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The Ramapough Lunaape Nation: Facing Health Impacts Associated with Proximity to a Superfund Site

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Abstract

Objective—To evaluate self-reported exposure to the Ringwood Mines/Landfill Superfund Site in relation to chronic health outcomes among members of the Ramapough Lunaape Turtle Clan nation and other local residents of Ringwood, New Jersey.

Methods—Community surveys on personal exposure to the nearby Superfund site, self-reported health conditions, and demographics were conducted with 187 members of the Ramapough Lunaape Turtle Clan Nation and non-Native Americans residing in Ringwood, New Jersey from December 2015 to October 2016. Multiple logistic regression was performed to assess the association between ethnicity and a Superfund site exposure score developed for this study, as well as between exposure score and several chronic health conditions.

Results—Native Americans were 13.84 times (OR 13.84; 95% CI 4.32, 44.37) more likely to face exposure opportunities to Superfund sites as compared to non-Native Americans in the same New Jersey borough. For the entire surveyed cohort, increased Superfund site exposure routes was significantly associated with bronchitis (OR 4.10; 95% CI 1.18, 14.23). When the analyses were restricted to Native Americans, the association between self-reported Superfund site exposure and bronchitis remained significant (OR 17.42; 95% CI 1.99, 152.45). Moreover, the association

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Compliance with Ethical Standards

The authors declare that they have no conflict of interest.

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between greater exposure score and asthma in this same population also reached statistical significance (OR 6.16; 95% CI 1.38, 27.49).

Conclusion—This pilot study demonstrated a significant association between being a Ringwood resident of Native American ethnicity and self-declared opportunities for Superfund site exposure. It also showed a strong association between self-reported Superfund site exposure and the prevalence of bronchitis and asthma.

Keywords

Ramapough Lunaape; Superfund; environmental exposure; chronic disease; American Indian/ Alaska Native

Introduction

For Native Americans, a disproportionately greater risk of adverse health outcomes, such as cardiovascular and kidney disease, asthma, and diabetes can be largely attributed to multigenerational poverty and political marginalization (1–3). Given that over 400,000 Native Americans live within three miles of a contaminated waste dump or EPA-listed Superfund site, they experience cumulative environmental exposures including poor food, water, and air quality, which could exacerbate pre-existing health disparities associated with poor socioeconomic status. (1, 4–7). Many epidemiological studies have examined health implications of Native American tribal members' exposure to Superfund sites and associated contaminants located on or near their land (8). For example, evidence of elevated prevalence or incidence of type II diabetes, breast cancer, and/or neurological deficits have been observed among the Mohawk at Akwesasne, Gila River Indian Community, and among the Alaskan Yupik tribe, all of whom have been exposed to persistent organic pollutants released by nearby industrial facilities, extensive application of pesticides on agricultural land, or former U.S. military bases (9–16). Studies have also revealed associations between Native Americans' exposure to a common Superfund contaminant, cadmium, and overall mortality, cancer incidence, elevated blood pressure, and cardiovascular disease in tribal members (from Arizona, Oklahoma, North Dakota, and South Dakota) investigated in the Strong Heart Study (17–20). All of the aforementioned studies have focused primarily on federally recognized tribes, while the association between exposure to toxic waste sites and health in the 66 state-only recognized tribes, including the Ramapough Lunaape Nation, have been relatively ignored.

The Ramapough Lunaape Tribal nation (located primarily in the Ramapo Mountains of New Jersey and New York state), were descended from the Munsee-speaking faction of the Lunaape nation, native to the Mid-Atlantic region of the United States. While most Lunaape relocated further West after European invasion, the Ramapough avoided colonists by moving into the Ramapo Mountains that border New York and New Jersey, where they numbered between 1,000 and 3,000 members. Racism and discrimination against tribal members were fomented by the New Jersey census, which, until 1870, stated that residents were only allowed to be classified as "white," "free black," or "black slave," none of which characterized the Ramapough. This forced the Ramapough to lead a highly secluded

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lifestyle, where they practiced tribal traditions in private and assimilated into mainstream American culture in public (21).

