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Human Health

Health Disparities and Respiratory Illness in Salton Sea Communities

Somiya Maheshwari, Diana Del Castillo and **David D. Lo**
BREATHE Center and Center for Health Disparities Research
UCR School of Medicine
University of California, Riverside, CA 92521

HIGHLIGHTS

- **Continued environmental degradation at the Salton Sea accompanied by increased production of dust and other air and water pollutants has already impaired the economic and social fabric of the region.**
- **In communities already subject to disparities in social and economic status, the environmental hazards are evident from the epidemiology of diseases, especially pulmonary diseases such as asthma.**
- **Comorbid factors including the high incidence of obesity, poverty, poor access to health care, and chemical exposures from agriculture work further degrade the quality of life, driving additional impacts on mental health in the community.**

According to the 2010 U.S. Census, there are 130,000 people living within 15 miles of the Salton Sea, with another 650,000 directly affected by the dust emitted from the shoreline and surrounding desert and agricultural landscapes (Johnston, 2019). These areas around the Salton Sea face many socioeconomic disparities with potential impacts on health, including linguistic isolation, lack of education, lack of funding and health profession shortages. These disadvantages likely exaggerate ongoing health disparities within these communities. Not only are is there lesser access to health care providers but also a higher incidence of health problems, including the regional respiratory health crisis associated with windblown dust.

The drying of the Salton Sea is exposing dry lakebed, or playa, and increasing levels of ambient aerosol dust

INNER CANAL at Desert Shores, left behind as the shoreline receded. Caroline Hung

(Box 6A). Dust storms have been linked with cardiovascular mortality, asthma hospitalization, Chronic Obstructive Pulmonary Disorder (COPD) and decreased pulmonary function, problems that are only expected to get worse in the coming years (Johnston et al., 2019).

The high prevalence of asthma around the Salton Sea is already making headlines, as 1 in 5 Imperial County residents have been diagnosed with asthma. The national U.S. prevalence for asthma is 7.7% for adults and 8.4% for children, in stark contrast to the 22.4% prevalence seen in these counties (Branin and Martinez, 2007). These rates are high even in comparison with other nearby regions. A comparison with neighboring cities near the Mexico–U.S. border, thereby controlling for location and demographics with a cross-border population, showed that while some areas in Imperial County had exceptionally high rates of asthma prevalence of 26.5%, comparable cities near the Mexican border had rates of only 5.8%.

It is evident that respiratory disease is already a public health crisis in the regions around the Salton Sea, particularly among children. Currently, Imperial County sees twice the number of pediatric asthma emergency room visits as California's average (California Department of Public Health). Children are immunocompromised from the impacts of air pollution, as their lungs and immune system are still developing. This not only makes children susceptible to asthma episodes or respiratory distress, but also at risk for long-term effects such as a decreased lung growth and airway inflammation.

Particulate matter (PM_{10}) levels found in the area frequently exceed California's 24-hour standard of 50 micrograms in a cubic meter ($\mu g/m^3$). They also regularly exceed federal standards of 150 $\mu g/m^3$ in a 24-hour period. These excesses often occur during dust episodes lasting multiple days. These excesses are expected to lead to increased mortality, with previous work showing that increases of 100 g/m^3 in PM_{10} can be expected to produce a 16% increase in death rate (Pope

et al., 1992). Occupational exposure to PM_{10} has been linked to COPD, Organic Dust Toxic Syndrome (ODTS), bronchitis, pneumoconiosis, rhinitis, and asthma (Cohen, 2014). PM_{10} can furthermore serve as a carrier for pollen allergens, further exacerbating allergic asthma in the area and increasing health risks.

Living further away from the exposed area reduces the risks of long term respiratory conditions; however, even at a greater distance from the Sea there is a link to an increased prevalence of cough, wheeze, bronchitis symptoms, eye irritation and nasal irritation (Figure 6.1). Additionally, the acreage being impacted by the dust particles is increasing dramatically, as exposed areas went from 862 to 16,542 acres between 2013–2016 (Formation Environmental, 2018). Therefore, it is predicted that the rate of asthma will increase in this area and may even be underreported and undiagnosed right now, specifically in children of Mexican origin.

