Oxidative Stress and the Pathophysiology of Nitric Oxide due to Increased Diesel Emissions in the Inland Empire

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Background: With the large industrialization of the Inland Empire, there has been an exponential increase in housing developments alongside the increase in the logistics industry. This development includes the need for infrastructure to support the needs of the local economy. Because of this, more land, warehouses, diesel trucks, and their associated pollutants have increased as well. While these developments have occurred for the good of the local economy, the conversation of the detrimental effects of the chemicals being emitted in the air has not been discussed enough. Without the necessary dialogue, many residents of the Inland Empire do not see the dangers that these chemicals in the air have on their health. Without awareness and understanding of the issues at hand, environmental groups and the legislation they push have a much harder time in backing and successfully achieving their goals. With ground-level community outreach that can open a conversation pertaining to foundational knowledge on why/how certain chemicals harm the human body, more urgency within the community may arise. With more urgency, the voices of those harmed by the pollution will be amplified in order to catalyze the proper dialogue that may lead to better support for future legislation.

Ethnography:

In order to encourage dialogue amongst community members of the Inland Empire regarding the negative health impacts of diesel-based air pollution, a bridge between science and the local population must be made. To do this, I first had to conduct a small-scale ethnography in order to get local perspectives on this issue. In this ethnography, I interviewed different residents of the Inland Empire and asked about their life histories, how the IE has changed, their perspectives on the growing logistics industry, whether air pollution was a personal concern or not, and how they feel change within the collective minds of groups of people can be reached. The interviewees included life-long residents, educators, farmers, medical professionals, warehouse workers, and public health officers.

Literature Review:

After having a better understanding of the perspectives of the residents, I read peer-reviewed journals regarding the pathophysiology of certain airborne pollutants (with a focus on nitric oxide). In my research, I learned what nitric oxides are, how they naturally play roles in human physiology, how they can negatively interact with the body through oxidative stress, and the roles that nitrogen oxides play in the pathophysiology of adverse health conditions through exposure to diesel emissions. With this information, I was then able to create a research paper outlining a couple of the mechanisms (regulatory disruption/oxidative stress) behind the negative effects of air pollution.

Educational Video:

With a research paper regarding cellular damage induced by oxidative stress and regulatory disruption of nitric oxide due to air pollutant exposure, I then converted what I learned into an educational video with the goals of being both accessible through the internet and easily understandable by the public.

Nitric Oxide:

Diesel trucks emit many pollutants in the process of combustion that include carbon monoxides, particulate matter, hydrocarbons, and nitrogen oxides. Nitric oxide (NO) is part of the gaseous compounds of nitrogen oxides (NOx). NO is a simple compound made of one nitrogen and one oxygen. It is a vital neurotransmitter in the body and plays a myriad of important roles. While NO serves as a neurotransmitter, it is also an unstable free radical that will take electrons from other compounds- causing damage at the molecular level. These reactions can lead to cellular damage and the production of more unstable free radicals. This process is called oxidative stress. With increased levels of NO, there will be a higher potential for the production of more free radicals, and thus, the potential for more oxidative stress. Overtime, the cellular damage on DNA, proteins, lipids, and carbohydrates increase leading to larger-scale tissue damage. With respect to respiratory function, NO is important in the regulation of the vasculature of smooth muscle, the communication of respiratory cells through neurotransmitters, mucosal movement, the production of surfactant, the development of lung tissue, ciliary stimulation, as well as in the regulation of the inflammatory response in the immune system. However with too much exposure to exogenous NO and other oxidative pollutants, the homeostasis of NO is disrupted causing deleterious effects. This may lead to bronchial hyperreactivity, vasodilation, free radical production, mucous hypersecretion, ciliary motility inhibition, and a proinflammatory effect. Within the respiratory system, the compounded damage to lung tissue from oxidative stress as well as the disrupted regulatory functions of NO may lead to breathing issues associated with poor lung development in children, exacerbated asthma, severe allergies, as well as COPD in adults.

Figure 1. Map showing the advantageous geographic location of the IE in relation to the logistics industry. Image Southern California Association of Governments (SCAG).

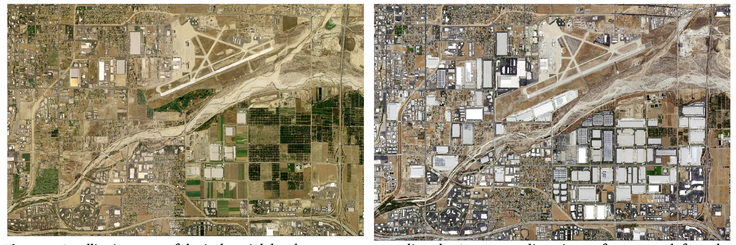

Figure 2. Satellite imagery of the industrial developments surrounding the San Bernardino airport from 2005 (left) and 2018 (right). Images CCAEJ/ESRI.