For almost five decades, the Ramapough Lunaape Turtle Clan have lived between 0.5 to two miles away from a heavily contaminated dump site in Ringwood, New Jersey. Beginning in the 1960s through the late 1970s, Ford Motor Company discarded millions of gallons of paint sludge and other toxic waste from its now-closed manufacturing plant in Mahwah, New Jersey into deserted mine shafts, buried underground and as slabs on the mountainsides that were washed over by nearby streams in upper Ringwood, New Jersey (22). The U.S. Environmental Protection Agency (EPA) tested the ground and surface water in the 1980s and detected toxic and carcinogenic heavy metals including lead, arsenic, and hexavalent chromium at concentrations vastly exceeding local state and federal standards (23). Most of these toxic metals are associated with an array of acute and chronic adverse health outcomes, including cancer (24–26). As a result of EPA testing, this 500-acre contaminated Ringwood site was added by the EPA in 1983 to the National Priority List (NPL), a list of hazardous waste sites eligible for long-term remedial action and financed under the federal Superfund program. The site was later removed from the Superfund list in 1994 following claims of a “complete” contamination cleanup. The site was then relisted as a Superfund site in 2006 following the EPA’s discovery that levels of heavy metals and benzene still registered between eight- to ten-fold above New Jersey State standards (23). As of today, the EPA has partially cleaned up the site by removing thousands of tons of paint sludge, associated soil, and 113 drums of waste material from non-residential areas (27).

Impacted soil from residential properties has been removed by the EPA and landfill areas that have yet to be mitigated have been fenced off. The reported EPA results of groundwater sampling in the area performed nearly annually from 2004 to the present indicated the inconsistent presence of lead, arsenic, benzene, or 1, 4-dioxane above state and/or federal standards (27). The EPA estimates that operation and maintenance of the original Superfund site would be completed by the close of 2019, which has yet to happen. In addition, the agency anticipates that remedial action of St. Peter’s Mine will be complete in March-May 2022, and remedial action of sitewide groundwater will begin in May-July 2022 (27). However, according to local news sources, federal officials reached a $21 million-dollar settlement with the local governing body that abandons the comprehensive cleanup plan in favor of capping 166,000 tons of contaminated soil, a less expensive option that could leave some local residents vulnerable to continued toxic exposure (28). The EPA’s most recently proposed cleanup plan includes the installation of wells near the Peters Mine Pit and Peters Mine Pit Airshaft that will introduce an oxygen-releasing compound into the aquifer to break up contaminants. The agency also plans to add granular activated carbon and resin into the airshaft to treat contaminants, after which it will be closed to facilitate recovery. These actions will be accompanied by monitoring and cleanup reviews every five years, and the estimated cost of cleanup is roughly $3.4 million (29).

Throughout the years of dumping, self-reported acute health effects observed in Ramapough children have included rashes, severe headaches, and bleeding from the eyes, nose, and throat (30). Many of these children are now adults residing either in the same community or in surrounding towns and have self-reported diagnoses of chronic diseases such as diabetes,

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reproductive complications, asthma, cancer (especially leukemia) and gastrointestinal diseases, resulting in a dramatic decrease in the Turtle Clan population (27, 31). A 2015 report conducted by the New Jersey Department of Health showed an elevated incidence of lung cancer among men, and cervical and other reproductive complications among women living in the Ringwood Mines area, as compared to the general New Jersey population (30). Despite these findings, as well as a significant number of self-reported cases of chronic illnesses over the years, there have yet to be any community-level health interventions mandated by the state or federal government to improve and/or reduce the Turtle Clan's environmental exposures.

At the request of the Ramapough Turtle Clan leadership, the Community Engagement Core of the National Institute of Environmental Health Sciences (NIEHS)-New York University (NYU) Core Center bi-directionally collaborated with the tribe to assess community environmental concerns, self-reported exposure to the Ringwood Mines/Landfill Superfund Site, and chronic health issues amongst themselves and other members of their households.

Methods

Community in-person and online surveys were conducted between December 2015 and October 2016 with a total of 187 participants. Of those, 103 participants self-identified as members of the Ramapough Lunaape Tribal Nation and 57 as non-Native Americans residing in the same or neighboring Ringwood towns. The surveys–which were designed, edited, and tested collaboratively with the Chief of the Turtle Clan, tribal leaders, and Ramapough members–asked respondents about their personal exposure to any Superfund sites, their own and other household members' known health conditions, and demographic characteristics. Participants who completed in-person surveys were identified and recruited through NYU-based environmental health information sessions held at a local Ringwood church (Church of the Good Shepherd), town hall meetings, community forums, and door-to-door home visits by CITI-trained Ramapough tribal members. All information collected on subjects remained anonymous and participants who completed the in-person survey were compensated for their time.

Those subjects who were unable to complete the in-person survey due to geographical or logistical constraints completed an online survey developed using a Qualtrics University survey system. This survey system ran on a secure PC in the NIEHS-NYU Community Engagement Coordinator's office and was licensed by New York University solely for student and faculty use. The link to the online survey was made available through third party applications including the Ramapough Nation Tribal Facebook and web pages, Ramapough Lunaape Nation-NYU Health Action Alliance, local library web pages, and other relevant web pages often used by the community and environmental groups who represent a diverse array of perspectives. The survey system anonymized responses by excluding participants' names, email addresses, and IP addresses. All third-party applications had no access to data from the survey link. No incentive was provided for online participation. All procedures were approved by the New York University School of Medicine Institutional Review Board (IRB).

