Environmentally- Driven Health Disparities: The Need for Toxicovigilance

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Abstract

•**PURPOSE:** Since environmental contaminants play a role in disease causation that impacts the quality of life, intervention strategies to mitigate exposure to these toxicants help build community resilience and sustainability. Socioeconomic and lifestyle factors interact with the environmental factors leading to disparities in health outcomes, which warrants toxicovigilance. Toxicovigilance is the identification and evaluation of chemical exposures and communicating it to the regulatory agencies to undertake remedial measures. How it is achievable by redesigning the curriculum in medical schools to equip students with skills to inform, and persuade communities to adopt health-promoting behaviors is the focus of our study. **METHODS:** The National Center for Medical Education Development and Research and the Health Disparities Research Center at Meharry have embarked on environmental health studies focusing on community susceptibility to environmentally-induced diseases, and prevention strategies. Findings from the work of these centers can be integrated in medical education curricular offerings in primary care training on the impact of environment on health outcomes of patients, and community. Toward that end, we are analyzing blood samples from individuals in Tennessee, who died of drug-, alcohol overdose, and unknown causes. We have measured Polycyclic aromatic hydrocarbons (PAHs); toxicants that are reported to cause neuro-, reproductive toxicities and lung, and colon cancers. **RESULTS:** The PAH residue concentrations detected were greater than those reported elsewhere. Among different racial groups, the residue levels were high in African Americans compared to Caucasians, Hispanics, and Asians. **CONCLUSION**: Our findings indicate that there are racial disparities in toxic chemical exposure, which calls for toxicovigilance. These findings can inform health professionals in clinical decisions making as well as public, policy- and decision-makers.

Introduction

- Environmentally-induced disease impacts the quality of life.
- People of color and racial and ethnic minority groups are more vulnerable to the onslaught of toxic chemicals as they reside near hazardous waste sites, abandoned factories, exposed to industrial emissions and engaged in occupations (fire fighters, oil refinery workers, waste-disposal workers etc.) that puts them in harm's way.
- In addition to the environmental factors, lifestyle factors modified by cultural norms, lack of education, income, unhealthy diet and stress caused by racial discrimination contribute to disproportionate burden of disease and mortality among these populations. How the health disparities are grounded in the environment and social determinants are shown in Figure 1.
- Some adverse health conditions that show disparity are obesity, diabetes, cardiovascular diseases, neurological disorders, sickle cell anemia, uterine cysts and cancers of the lung, prostate, breast, colon and ovary.
- In view of the role played by environmental toxicants in disease causation, intervention strategies to mitigate exposure to these toxicants help build community resilience and sustainability. Toxicovigilance is necessary in order to understand the interaction between socioeconomic and lifestyle factors leading to disparities in health outcomes.

What is Toxicovigilance?

- Active detection, validation and follow-up of clinical adverse events related to toxic exposures outcomes.
- Requires in-depth assessment of acute and/or chronic toxicities.
- Toxicological expertise helps in identifying hazards and assessing the risk.

Overall Goals

- To explore ways and means by which toxicovigilance could be achieved at the individual and community level.
- To redesign and enhance the health education curriculum in medical and public health schools to promote toxicovigilance in the context of health disparities.
- To equip students and trainees with skills to inform, motivate and persuade individuals or communities to change their attitudes and adopt health-promoting behaviors.

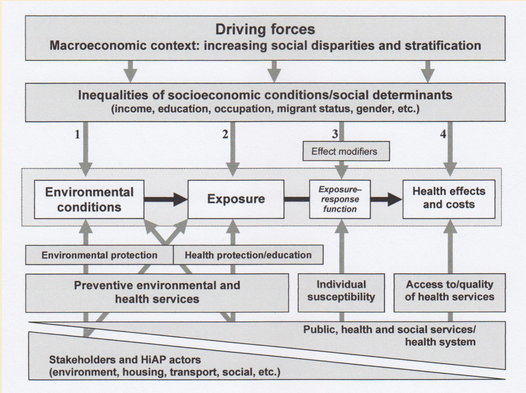

Figure 1: The WHO framework model on social inequalities and environmental risks (WHO, 2004).

