information regarding the extent of CBR-related activities within the city. Thus, this project sought to deliver an evidence-based characterization of CBR within city vicinities. In Baltimore City, rail line and street crossings are disproportionately located in low-income and African-American communities, making questions of CBR-related riskscapes an environmental justice concern (*11*).

As fracking and CBR transport—and potentially VOC exposure—surge across North America, the ramifications for adverse public health impacts also increase. In addition to headaches, respiratory irritation, and nausea, VOCs have been associated with more severe health outcomes, including kidney and liver damage, and are potential carcinogens. Considering the cities and states across America with CBR transit, methods to assess regulatory adherence and studies of the temporal association between CBR train traffic and VOC emissions are warranted.

Problem

Baltimore City residents and community-based organizations, particularly Clean Water Action (CWA) and Chesapeake Climate Action Network (CCAN), have been engaging in an ongoing policy campaign to limit the amount of crude oil transported through Baltimore City, with mixed results to date (*5*, *9*). CWA and CCAN identified a critical need to provide policy makers with evidence-based estimates of the periodicity (time of day, number, and peak of CBR transit), regulatory compliance (speed limits, presence of tanker car safety upgrades, etc.), and potential for exposure to VOCs at residences proximal to CBR corridors in Baltimore City. Few studies have focused on policy-relevant environmental health data collection and analyses that could advance a community's understanding of CBR regulatory compliance and exposure risks and serve as a model for community-based participatory research (CBPR) in communities across the United States proximal to CBR transit corridors.

Approach

In partnership with community organizations, the research team aimed to assess the frequency of CBR transit and regulatory compliance throughout Baltimore City, examine the relationship between CBR traffic and VOC emissions at nearby residential sites, and develop best practices for assessing CBR patterns and impacts in other U.S. communities affected by CBR. To characterize these components of CBR through Baltimore City in a cost-effective and relatively simple way, the researchers utilized motion-sensing, night-vision image capture by deer cameras, VOC monitors, and noise dosimeters to record passing trains. The researchers also examined an affordable, efficient, and adaptable protocol to understand CBR patterns and serve as a model that can be expanded to other U.S. communities impacted by CBR transit. To the researchers' knowledge, this is the first study of its kind and offers an opportunity to create a blueprint for other U.S. communities to advance a policy-relevant, evidence-based summary of CBR transit's local environmental health risks. This investigation had three overarching goals: (a) characterize the periodicity and regulatory compliance of CBR train transit through Baltimore City; (b) determine the temporal relationship between CBR train traffic and VOC emissions at residential, recreational, faith-based, business, and/or other sites proximal to CBR corridors; and (c) develop lessons learned and best practices suitable for other U.S. communities affected by CBR. These goals were accomplished through a series of five different tasks:

- Study recruitment.
- Data collection.
- Systematic literature review.
- Data analysis.

Methodology

Exposure Assessment

Site Selection and Monitor Placement

The researchers tested equipment and conducted site visits along two major sites for rail corridors in Baltimore City to identify potential community locations where real-time deer cameras, VOC monitoring instruments, and noise dosimeters could be located. These site visits resulted in the identification of several ideal data collection locations with optimal distances for camera image resolution and capture of source-relevant pollutants, such as within 100 ft of CBR tracks, and with an unobstructed view of the tracks during the daytime and nighttime. Students participated in scouting eligible properties and placing collocated cameras, VOC, and noise monitors.

With the permission of the Maryland Institute College of Art (MICA) Coordinator of Sustainability and Social Practice Hugh Pocock, the researchers set up motion-censored cameras and VOC pollutant monitors at the Mount Royal Train Station located on MICA's campus, which has two tracks. Nima Afshar, a postdoctoral student in Johns Hopkins Bloomberg School of Public Health Professor Gurumurthy Ramachandran's lab, played a lead role in collecting data at the site.

The researchers also collected data on the frequency, timing, volume, and noise of trains carrying hazardous materials from January 2018 through May 2018 in southwest Baltimore. The primary data collection instrument was a professional hunting camera that took photos and videos of every movement, captured by its motion-activated sensors. The hunting camera, along with a noise dosimeter, was placed on utility poles within 100 ft of the train tracks in a lot owned by the neighborhood community association (Figure 1). Drew Cantor and Ryan Burgess, Master of Public Health students at Johns Hopkins Bloomberg School of Public Health, played a lead role in collecting data at the site.