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Statistical Analysis

Cross-sectional analyses used responses from both in-person and online surveys to examine any association between exposure opportunities to a Superfund site and various acute and chronic physician-diagnosed health outcomes. The analytic sample size (n = 151) was restricted to those respondents for whom there were complete data on age, sex, and race/ethnicity. The survey inquired about five exposure variables, which included: 1) Currently and ever living/residing on or near the Superfund site; 2) Ever worked near a Superfund site; 3) Ever played or recreated regularly in/on any Superfund site after 1964; 4) Lived, played regularly, or worked in an area where chemicals or Superfund contaminated waste was burned by yourself or others; and 5) Ever eaten food grown in a contaminated Superfund area. Residing near the Superfund fund was based on having lived either in Upper Ringwood (New Jersey); Hillburn Sixth Avenue (New York); Mahwah Avenue A (New Jersey); or Torne Valley (New York). Those who responded that they did, in fact, live in one of these areas were then asked to clarify whether they lived less than 100 feet, less than two miles, less than five miles, or greater than six miles away from the designated waste dump/Superfund site. Among participants with responses for all five exposure variables, those who had none of the queried exposure parameters were given an exposure score of 0. Those with one or more exposure criteria were scored as follows: a single positive criterion was given a score of 1; two exposures received a score of 2; three exposures a score of 3; and four or five positive exposures a score of 4 or 5, respectively.

Bivariate statistics were used to assess potential associations of ethnicity with demographics and five exposure variables. Unconditional logistic regression was then performed to assess each of the ethnicity and demographic variables in relation to having an exposure score greater than 1, while adjusting for age, sex, smoking history, and level of educational attainment. Unconditional logistic regression was also conducted to evaluate the association between having a greater than 1 exposure score and selected health outcomes, while controlling for ethnicity, age, and sex. The analyses were first performed for the overall study population and then restricted only to Native Americans. Odds ratios for different health outcomes adjusted for history of smoking were also calculated, but smoking was not included in the final model as it highly reduced the analytic sample size, and point estimates were not substantially different from those derived from multivariate regressions not controlling for history of smoking. This was followed by sensitivity analyses of the association between imputed exposure scores and imputed bronchitis using various iterations of missingness in the exposure criteria. All analyses were conducted in STATA SE 15 (StataCorp, College Station, TX).

Results

The majority of personal and online participants self-identified as Native American (64.3%). All participants had a mean age of 51.9 (SD = 14.6) and 74.2% of all respondents were women (Table 1). All participants' average duration of current residence was 20.21 years (SD = 17.77). Most Native American respondents had a history of smoking (64.5%) and roughly half were solely high school educated (51.1%). Approximately half of all respondents reported currently living on or near a Superfund site (51.0%), ever having

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played or recreated regularly in a Superfund site after 1964 (49.3%), and ever having eaten food or vegetables grown on or near a chemically contaminated area (51.3%). Among the 51% who reported living near the Superfund site, 60% lived within two miles and 84% lived within five miles. The entirety of those living within 100 feet of the Superfund site self-identified as Native American, and 78.2% of those living within two miles of the site identified as Native American. In contrast, fewer total survey respondents reported ever having worked near a Superfund waste site (21.3%) or having lived, played regularly, or worked where chemicals or contaminated waste were burned (30.7%). The overall average exposure score for all participants, out of a maximum of 5.0, was 2.2 (SD = 1.6). Importantly, the average exposure score was 2.8 (SD = 1.4) when considering only self-declared Native Americans and 1.0 (SD = 1.3) among only non-Native Americans ($p < 0.01$). Native American residents were also significantly more likely to have a history of smoking ($p < 0.01$) and to have graduated high school ($p < 0.01$), as compared to Non-Native American respondents (Table 1).

Unconditional logistic regression predicted exposure scores greater than 1 based on several demographic variables. After controlling for ethnicity, age, history of smoking, sex, and education level, only ethnicity was significantly associated with having a Superfund exposure score greater than 1, such that Native Americans were 13.84 times (95% CI 4.32, 44.37) more likely to have an exposure score greater than 1 as compared to non-Native Americans. Male sex (OR 1.81; 95% CI 0.55, 5.95) and having a high school diploma (OR 2.81; 95% CI 0.95, 8.31) were also associated with an exposure score greater than 1, although neither were significant (Table 2).