Respiratory Symptoms

There is still work to be done in identifying possible connections between dust particles and their components to the respiratory symptoms seen in the area (Box 6A). Geothermal vents at the southeast margin of the Salton Sea are observed sources of free ammonia, which is known to cause coughing, nose and throat irritation (Tratt et al., 2011). Salton Sea playa has also been found to contain a relatively high fraction of soluble sulfate (Frie et al., 2017), which is known to further exacerbate allergic asthma. Mineral dust is also primarily made up of silica, which is known to cause chronic bronchitis or pneumoconiosis. Inhalation of dust exacerbates respiratory effects, increases hospital admissions, increases blood pressure and decreases lung function in young adults (Ostro et al., 2009). Dust storms become even more problematic as studies show that the dust can be associated with allergens, microbes, fungi, and viruses. This means that there is not only potential for asthma and respiratory distress with dust storms, but also infections and mass transmission of infectious disease.

In addition, contaminants in the Salton Sea such as pesticides and heavy metals (e.g., selenium, arsenic) can be carried as components of the dust particles generated from playa emissions, and these compounds could also have effects on respiratory health. Pesticides are known to impact pulmonary health in the context of direct inhalation during agricultural activities (Hernandez et al., 2008). These components are commonly detected in agricultural runoff (Sapozhnikova et al., 2004). These compounds may be largely sequestered in the bottom sediments (Schroeder et al, 2002); however, these sediments may become exposed and emissive as the sea continues to shrink.

Finally, another factor that needs to be taken into account is the ecological instability in the drying Salton Sea itself and its contribution to environmental hazards associated with playa dust. For example, cyanobacteria detected in the Salton Sea can contribute potent liver toxins that may contribute to migratory bird deaths (Carmichael and Li, 2006). These and similar microbial toxins may be an important contributor to the playa dust with consequent pulmonary health impacts for humans as well.

Vulnerable Population

The communities living around the Salton Sea are primarily low-income, rural, and Latino, making them particularly vulnerable to the detrimental effects of low air quality and the long-term effects of chronic disease. In particular, inadequacies already exist in asthma management among Hispanic Americans, the predominant local population. High uninsured rates contribute to these vulnerabilities: 33% of adults and 15% of teens and children are uninsured in Coachella Valley (UCLA Center for Health Policy Research, 2011), however other factors leading to these disparities need to be addressed.

Table 6.1 Current and projected populations that will be affected by Salton Sea dust. Coachella Valley populations beyond 2035 County projection estimate at 1% annual growth rate. Source: Cohen (2014)

	2013	2015	2020	2035	2045	Source
Coachella Valley	469,248	488,300	576,161	842,960	931,150	Riverside County Projections
Imperial County	179,527	192,707	222,920	277,418	311,360	California Dept. of Finance
Total	648,775	681,012	799,081	1,120,378	1,242,512	

Components and Sources of Dust

BOX 6A

NOT ALL COMPONENTS OF WINDBLOWN DUST are equally harmful to human health. Particulate matter is known to have adverse effects on the pulmonary and cardiac systems (Pope, 2000), but in the Salton Sea region, dozens of different types of coarse particulate matter up to 10 µm in aerodynamic size (PM_{10}) originate from at least eight sources on the lake and surrounding landscapes (Figure 6.1). Fumaroles above the Salton Sea Geothermal Field emit free ammonia known to irritate mucus membranes, for example, and the exposed lakebed, or playa, along the receding shoreline releases sulfate (SO_4^{2-}), which is known to exacerbate allergic asthma. Most PM_{10} sources will become more prevalent as the acreage of playa increases.

Further research is critical to help regional planners design the most efficient mitigation plans as the Sea continues to shrink. Without establishing clear epidemiological connections between specific dust components and known respiratory illness in local communities, it is impossible to discern what mitigation efforts will have the biggest pay-off from a public heath perspective. If we rely only on the simplest association between pulmonary health and windblown dust, then increasing acreage of exposed playa will likely produce the worst outcome in terms of health effects.