Figure 1. Camera and noise dosimeter.

All students and community members participating in data collection were trained and accompanied by Johns Hopkins Bloomberg School of Public Health faculty on initial site visits. Students and community partners ensured twice-weekly returning visits to the site to collect the SD cards and replace each with an empty SD card to record the next data collection period's CBR traffic.

Real-Time Trail Camera Data Collection

In concert with community members and students, the researchers placed trail cameras facing train tracks to monitor CBR trains. Two cameras were placed at each site at different angles to the track to capture as much information as possible. The cameras were placed between 25 to 50 ft from the tracks with an unimpeded view of the train tracks and in a position that was unlikely to be triggered by other moving objects. The presence and identification of hazardous materials were assessed using the diamond-shaped hazardous material placard and corresponding four-digit code on DOT-111 black cylindrical cars (Figure 2). The researchers used pilot tests to determine the optimal positioning of each camera. The cameras were in place for a minimum amount of 14 days and up to 3 months depending on the quality of data available at each site. The researchers utilized the capture of time-lapsed photo bursts.

Figure 2. Diamond-shaped hazardous material placard (13).

Real-Time Volatile Organic Compound Air Measurements

To characterize the emissions from crude oil being transported, VOC monitors (GrayWolf AdvancedSense® for VOCs including total VOCs) with photoionization detectors were used. These photoionization detectors equipped VOC monitors to measure, log data, and report VOCs (>250 compounds detected), percent relative humidity, and temperature and were already available via Dr. Ramachandran. These real-time VOC measurement instruments were co-located with trail cameras to determine whether changes in VOC concentrations were temporally related to the passage of CBR trains in the neighborhoods.

Noise

Some community members expressed concern about the lack of information on the extent to which CBR traffic occurs at night when people are sleeping or whether it presents an exposure and/or health risk in their towns. They had found it hard to access relevant information to address their concerns. Thus, the researchers used dosimeters co-located with train movement to measure noise levels from CBR traffic at the Baltimore sites. Dosimeters were calibrated at 94.0 dB and configured to U.S. Department of Labor Occupational Safety and Health Administration specifications including weight, exchange rate at 5 dB, threshold level at 80 dB, criterion level at 90 dB, and criterion duration at 8 hours.

Data Analysis

Statistical analyses were planned to test the hypotheses that (a) CBR traffic patterns would be temporally associated with changes in airborne VOC levels at residential locations proximal to CBR railways, and (b) rail traffic/noise would be more frequent at night and may exceed current U.S. Department of Labor Occupational Safety and Health Administration standards. Real-time VOC concentration data were reviewed, cleaned, and merged into a repeated-measures dataset suitable for fixed-effects linear regression analyses. The researchers tabulated the daily number and timing of CBR tankers and basic statistical analyses assessing the correlation between different characteristics. To assess noise related to rail traffic in Baltimore City, the researchers took the average between the two dosimeters at each time point and then calculated the average and median for all time points at that location. Time series of noise levels were created and used to analyze noise pollution from trains. Average 24-hour noise exposure from both dosimeters was calculated for the surrounding community. The outcomes fitted to general linear regression analyses adjusted for clustering included total number of train cars by hour (24 hours), total number of DOT-111 black cylindrical cars by hour (24 hours), cumulative number of train cars by hour (24 hours), and cumulative number of DOT-111 black cylindrical train cars by hour (24 hours).

Literature Review

The researchers conducted a literature review to identify current CBR public health policies in place throughout the United States that may be implemented in communities highly impacted by CBR transit. A student investigator, Emma Cogan, a Master of Public Health student in global environmental sustainability and health at Johns Hopkins Bloomberg School of Public Health, worked with Johns Hopkins Bloomberg School of Public Health faculty to review CBR policies by identifying existing and pending public health policy; evaluating the types of public protections in place related to CBR transit, policy domain and scale, and contradictions or gaps in policies; and creating an overall summary of the state of public health protections in place related to CBR transport across the United States. Web of Science, PubMed, and Scopus were preliminarily looked at to determine which database had the most pertinent results. Based on these search results, Scopus was selected as the database to be systematically reviewed. Four additional publications were also selected through citation searching and background research.