Adjusted odds ratios controlling for age, sex, and ethnicity were calculated to determine the association between exposure scores greater than 1 and selected chronic diseases (Table 3). Data revealed that, in the population as a whole, having an exposure score greater than 1 was significantly associated with bronchitis (OR 4.10; 95% CI 1.18, 14.23). An exposure score greater than 1 was also associated, although not significantly, with a greater prevalence of allergies (OR 1.23; 95% CI 0.43, 3.54), asthma (OR 2.03; 95% CI 0.64, 6.41), arthritis (OR 2.57; 95% CI 0.80, 8.23), heart disease (OR 1.98; 95% CI 0.59, 6.63), and high blood pressure (OR 2.81; 95% CI 0.87, 9.08) as shown by the elevated odds ratios. When the analysis was restricted to only self-declared Native Americans, the association between an exposure score greater than 1 and bronchitis remained significantly elevated (OR 17.42; 95% CI 1.99, 152.45), and the association between higher exposure scores and asthma reached statistical significance (OR 6.16; 95% CI 1.38, 27.49) (Table 3) in the same Native American population.

There were very few missing data in each of the exposure questions (1.3% to 16.6% missing for each question) and only 17 (11.3%) of the 151 participants were missing responses on more than one question. Sensitivity analyses showed that the associations between dichotomous imputed exposure scores and imputed bronchitis remained similar both among respondents with no missing exposure criteria (OR 2.83; 95% CI 0.82, 9.79), as well as those with one or fewer missing exposure criteria (OR 3.78; 95% CI 1.16, 12.33).

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Discussion

Despite the small sample size, this study demonstrates a strong association between identifying as Native American and having a greater opportunity for exposure to a Superfund site. While the association between Native American ethnicity and potential for a Superfund site exposure score greater than 1 (after adjustment for several other demographic variables) is not novel, it is highly relevant, particularly for the Ramapough Lunaape Turtle Clan Nation among whom such studies had never been performed. This study revealed a significant association between self-reported exposure to a Superfund site and the incidence of bronchitis. Although no significant association was observed between exposure score and other chronic illnesses, odds ratios for several other chronic conditions, including asthma, allergies, arthritis, heart disease, and high blood pressure, were elevated among those individuals reporting multiple interactions with a Superfund site. Furthermore, these associations became more apparent for allergies, asthma, and bronchitis when analyses were restricted to only Native American survey respondents living in the Ringwood vicinity. The significant association observed between exposure criteria and bronchitis in this study is consistent with the plethora of environmental justice literature that asserts that communities of color and low socioeconomic status, particularly Native Americans such as the Ramapough Lunaape, are subjected to higher levels of environmental hazards (32–35).

This community-based health and environmental exposure survey is the first of its kind to be conducted among the Ramapough Lunaape Nation. Members of the Turtle Clan, who grew up and/or have continued to live in the contaminated area for an extended period of time, are likely to have experienced long-term exposure to toxic/carcinogenic contaminants identified by the EPA (e.g., arsenic, benzene, benzo[a]pyrene, bis(2-ethylhexyl)phthalate, cadmium, lead, manganese, mercury, nickel, polychlorinated biphenyls, (PCBs) thallium, total petroleum hydrocarbons, vanadium, xylene, and zinc) to be associated with the upper Ringwood Mines/Landfill Superfund Site at levels exceeding federal/state standards (31).

Cornerstone Engineering Group, on behalf of Ford Motor Company, completed its most recent Annual Groundwater, Mine Water, and Surface Water Sampling of the Ringwood Mines/Landfill Superfund Site in 2018. Results revealed that volatile organic compounds, semi-volatile organic compounds, and heavy metals were still detected in some locations at levels exceeding acceptable New Jersey groundwater standards. These chemicals included the volatile organic compounds benzene and chloroethane, and the semi-volatile organic compounds 1,4-dioxane and hexachlorobenzene. Toxic metals such as arsenic, manganese and total lead also still remain at elevated levels inconsistently at some of the tested sites. Exposure to many of the aforementioned contaminants can exacerbate health disparities rooted in low socioeconomic status, historical trauma, and associated adverse risk behaviors, all of which are common factors influencing health disparities in Indigenous populations (36–38). It is also possible that early life exposure to these same chemical contaminants could have impacted the long-term health and well-being of those adult residents who have since moved away (39–41).