If we take into consideration the role of specific dust sources, however, the worst case scenario may be surprisingly different. Consider a case in which microbial toxins from harmful algal blooms in the Salton Sea turn out to be the greatest health threat. In this hypothetical situation, designing a plan to reduce of biological toxins in the lake may be a more cost-effective public health investment than constructing dust mitigation berms on the playa to lower the overall production of dust.

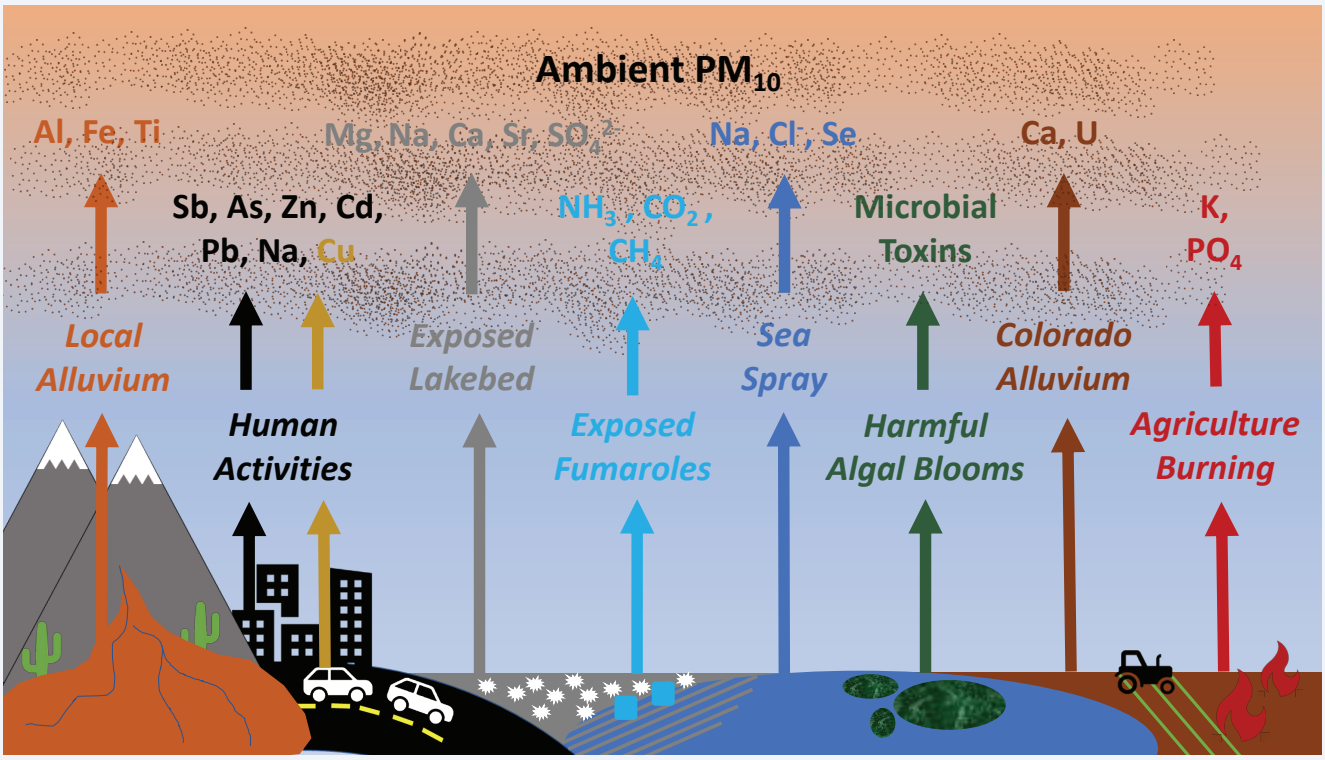

FIGURE 6.1 Sources and components of coarse particulate matter (PM_{10}) in and around the Salton Sea. Some of these compoents, such as microbial toxins and selenium (Se) are much more dangerous to human health than others. Credit: Alexander Frie and Roya Bahreini.