Results

Analytic Results

Volatile Organic Compounds

The researchers recorded passing trains for several weeks and monitored VOCs (Figure 3), with the sensor continuously recording the total concertation of airborne VOCs every minute. Except for a few hours of one day, all other recorded values in the output log were zero. For those hours of non-zero readings, there was no correspondence with the passing trains. The researchers then tested the sensors within the laboratory setting by placing the sensor next to a barrel of crude oil as well as next to a vehicle's exhaust; the sensor exhibited very good sensitivity, indicating that there was no malfunctioning of the instrument. Additionally, the researchers returned to the MICA station site and held the sensor next to the mounted camera as a train passed, and there was no detection by the sensor. The researchers hypothesized multiple reasons that the passing trains may have been below the limit of detection: (a) the station forms a wind tunnel which, in turn, forms a natural air ventilation, likely sweeping away generated air pollutants; (b) while the researchers did observe tanker wagons, the exact placards did not match exactly with crude oil but with other hazardous substances, and there was no way to predetermine whether crude oil transit would coincide with the period of tracking; and (c) VOCs leaked from a tanker might not be high enough to be detected a few meters away from the moving source where the researchers were able to safely secure the sensor. Future investigations may need to assess airborne particles such as black carbon.

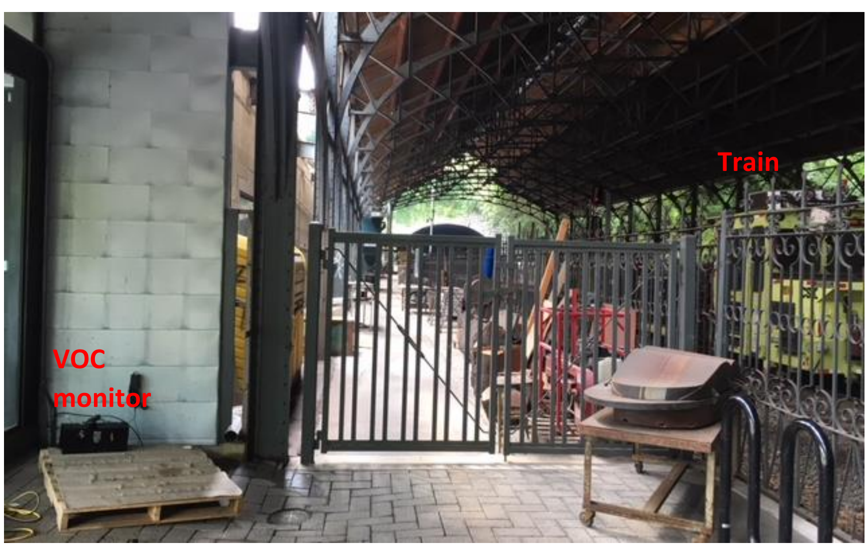

Figure 3. Maryland Institute College of Art train station set up in Baltimore City.

Noise

On average, there were 22.4 more train cars passing during the night than the day ($p < .033$). Additionally, there were on average 11.4 more DOT-111 black cylindrical cars that passed during the night than the day ($p < .0001$). A scatterplot of a cumulative number of DOT-111 cars by hour of day can be found in Figure 4. When trains were absent, the average dB measurement over the 24-hour period ranged from 60–65 dB. With trains present, the highest measurement exceeded 100 dB. According to U.S. Department of Labor Occupational Safety and Health Administration guidelines, workers should not be exposed to an 8-hour weighted average dB measurement greater than 90 dB. Given the 100.9 dB reading, further analysis with a longer recording period could reveal a significant pattern in dB measurements that exceed U.S. Department of Labor Occupational Safety and Health Administration's occupational guidelines. The results from this preliminary analysis corroborate the communities' belief that more trains—and particularly trains carrying hazardous materials—are passing at night rather than during the day.