Several limitations of this study are recognized. First, 187 people out of a total population of approximately 12,200 Ringwood residents and roughly 5,000 to 8,000 Ramapough Lunaape

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members nationwide completed the health survey (42). Only 151 of those surveyed were included in the analysis due to missing data on ethnicity, exposure, and/or health outcomes. The small sample size reduced the power of the analysis to detect significant associations between exposure score and health conditions and reduced the ability to control for additional covariates. Secondly, exposure and physician-diagnosed disease were self-reported, which could introduce information bias into the study. That being said, several studies have found validity in self-reported health data (43–45). Finally, the cross-sectional nature of the study precluded the ability to observe a temporal association between exposure to a Superfund site and later onset of disease as is necessary to determine a causal association. Future longitudinal studies should include additional tribal and non-tribal community members to assess environmental exposures and health outcomes through sophisticated biomarkers, diagnostic, and geospatial analyses. Moreover, such longitudinal analyses could examine exposure to the Ringwood Mines Superfund site as a potential mediator between Native American ethnicity and bearing a disproportionate burden of disease due to heightened exposure using definitive biological markers of both exposure to toxicants and subsequent health conditions.

While it is not possible based on these studies to firmly conclude that contact with any particular Superfund site was responsible for the observed effects, it could be speculated that the excessive burden of disease amongst the Ramapough Lunaape Turtle Clan members could, in part, be attributed to their contact with the Ringwood Mines Superfund site and the legacy of industry's toxic environmental waste dumping in this residential community.

Conclusion

Findings from this study clearly demonstrate that Ramapough Lunaape Turtle Clan members are more likely to come into contact with Superfund or waste dump sites than non-Native Americans living in the same vicinity, and that their increased exposure opportunities are significantly associated with certain later-life chronic diseases. This community-collaborative study was undertaken to help build capacity, engage, and empower the Ramapough Lunaape Turtle Clan Nation to continue seeking action aimed at regaining some of their cultural traditions such as hunting and fishing; to identify, address, and mitigate health disparities; and obtain sustainable human and environmental rights. Moreover, this work also demonstrates the importance of sustained community-academic partnerships as a critical factor for translation, dissemination, and evidence-based assessments to help guide research agendas and set appropriate policy

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References

1. Brenneman G, Rhoades E, Chilton L. Forty years in partnership: the American Academy of Pediatrics and the Indian Health Service. Pediatrics. 2006; 118(4):e1257–63. doi:10.1542/peds.2006-036210.1542/peds.2006-0362. [PubMed: 17015514]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

2. Acton KJ, Ríos Burrows N, Moore K, Querec L, Geiss LS, Engelgau MM. Trends in Diabetes Prevalence Among American Indian and Alaska Native Children, Adolescents, and Young Adults. Am J Public Health. 2002; 92(9):1485–90. [PubMed: 12197981]

3. Jones DS. The Persistence of American Indian Health Disparities. American Journal of Public Health. 2006; 96(12):2122–34. doi:10.2105/ajph.2004.054262 [PubMed: 17077399]

4. Disparities | Fact Sheets. Indian Health Service. 2018 https://www.ihs.gov/newsroom/factsheets/disparities/.

5. American Indian/Alaska Native Programs. American Diabetes Association. 2014 http://www.diabetes.org/in-my-community/awareness-programs/american-indian-programs/.

6. IHS US. Changing the Course of Diabetes: Turning Hope into Reality: Indian Health Service, Indians SDPf;2014.

7. EPA US. Hazardous waste releases on Indian land: Beginning the Superfund process. Washington, DC: EPA; 1989.

8. Meltzer GY, Watkins B-X, Vieira D, Zelikoff JT, Boden-Albala B. A Systematic Review of Environmental Health Outcomes in Selected American Indian and Alaska Native Populations. Journal of Racial and Ethnic Health Disparities. 2020. doi:10.1007/s40615-020-00700-2

9. Codru N, Schymura MJ, Negoita S, Akwesasne Task Force on E, Rej R, Carpenter DO. Diabetes in relation to serum levels of polychlorinated biphenyls and chlorinated pesticides in adult Native Americans. Environ Health Perspect. 2007; 115(10):1442–7. doi:10.1289/ehp.10315 [PubMed: 17938733]

10. Aminov Z, Haase R, Carpenter DO. Diabetes in Native Americans: elevated risk as a result of exposure to polychlorinated biphenyls (PCBs). Rev Environ Health. 2016; 31(1):115–9. doi:10.1515/reveh-2015-0054 [PubMed: 26943594]

11. Aminov Z, Haase R, Rej R, et al. Diabetes Prevalence in Relation to Serum Concentrations of Polychlorinated Biphenyl (PCB) Congener Groups and Three Chlorinated Pesticides in a Native American Population. Environ Health Perspect. 2016; 124(9):1376–83. doi:10.1289/ehp.1509902 [PubMed: 27035469]

12. Grice BA, Nelson RG, Williams DE, et al. Associations between persistent organic pollutants, type 2 diabetes, diabetic nephropathy and mortality. Occup Environ Med. 2017; 74(7):521–7. doi:10.1136/oemed-2016-103948 [PubMed: 28438788]

13. Holmes AK, Koller KR, Kieszak SM, et al. Case-control study of breast cancer and exposure to synthetic environmental chemicals among Alaska Native women. International journal of circumpolar health. 2014; 73:25760.