Resident Perspectives:

"When we first moved here, there was a lot of agriculture and undeveloped land- a lot of dairy farms, mosquitos, and flies."
- M. Stokes, Primary Educator and Life-Long Resident

"My most pressing concern is that we're going to lose the opportunity to continue our business because our landlord has sold this land to a warehouse developer. Even if we do stay, we would be this tiny 10-acre farming island in a sea of warehouses."
- R. Bekendam, Farmer and Businessman

"There's a vague concern about the chemicals I breathe in the air...but yes, I'm sure If I was more educated on it, I would be more concerned."
- K. Cooper, Physician and Professional Cyclist

"I wish air pollution and industrialization were talked about more- not only talked about more but something done about it."
- A. Vidaurre, Policy Coordinator and Life-Long Resident

"I think we're still too young to really see the effects. Most of us who started out in the warehouses are just 23-34, you know, so we haven't really seen the effects of what all this pollution is doing to us."
- E. Godinez, Warehouse Worker

"Educators need to be much clearer in creating the language that will help people to understand the effects of what air does to you."
- J. Nelson, High School Educator

"These community based organizations help to inform governmental organizations as to what's happening in their community and how it's impacting them. The policies that come out of these partnerships are usually a direct result of these types of grassroots advocacy."
- S. Tsang, Physician and Public Health Officer

Ethnographic Findings:

- The Inland Empire has changed dramatically in the last 30 years from agrarian to increasingly industrial.
- While many residents are aware air pollution exists, they are more concerned with the traffic involved and the prioritization of industrial buildings over homes and parks.
- Many residents are not aware of the specific chemicals that are emitted by diesel trucks.
- Many residents do not know how emitted chemicals interact with the body.
- Many residents do not really feel the effects of short-term air pollution exposure and therefore do not see it as a danger.
- Those interviewed do agree that if they were more educated on the topic, they may have a greater sense of urgency towards the negative health effects that air pollution causes.

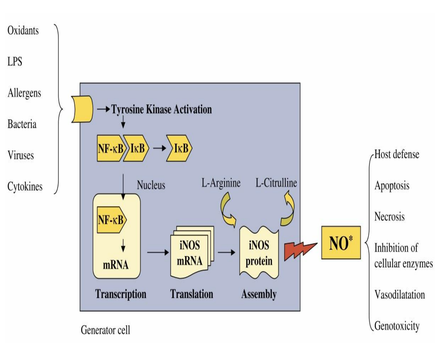

Figure 3: Schematic summary of how inhaled proinflammatory oxidants from pollutants react to induce the immune response as carried out by inductive nitric oxide synthase (Ricciardolo et al., 2004, p. 734).

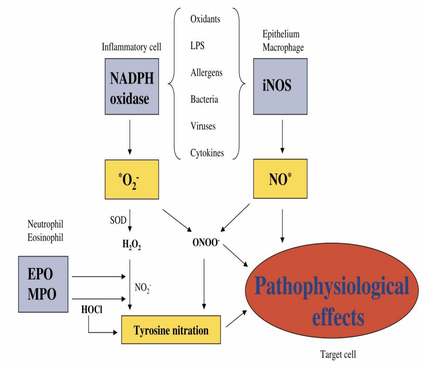

Figure 4: Schematic summary of how inhaled proinflammatory oxidants from pollutants react to form reactive oxygen species and nitrogen species in the airways causing pathophysiological effects by means of overstimulating the immune response ((Ricciardolo et al., 2004, p. 744).

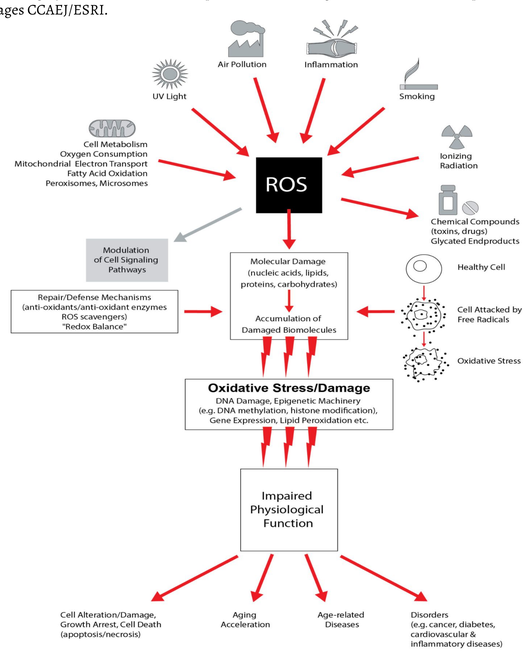

Figure 5: Overview of how different sources create reactive oxygen species causing oxidative stress and molecular damage that leads to tissue damage. Image Promocell GmBH.

Physiology	Pathophysiology
Neurotransmission (iNANC)	Bronchial hyperreactivity
Bronchodilation	Vasodilation
Surfactant production	Free radical production
Mucous secretion	Mucous hypersection
Ciliary motility stimulation	Ciliary motility inhibition
Antiinflammatory effect	Proinflammatory effect

iNANC – inhibitory non-adrenergic non-cholinergic nervous system.

Figure 6: Comparison of the physiological and pathophysiological effects of NO in the respiratory system. Pathophysiological effects are closely tied to normal functions of NO (Antosova et al., 2017, p. S162).

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