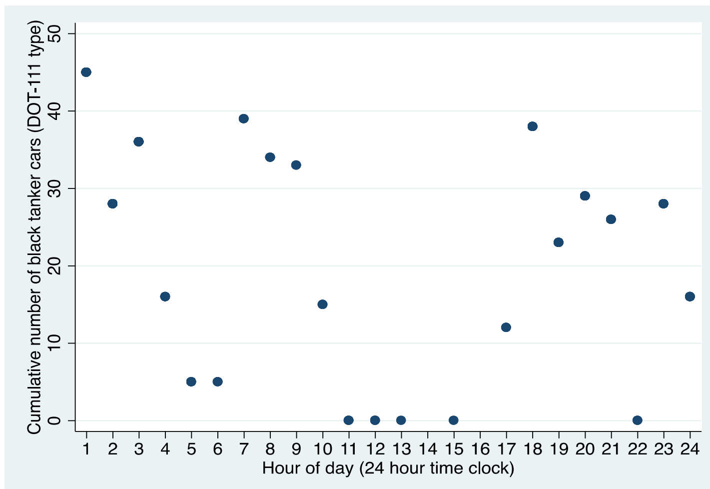

Figure 4. Scatterplot of cumulative DOT-111 by hour of day.

Data collected at the study sites in Westport and Mount Vernon indicated an increased transport of all hazardous materials at night, as well as an increased speed of train cars. These findings were included in the research team's R01 grant proposal to link health data to CBR traffic exposures, submitted to the National Institutes of Health through the Research to Action R01 grant mechanism.

Literature Review

The researchers identified valuable information on current CBR public health policies; however, these protections were limited in nature since CBR transport is only recently heightened across the United States. Scopus returned 56 articles, of which 13 were relevant to CBR and health. Additions from the citation search brought the total to 17 reviewed publications (Table 1), which fell under three categories: chronic exposure, acute exposure, and risk management and mitigation. Consensus that acute derailments pose potential harm to human life was reached, but the publications were inconclusive in their risk assessment and presentation of chronic exposure pathways. Considering millions of U.S. residents live within close proximity to rail lines carrying hazardous materials and that crude oil usage has clear links to greenhouse gas emissions, additional research is warranted to more fully explore any health risks associated with CBR so that appropriate and tailored risk mitigation techniques can be employed.