14. Newman J, Aucompaugh AG, Schell LM, et al. PCBs and cognitive functioning of Mohawk adolescents. Neurotoxicol Teratol. 2006; 28(4):439–45. doi:10.1016/j.ntt.2006.03.001 [PubMed: 16809019]

15. Newman J, Behforooz B, Khuzwayo AG, Gallo MV, Schell LM, Akwesasne Task Force on the E. PCBs and ADHD in Mohawk adolescents. Neurotoxicol Teratol. 2014; 42:25–34. doi:10.1016/j.ntt.2014.01.005 [PubMed: 24462617]

16. Carpenter DO, Miller PK. Environmental contamination of the Yupik people of St. Lawrence Island, Alaska. Journal of Indigenous Research. 2011; 1(1).

17. Franceschini N, Fry RC, Balakrishnan P, et al. Cadmium body burden and increased blood pressure in middle-aged American Indians: the Strong Heart Study. Journal of human hypertension. 2017; 31(3):225–30. doi:10.1038/jhh.2016.67 [PubMed: 27629244]

18. Oliver-Williams C, Franceschini N, Howard AG, Navas-Acien A, Howard BV. Cadmium exposure and blood pressure: results from a prospective cohort study in American Indians. Journal of human hypertension. 2016; 30(10):645–.

19. Garcia-Esquinas E, Pollan M, Tellez-Plaza M, et al. Cadmium exposure and cancer mortality in a prospective cohort: the strong heart study. Environ Health Perspect. 2014; 122(4):363–70. doi:10.1289/ehp.1306587 [PubMed: 24531129]

20. Tellez-Plaza M, Guallar E, Howard BV, et al. Cadmium exposure and incident cardiovascular disease. Epidemiology. 2013; 24(3):421–9. doi:10.1097/EDE.0b013e31828b0631 [PubMed: 23514838]

21. Remnick N The Ramapough vs. The World. The New York Times. 2017 4 14, 2017.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