AGRICULTURAL FIELDS in the Imperial Valley. Jonathan Nye

A significant percentage of people who identify as foreign born, primarily from Mexico and Latin America, experience unique barriers in language and culture. Compared to the California average of 22.1%, Imperial and Coachella counties have higher rates of English learners in public schools with 43.8% and 53.6%, respectively (California Department of Education, 2019), pointing toward communication obstacles that adversely affect quality of health care. Potentially due to these reasons, Hispanic populations are also less likely than other populations to seek medical care, opting for self-treatment and home remedies before seeking medical attention at a traditional healthcare facility. Thus, inadequate health education among communities may lead to the suboptimal medication use, adherence to treatment and preventative care measures.

Comorbidities can also have a significant impact. This area suffers from some of the highest rates of adult and pediatric obesity (UCLA Center for Health Policy Research, 2011), where obesity is linked to worse overall asthma control outcomes potentially due to synergistic effects through inflammation. Overall, linguistic barriers, the lack of cultural competency of healthcare providers and inadequate health education within communities carry transgenerational effects and negatively impact asthma management trends.

Agricultural Workers

Situated within the thriving agricultural hubs of Eastern Coachella Valley and Imperial County, the Salton Sea communities have a comparatively large percentage of the population working in these industries. For the farmworker communities such as Mecca, Thermal, Oasis and North Shore, specific data on health impacts is difficult to assess; however, it is reported that more than a third of the population lives below the poverty line, with poverty levels as high as 43% in Oasis (U.S. Census Bureau, 2018). The immediate impact on agricultural workers, brought about by the long hours outdoors and physically intense labor, may further aggravate potential exposure to harmful pollutants.

Agricultural workers are already disproportionately affected by respiratory conditions and are at higher risk for developing chronic conditions, yet a majority do not have health insurance (Ayala et al., 2001). An evaluation of agricultural worker health and housing found that many of these workers not only suffer from the healthcare disparities already mentioned, but also through struggling home environments where mobile homes make up a significant proportion of housing coupled with hazardous electrical hookups, contaminated well water and inadequate septic systems (Branin and Martinez, 2007). This area experiences some of the harshest weather during summers and unreliable air conditioning can pose a threat through further exposure to the poor air quality as open windows are the only ventilation option.

Moreover, the agricultural industry is a significant contributor to Salton Sea pollutants through irrigation runoff containing pesticides, such as organophosphorus insecticides, chlorpyrifos and industrial contaminants as well as contributing to aerosolized particulate matter (Johnston et al., 2019), in addition to direct hazards to the workers as part of agricultural activity.

Mental Health

There is also the issue of the effects on mental health and the existing difficulties in care. As recently as 2019,

Health and Socioeconomic Disparities

BOX 6B

COMMUNITIES SURROUNDING the Salton Sea face an alarming deficiency in access to health care. The U.S. national average of Primary Care Physicians (PCPs) is 68 per 100,000 people in rural areas and 84 per 100,000 people in urban areas (Petterson et al., 2013). By contrast, only 52 PCPS serve the roughly 130,000 people who live within 15 miles of the Salton Sea (21 PCPs in Imperial County, at the southern end of the lake, and 31 PCPs in Coachella Valley at the northern end), which qualifies this region as a Medically Underserved Area (MUA). Coachella Valley and Imperial County also face additional socioeconomic barriers. For example, California's average poverty level is 12.8%, while poverty levels in Imperial County and Coachella Valley are 23.2% and 19.9%, respectively. This disparity is also apparent in per capita income: Imperial County residents average $16,920 per year while Coachella Valley residents average $25,595, much lower than the California state average of $37,124. Educational achievement also lags behind state averages, with high school diploma attainment rates 14% lower in Imperial County and 11% lower in Coachella Valley. The discrepancy is even greater for higher education, with bachelor degree attainment rates 20% lower than state averages in Imperial County and 18% lower in Coachella Valley (U.S. Census Bureau, 2018).