Table 1. Summary of Literature Related to Crude Oil by Rail Transport and Health

Category	Publications
Chronic exposure	• Chambers, D.M., Reese, C.M., Thornburg, L.G., Sanchez, E., Rafson, J.P., Blount, B.C., Ruhl, J.R.E., III, and De Jesús, V.R. (2018). Distinguishing petroleum (crude oil and fuel) from smoke exposure within populations based on the relative blood levels of benzene, toluene, ethylbenzene, and xylenes (BTEX), styrene and 2,5-dimethylfuran by pattern recognition using artificial neural networks. *Environmental Science and Technology*, 52(1): 308–316, https://doi.org/10.1021/acs.est.7b05128. • Kim, J., Noh, S.R., Cheong, H., Ha, M., Eom, S., Kim. H., Park, M., Chu, Y., Lee, S., and Choi, K. (2017). Urinary oxidative stress biomarkers among local residents measured 6 years after the *Hebei Spirit* oil spill. *Science of the Total Environment*, 580: 946–952, https://doi.org/10.1016/j.scitotenv.2016.12.044. • Mejia-Avendaño, S., Munoz, G., Vo Duy, S., Desrosiers, M., Benolt, P., Sauvé. S., and Liu, J. (2017). Novel fluoroalkylated surfactants in soils following firefighting foam deployment during the Lac-Mégantic railway accident. *Environmental Science and Technology*, 51(15): 8313–8323, https://doi.org/10.1021/acs.est.7b02028.
Acute exposure	• Horn, M. (2017). A quantitative evaluation of trajectory, fate, and effects from crude-oil-by-rail releases: A case study using the proposed shell Puget sound refinery Anacortes rail unloading facility. Proceedings of the Fortieth AMOP Technical Seminar, Environment, and Climate Change, Canada, Ottawa, ON, pp. 1164–1186. • Mickunas, D.B., Powell, G., Hoppe, M., Blaze, S., Newhart, G. (2017). Utilizing the trace atmospheric gas analyzer (TAGA) mass spectrometer/mass spectrometer (MS/MS) to monitor downwind benzene concentrations and calculate its emission rates as function of time during a Bakken crude release. Proceedings of the Fortieth AMOP Technical Seminar, Environment, and Climate Change, Canada, Ottawa, ON, pp. 132–141. • Burgess, C. and Wheeler, R. (2016). Canadian national railway ruel 88.7 gogama derailment: An account of Mattagami first nation involvement. Proceedings of the Thirty-Ninth AMOP Technical Seminar, Environment, and Climate Change, Canada, Ottawa, ON, pp. 668–685. • Marruffo, A., Yoon, H., Schaeffer, D.J., Barkan, C.P.L., Saat, M.R., and Werth, C.J. (2012). NAPL source zone depletion model and its application to railroad-tank-car spills. *Groundwater*, 50:4, https://doi.org/10.1111/j.1745-6584.2011.00863.x. • U.S. Pipeline and Hazardous Materials Safety Administration. (2017). Incident Statistics. https://www.phmsa.dot.gov/hazmat-program-management-data-and-statistics/data-operations/incident-statistics. Accessed April 8, 2018. • Fingas, M. and Michel, J. (2016). *Fossil fuels: Current states and future directions*. New Jersey: World Scientific.
Risk assessment and mitigation	• Basu, R. and Verma M. (2017). An expected consequence approach to assessing the viability of multimodal transportation of crude oil in eastern Canada. *Case Studies on Transport Policy*, 5(3): 518–526, https://doi.org/10.1016/j.cstp.2017.05.001. • Lambert, P.G., Goldthorp, M., Fieldhouse, B., Jones, N., Laforest, S., and Brown, C.E. (2016). Health and safety concerns at dilbit crude oil spills for environment Canada's responders. Proceedings of the Thirty-Eighth AMOP Technical Seminar on Environmental Contamination and Response, Environment, and Climate Change, Canada, Ottawa, ON, pp. 554–571. • Etkin, D.S., Joeckel, J., Walker, A.H., Scholz, D., Hatzenbuhler, D.L., Lyman, E.J., Patton, R.G. (2016). New risks from crude-by-rail transportation. Proceedings of the Thirty-Eighth AMOP Technical Seminar on Environmental Contamination and Response, Environment, and Climate Change, Canada, Ottawa, ON, pp. 900–923. • Brooks, D.M. (2015). Human factors considerations: Midstream process safety integration. Process Safety Spotlights 2015—Topical Conference at the 2015 AICHE Spring Meeting and Eleventh Global Congress on Process Safety. • Andrews, A. and Congressional Research Service. (2019). Crude oil properties relevant to rail transport safety: In brief. http://glslcrudeoiltransport.org/publication/crude-oil-properties-relevant-to-rail-transport-safety-in-brief/. • Frittelli, J., Andrews, A., Parfomak, P.W., Pirog, R., Ramseur, J. L., and Ratner, M. (2014). U.S. rail transportation of crude oil: Background and issues for Congress. Congressional Research Service. https://fas.org/sgp/crs/misc/R43390.pdf. Accessed March 24, 2018. • The National Academies of Sciences, Engineering, and Medicine. (2018). Safely transporting hazardous liquids and gases in a changing U.S. energy landscape. https://www.nap.edu/catalog/24923/safely-transporting-hazardous-liquids-and-gases-in-a-changing-us-energy-landscape. Accessed April 7, 2018. • Shea, D., Hartman, K., and Qiu, S. (2015). Transporting crude oil by rail: State and federal action. National Conference of State Legislatures. http://www.ncsl.org/research/energy/transporting-crude-oil-by-rail-state-and-federal-action.aspx. Accessed March 27, 2018.

Synthesis and Dissemination of Findings

During this investigation, the researchers spent additional time discussing the issue of CBR with numerous community members, organizations, and institutions. Several members of the study team were able to attend meetings with the Mount Winans community group to discuss camera placements and community participation in the investigation. The researchers received feedback on their current methods and ideas for future expansion of research and/or collaborations with others, including the Crude Awakening Network, a nationwide organization devoted to advocating for protections against CBR. Additionally, Yinka Bode-George, program manager for the Maryland Environmental Health Network and former Johns Hopkins graduate student, joined the efforts to increase awareness across environmental organizations. Several members of the study team—Genee Smith (PI, assistant professor), Valerie Butler (Mount Winans community resident), Emma Cogan (Master of Public Health student at Johns Hopkins Bloomberg School of Public Health), and Irena Gorski (Ph.D. student at Johns Hopkins Bloomberg School of Public Health)—led a panel on CBR and health in Baltimore at the Fourth University of Maryland Symposium on Environmental Justice and Health Disparities at The University of Maryland-College Park. The researchers also sent emails, made phone calls, attended legislative sessions, and wrote letters to Baltimore City Mayor Catherine Pugh to pass the Crude Oil Terminal Prohibition in 2018, which prevents the construction of crude oil terminals expected to encourage increases of CBR traffic (Figure 5).