22. Depalma A Ramapough Tribe Sues Ford Over Sludge Dumping in New Jersey. New York Times. 2006 1 19, 2006.
23. Surface Water Quality Standards Last Amended - 1 18, 2011 (43 N.J.R. 174(b)), 7:9B (2016).
24. Abadin H, Taylor J, Buser M, et al. Toxicological Profile for Lead: Agency for Toxic Substances and Disease Registry, Services USDoHaH;2019 Report No.: CS274127-A Contract No.: CS274127-A.
25. Chou S, Harper C, Ingerman L, et al. Toxicological Profile for Arsenic: Agency for Toxic Substances and Disease Registry, Services USDoHaH;2007 Contract No.: 7440-38–2.
26. Wilbur S, Abadin H, Fay M, et al. Toxicological Profile for Chromium: Agency for Toxic Substances and Disease Registry, Services USDoHaH;2012 Report No.: 7440-47–3.
27. US EPA O. RINGWOOD MINES/LANDFILL Site Profile. 2017 https://cumulis.epa.gov/supercpad/SiteProfiles/index.cfm?fuseaction=second.contams&id=0200663.
28. Fallon S Most of Ford's remaining pollution to stay in Ringwood under cheaper cleanup deal with EPA. North Jersey Record 2019.
29. Rodriguez E EPA Proposes Cleanup Plan to Address Groundwater Contamination at the Ringwood Mines/Landfill Superfund Site in New Jersey. Ringwood, New Jersey: Environmental Protection Agency; 2020.
30. Fagliano J, McGreevy K, Agovino P. Birth Outcomes, Cancer Incidence and Mortality among the Ramapough Lenape Nation Turtle Clan Communities in Ringwood and Mahwah, New Jersey. Trenton, New Jersey: New Jersey Department of Health 2015.
31. Ahmed T, Petix JR, Berry M, Haltmeier P. Public Health Assessment: Ringwood Mines/Landfill Site Ringwood Passaic County. Trenton, NJ: NJ Department of Health and Senior Services 2006.
32. Whyte KP. Environmental Justice in Native America. Environmental Justice. 2011; 4(4):185–6. doi:10.1089/env.2011.4401
33. Vickery J, Hunter LM. Native Americans: Where in Environmental Justice Research? Soc Nat Resour. 2016; 29(1):36–52. doi:10.1080/08941920.2015.104564410.1080/08941920.2015.1045644. [PubMed: 27103758]
34. Brook D Environmental Genocide. American Journal of Economics and Sociology. 1998; 57(1):105–13. doi:10.1111/j.1536-7150.1998.tb03260.x
35. Burger J, Gochfeld M. Conceptual Environmental Justice Model for Evaluating Chemical Pathways of Exposure in Low-Income, Minority, Native American, and Other Unique Exposure Populations. American Journal of Public Health. 2011; 101(S1):S64–S73. doi:10.2105/ajph.2010.300077 [PubMed: 21551379]
36. Cobb N, Espey D, King J. Health Behaviors and Risk Factors Among American Indians and Alaska Natives, 2000–2010. American Journal of Public Health. 2014; 104(S3):S481–S9. doi:10.2105/ajph.2014.301879 [PubMed: 24754662]
37. Denny CH, Holtzman D, Goins RT, Croft JB. Disparities in chronic disease risk factors and health status between American Indian/Alaska Native and White elders: findings from a telephone survey, 2001 and 2002. American journal of public health. 2005; 95(5):825–7. doi:10.2105/AJPH.2004.043489 [PubMed: 15855458]
38. Sarche M, Spicer P. Poverty and health disparities for American Indian and Alaska Native children: current knowledge and future prospects. Ann N Y Acad Sci. 2008; 1136:126–36. doi:10.1196/annals.1425.017 [PubMed: 18579879]
39. Vaiserman A Epidemiologic evidence for association between adverse environmental exposures in early life and epigenetic variation: a potential link to disease susceptibility? Clinical Epigenetics. 2015; 7(1):96. doi:10.1186/s13148-015-0130-0 [PubMed: 26366233]
40. Gluckman PD, Hanson MA, Cooper C, Thornburg KL. Effect of In Utero and Early-Life Conditions on Adult Health and Disease. New England Journal of Medicine. 2008; 359(1):61–73. doi:10.1056/NEJMra0708473 [PubMed: 18596274]
41. Schug TT, Janesick A, Blumberg B, Heindel JJ. Endocrine disrupting chemicals and disease susceptibility. The Journal of Steroid Biochemistry and Molecular Biology. 2011; 127(3):204–15. doi:10.1016/j.jsbmb.2011.08.007 [PubMed: 21899826]
42. QuickFacts: Ringwood borough, New Jersey. U.S. Census Bureau. 2018 http:////www.census.gov/quickfacts/fact/table/ringwoodboroughnewjersey/BZA010216 2019.

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43. Bourne PA. The validity of using self-reported illness to measure objective health. N Am J Med Sci. 2009; 1(5):232–8. doi:10.4297/najms.2009.5232 [PubMed: 22666701]

44. Vargas CM, Burt VL, Gillum RF, Pamuk ER. Validity of self-reported hypertension in the National Health and Nutrition Examination Survey III, 1988–1991. Prev Med. 1997; 26(5 Pt 1):678–85. doi:10.1006/pmed.1997.0190 [PubMed: 9327477]

45. Fosse NE, Haas SA. Validity and stability of self-reported health among adolescents in a longitudinal, nationally representative survey. Pediatrics. 2009; 123(3):e496–e501. doi:10.1542/peds.2008-1552 [PubMed: 19254984]

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Table 1

Distribution of selected population characteristics and exposure variables by ethnicity (N = 151)

	Total	Ethnicity		
	N (%) N = 151	Non-Native American n (%) n = 54	Native American n (%) n = 97	*p-value*[2]
Sex				
Female	112 (74.17)	40 (74.07)	72 (74.23)	
Male	39 (25.83)	14 (25.93)	25 (25.77)	0.984
Age (years), mean (SD)[2]	51.85 (14.58)	52.33 (2.19)	51.58 (1.40)	0.761[3]
Smoking status[4]				
Never	43 (35.54)	22 (52.38)	21 (26.58)	
Ever	78 (64.46)	20 (47.62)	58 (73.42)	0.005
Education[3]				
≤ High school	70 (48.95)	45 (86.54)	25 (27.47)	
> High school	73 (51.05)	7 (13.46)	66 (72.53)	<0.001
Marital status[3]				
Married or domestic partnership	81 (54.00)	31 (57.41)	50 (52.08)	
Single	37 (24.67)	12 (22.22)	25 (26.04)	
Separated, widowed, or divorced	32 (21.33)	11 (20.37)	21 (21.88)	0.810
Currently living on or near a contaminated waste or Superfund Site[3]				
No	73 (48.99)	30 (56.60)	43 (44.79)	
Yes	76 (51.01)	23 (43.40)	53 (55.21)	0.167
Distance between home and Superfund Site[3]				
Less than 100 feet	22 (29.33)	0 (0.00)	22 (41.51)	
Less than two miles	23 (30.67)	5 (22.73)	18 (33.96)	
Less than five miles	18 (24.00)	12 (54.55)	6 (11.32)	
Greater than six miles	12 (16.00)	5 (22.73)	7 (13.21)	<0.001[4]
Duration of current residence (years), mean (SD)[3]	20.21 (17.77)	17.48 (15.31)	21.71 (18.91)	0.165
Ever worked near a contaminated waste or Superfund Site after 1964[3]				
No	118 (78.67)	49 (92.45)	69 (71.13)	
Yes	32 (21.33)	4 (7.55)	28 (28.87)	0.002[5]
Ever played or recreated regularly in the Superfund Site after 1964[3]				
No	77 (50.66)	45 (80.36)	32 (33.33)	
Yes	75 (49.34)	11 (19.64)	64 (66.67)	<0.001
Lived, played regularly, or worked in an area where chemicals or contaminated waste was burned by yourself or others[3]				
No	104 (69.33)	47 (88.68)	57 (58.76)	