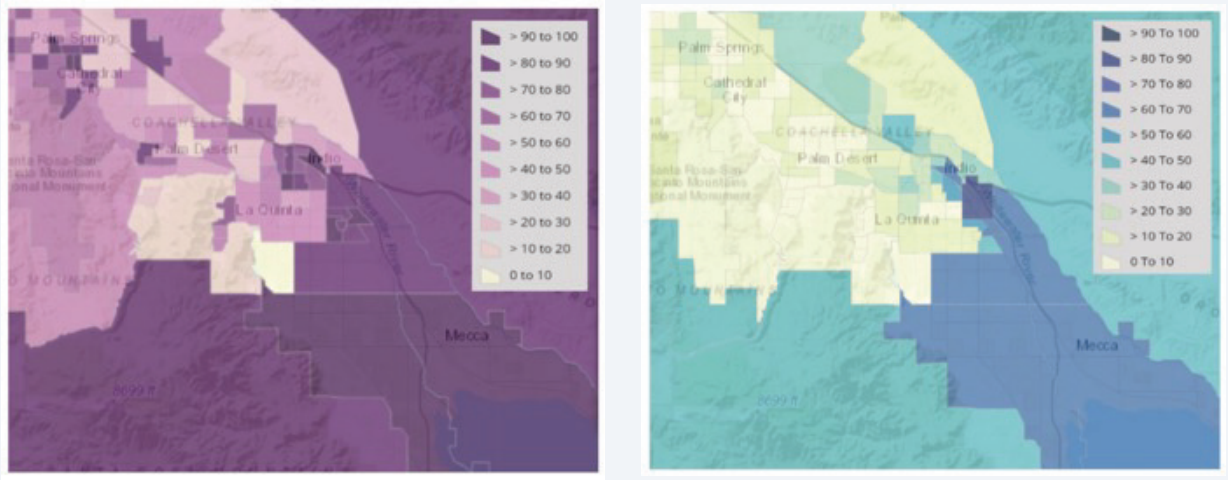

Figure 6.2 Coachella Valley poverty percentiles (left) and pollution burden percentiles (right). Adapted from the CalEnviroScreen 3.0 Overall Results and Individual Indicator Maps provided by the California Office of Health Hazard Assessment (OEHHA). Credit: Faust and August (2017).

Coachella Valley community leaders reported mental health as the issue requiring the most priority due to the risk of significant impact to the community, a worsening prospective and the severe lack of resources (Eisenhower Health, 2019). In 2005, of all the counties in California, Imperial County and Riverside County had the two lowest percentages of those who reported to see mental health specialists in the last year, with only 4.2% and 5.2% in each county respectively as well as some of the lowest per capita rates of mental health providers and resources- Imperial county being the lowest in almost all categories. This need is further complicated when the language sensitive communication of mental health is paired with linguistic barriers and the stigma around mental health issues within Hispanic communities.

Additionally, some studies have identified migrant farm workers as particularly vulnerable to psychological distress (Ayala et al., 2001) and others have found a relationship between mental health and asthma severity, particularly with anxiety and depression (Ledford and Lockey, 2013). With already high documented rates of anxiety in Imperial County, the lack of access to mental health providers and resources is a worrisome

OLD DOCK along receded shoreline. Jonathan Nye

disparity that may be exaggerated by health effects of the pollution and decreasing property value.

This discussion has been based largely on various data sources that point to a connection between playa dusts and health impacts, and statistical associations between the Salton Sea and the locally high incidence of asthma. These associations are strongly suggestive and have driven the initiatives to mitigate local dust generation and address the problem of the retreating Salton Sea. However, the health impact associations and proposed mitigation activities are based on a number of inferences and assumptions. At UCR, ongoing studies are aimed at establishing direct connections rather than rely on inference, and we propose that many more targeted research studies will be critical to validate the assumed connections so that the mitigation and other initiatives are actually directed at solving the true underlying causes of disease.