Figure 5. Public pressure generated by community leaders, workers, and researchers against CBR.

With the data and results from this feasibility study, the researchers were able to build proposals for an external funding source on a multi-investigator project to further develop and evaluate interventions to reduce the environmental health challenges associated with oil trains. The researchers have submitted an R01 Research to Action Grant to the National Institutes of Health (PA-19-056) entitled "Pollutant Exposures and Health in Communities Proximal to Rail Lines."

Conclusions and Recommendations

This project represents an interdisciplinary team formed through a partnership with CWA and CCAN to bolster the ongoing work of local residents and community organizations seeking to impact local, state, and national policies related to the safety of CBR transit. The researchers leveraged existing partnerships to further their understanding of CBR traffic and its impact on pollutants and the health of nearby residents. Still, CBR transit is a much-needed area of future research and policy development that has the ability to impact millions of U.S. residents living, working, and attending school near rail lines.

The following recommendations will help to move this body of work forward. First, further evaluation of research approaches related to CBR is needed. More specifically, work should be completed to understand how to improve

VOC (and other pollutant) detection at sites proximal to rail lines. Proper placement and launching of sensors, along with appropriate pollutant selection, will be critical in understanding risks associated with CBR. Second, communities need to be equipped with tools to advocate for transit-based environmental justice through citizen science. Arming communities with simple methods that stand up to scientific scrutiny provides them with skills to assess environmental concerns and empowers communities to advocate on their own behalf. Last, more research is needed to inform the independent and combined effects of noise and air pollution from CBR on residents living proximal to rail lines.

Outputs, Outcomes, and Impacts

Research Outputs, Outcomes, and Impacts

Below is a description of research outputs, outcomes, and impacts resulting from this study:

- Dr. Genee Smith (PI, assistant professor, John Hopkins University), Valerie Butler (Mount Winans community resident), Emma Cogan (Master of Public Health student at Johns Hopkins Bloomberg School of Public Health), and Irena Gorski (Ph.D. student at Johns Hopkins Bloomberg School of Public Health) led a panel on CBR and health in Baltimore at the Fourth University of Maryland Symposium on Environmental Justice and Health Disparities at The University of Maryland-College Park.
- The study team submitted an R01 Research to Action Grant to the National Institutes of Health (PA-19-056) entitled “Pollutant Exposures and Health in Communities Proximal to Rail Lines.”
- Zoning Bill 17-0150—Prohibiting Crude Oil Terminals in Baltimore City, for which the study team submitted a letter outlining the current knowledge of public health impacts of transporting CBR during the previous quarter, was signed into law by Baltimore City Mayor Catherine Pugh (*14*).

Technology Transfer Outputs, Outcomes, and Impacts

Through this pilot study, the researchers solidified strategic partnerships formed to inform CBPR and promote policy campaigns to reduce CBR throughout Baltimore City, Maryland, and the United States. Partners include:

- Mount Winans Community Association.
- Westport Neighborhood Association.
- Chesapeake Climate Action Network.
- Clean Water Action.
- Maryland Environmental Health Network.
- Maryland Institute College of Art.
- Crude Awakening Network.

Education and Workforce Development Outputs, Outcomes, and Impacts

Below is a description of all education and workforce development outputs, outcomes, and impacts resulting from this study:

- Students participated in scouting eligible properties and placing collocated cameras, VOC monitors, and noise dosimeters.
- Findings were reported to community members through panels and community meetings.
- Participating Master of Public Health students at Johns Hopkins Bloomberg School of Public Health fulfilled their capstone project requirements and gained skills in conducting CBPR and a literature review on CBR public health policies.

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