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	Total	Ethnicity		
	N (%) N = 151	**Non-Native American n (%) n = 54**	**Native American n (%) n = 97**	***p-value*[2]**
Yes	46 (30.67)	6 (11.32)	40 (41.24)	<0.001
Ever eaten food grown in a contaminated area[3]				
No	73 (48.67)	46 (86.79)	27 (27.84)	
Yes	77 (51.33)	7 (13.21)	70 (72.16)	<0.001
Exposure score, mean (SD)[3]	2.17 (1.58)	0.97 (1.27)	2.80 (1.35)	<0.001[2]

[2]Pearson's χ^2 unless otherwise indicated

[3]Two-sample t test with equal variances

[4]Totals do not add up to N due to missing values

[5]Fisher's exact

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Table 2

Binomial regression predicting exposure scores[5] greater than 1, N = 111

	Crude Odds Ratios (95% CI)	Multivariate Odds Ratio[5] (95% CI)
Ethnicity		
Non-Native American	1.00	1.00
Native American	12.36 (5.4228.20ď) **	13.84 (4.3244.37ď) **
Age	1.00 (0.981.02ď)	1.00 (0.961.03ď)
History of Smoking		
No	1.00	1.00
Yes	1.59 (0.733.45ď)	0.83 (0.272.55ď)
Sex		
Female	1.00	1.00
Male	1.53 (0.713.28ď)	1.81 (0.555.95ď)
Education level		
≤ High school	1.00	1.00
> High school	6.36 (3.0013.50ď) **	2.81 (0.958.31ď)

* *p*-value < 0.05

** *p*-value < 0.01

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Table 3

Association between exposure scores[5] and selected diseases

	Exposure score 0–1		Exposure score > 1		
	Cases/non-cases (*n*)	**OR (95% CI)**	**Cases/non-cases (n)**	**Crude OR (95% CI)**	**Adjusted OR[5] (95% CI)**
Allergies	14/26	1.00	35/24	2.71 (1.18–6.22) *	1.23 (0.43–3.54)
Native American	5/6	1.00	17/34	2.40 (0.64–9.00)	2.46 (0.65–9.30)
Asthma	10/30	1.00	43/21	6.14 (2.53–14.89) **	2.03 (0.64–6.41)
Native American	4/6	1.00	43/13	4.96 (1.21–20.30) *	6.16 (1.38–27.49) *
Bronchitis	5/34	1.00	33/27	8.31 (2.86–24.17) **	4.10 (1.18–14.23) *
Native American	1/9	1.00	33/19	15.63 (1.84–133.09) *	17.42 (1.99–152.45) *
Arthritis	12/28	1.00	37/24	3.60 (1.54–8.41) **	2.57 (0.80–8.23)
Native American	5/6	1.00	34/19	2.15 (0.58–7.98)	2.32 (0.58–9.31)
Heart disease	8/34	1.00	26/37	2.99 (1.19–7.49) *	1.98 (0.59–6.63)
Native American	4/7	1.00	23/31	1.30 (0.34–4.97)	1.49 (0.34–6.49)
High blood pressure	15/27	1.00	52/17	5.51 (2.39–12.70) **	2.81 (0.87–9.08)
Native American	9/2	1.00	47/13	0.80 (0.15–4.19)	0.88 (0.13–5.78)
Type 2 diabetes	7/34	1.00	18/43	2.03 (0.76–5.43)	0.72 (0.19–2.73)
Native American	5/6	1.00	17/36	0.57 (0.15–2.12)	0.54 (0.13–2.31)

* *p*-value < 0.05

** *p*-value < 0.01