Research Needs

In the context of possible futures of the Salton Sea, ongoing research will be needed to guide predictions of how each scenario may impact the local health effects. As noted here, work is still needed to identify the main contributors to the aerosols with the most potent pulmonary health effects. If we rely only on the simplest association between pulmonary health and dusts, then the first two scenarios, leaving more exposed playa, will likely be worst in terms of health effects. However, if we also take into consideration the role of Salton Sea ecology and potential contribution of biological toxins, then it may be determined that reducing biological toxins may have a greater impact on health than improved dust levels from reductions of exposed playa. Thus, changes in the salinity may have disproportionate impact on ecosystem and microbiome stability, with impact on microbial toxin production. Indeed, one possible outcome from Scenario 1 is that at a higher end salinity, the ecosystem stabilizes and toxin production drops. Moreover, at higher salinity, pesticides and heavy metals in the water and food chain may be more stably sequestered in sediments, reducing their presence in playa dusts.

Thus, ongoing research is essential for understanding the various environmental hazards and their impacts on health. One area where new research is absolutely critical is in the detailed epidemiology of

clinical disease in the various Salton Sea communities. The aerosols in the region show seasonal changes due to wind direction and variation in emissivity at different locations around the sea (Chapter 4), so populations affected by the aerosols may also show variation in clinical symptoms. In addition, the clinical term "asthma" is a rather general diagnosis referring only to airway hyperreactivity. Given the apparent connection to environmental aerosols in the region, there may be a number of factors leading to clinical asthma, which may be rather different from those inducing more conventional allergic (or "atopic") asthma. A detailed clinical study is critically needed to establish the actual clinical entity diagnosed as asthma in the region. If the underlying cause for airway hyperreactivity is connected to some previously unknown source at the Salton Sea, this knowledge could drive a more targeted and appropriate strategy for mitigating the health impacts.

Because available evidence implies a direct relationship between the Salton Sea and health impacts, the evident ecologic instability of the sea may also be a key factor; yet there are no studies focused on the changing ecology and its potential impact on health in the region. The contributions of the local geochemistry and pesticide and chemical runoff into the sea may further stress the system. The health impacts could be through microbial components or toxins that may contribute to the aerosols; while some studies have tracked chemical sources of dusts, a pathway from the sea's organic and biological components into local aerosols has not yet been established.

Finally, this compilation refers to scenarios representing different mitigation strategies. For the reasons discussed here, since we have not yet identified the key sources of health impacts at the Salton Sea, evaluating the effects of the different mitigation scenarios will have to depend on understanding which effects are most important to the health effects, whether it involves ecological stability, overall dust emissions from exposed playa, or other factors. Moreover, it is not clear whether any of the critical health disparities will be addressed by any of the scenarios, since restoration of the local economy and associated improvements in health care access are not addressed.

In sum, these are not insurmountable issues. It is our hope that the discussion in this report will begin to provide the necessary focus on the key issues affecting health in the region.

Current Research

BOX 6C

FOUR ONGOING, INTERDISCIPLINARY research projects at the University of California, Riverside (UCR) address health issues at the Salton Sea. The overall goal of these studies, led by researchers in the BREATHE Center and the Center for Health Disparities Research in the UCR School of Medicine, is to determine health responses to the particulate compositions around the Salton Sea to provide insights on the local disparities and risk factors to health. Of particular interest is understanding how local aerosols contribute to the incidence of childhood asthma with the hope of leading to better diagnosis and treatment of pulmonary disease in the region.

1. **A Community Advisory Board in East Coachella Valley has been created to build a network among families living with asthma. The board will act as a conduit to obtain qualitative data on asthma-like symptoms to assess impact on local resident families.**
2. **Atmospheric modelers are studying spatial patterns of aerosol and pollutant transport to determine population exposures.**
3. **Environmental scientists and microbiologists are identifying elemental and microbial sources of aerosol particles and their sources in and around the Salton Sea such as topsoil, drying lakebed or marine organisms.**
4. **Biologists and medical experts are studying animal models in environmental chamber exposures to simulate and assess the effects of aerosol particulates and aerosolized environmental components such as Salton Sea spray. Preliminary studies have been examining the impact of local aerosols on pulmonary inflammation and their potential relationship to asthma. Future studies will examine the combinatorial effects of pollution, particulates and biological components from the area.**

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