Methods

- The National Center for Medical Education Development and Research and the Health Disparities Research Center at Meharry have embarked on significant environmental health studies focusing on community susceptibility to environmentally-induced diseases, and prevention strategies over the life course.
- To examine the environmental influences on health outcomes, we have analyzed blood sera samples from individuals in Tennessee, who died of drug-, alcohol overdose, and unknown causes.
- We have measured Polycyclic aromatic hydrocarbons (PAHs), a family of prototypical environmental toxicants that are reported to cause neuro-, reproductive-, developmental-, cardiovascular toxicities and lung, breast, and colon cancers.
- Samples were extracted using solid phase and liquid-liquid extraction methods and analyses were done using an gas chromatograph coupled with a mass selective detector (GC-MS; Agilent).
- Study was approved by the Institutional Review Board at Meharry Medical College.

Results & Discussion

- Our findings indicates that there are racial disparities in toxic chemical exposure, which calls for toxicovigilance.
- Out of 650 postmortem sera samples received for a drug screen, PAHs were detected in 305 samples. Most samples that were positive for PAHs were from children, teens, and adults in their sixties. Very few samples from septuagenarian and octogenarian decedents showed PAHs (Tables 1 & 2).
- Samples from African Americans (AA) registered greater levels of PAHs, compared to Caucasians, Hispanics and Asians, which could be attributed to polymorphisms in drug metabolizing enzymes resulting in an increased likelihood of health risk in AA due to PAH exposures from dietary, smoking habits and environment (Ford *et al.*, 2000; O'Keefe *et al.*, 2007; Steck *et al.*, 2014).
- Aside from exposure to mainstream or side stream cigarette smoke (Castaño-Vinyals *et al.*, 2004), the variations in PAH residue levels could be attributed to inter-individual differences in dietary habits, (Duarte-Salles *et al.*, 2010) and uptake and biotransformation of the PAHs (Zhong *et al.*, 2011) and other preexisting pathophysiological conditions.

Table 1

Concentrations (ng/mL) of ΣPAH residues in serum samples from autopsy cases.

Racial Groups	Children & Teens	Twenties & Thirties	Forties & Fifties Male	Sixties & above Female
Caucasian male	5.2 ± 1.5 (3)	4.5 ± 0.76 (25)	4.4 ± 0.55 (39)	3.4 ± 0.96 (14)
Caucasian female	5.2 ± 1.2 (9)	4.4 ± 1.3 (14)	6.2 ± 2.0 (23)	3.9 ± 1.7 (5)
African American male	6.8 ± 2.1 (9)	4.5 ± 0.39 (54)	5.2 ± 0.98 (28)	5.0 ± 1.3 (8)
African American female	5.3 ± 2.5 (7)	6.1 ± 0.87 (39)	9.0 ± 1.84 (13)	6.8 (2)
Hispanic male	ND	3.4 ± 0.78 (5)	7.5 (1)	ND
Hispanic female	ND	ND	ND	ND
Asian male	12.8 (1)	9.1 (1)	ND	ND
Asian female	ND	ND	ND	ND

Values were presented as mean ± standard error. Values in parentheses indicate number of samples that were positive for PAHs. ND denote none of the. PAHs were detected.

Table 2

Percent composition of PAH residues in serum samples from autopsy cases.

Racial Groups	Children & Teens			Twenties & Thirties			Forties & Fifties			Sixties & Above		
	B(a)P	B(b)f	Others & B(k)f	B(a)P	B(b)f	Others & B(k)f	B(a)P	B(b)f	Others & B(k)f	B(a)P	B(b)f	Others & B(k)f
Caucasian male	60	40	0	60	35	5	60	35	5	60	35	5
Caucasian female	50	45	5	50	45	5	50	45	5	50	50	0
African American male	60	40	0	60	40	0	60	40	0	60	40	0
African American female	50	50	0	50	47	3	50	45	5	50	45	5
Hispanic male	ND	ND	ND	55	45	0	55	45	0	ND	ND	ND
Hispanic female	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Asian male	50	47	3	50	45	5	ND	ND	ND	ND	ND	ND
Asian female	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Values were presented as percent composition of individual PAH compound(s) in the sum total of PAHs measured. The abbreviations are; B(a)P-benzo(a)pyrene, B(b)f-benzo(b)fluoranthene, B(k)f-benzo(k)fluoranthene, "others" indicate a mixture of benzo(g,h,i)perylene, acenaphthene, anthracene, and fluoranthene. ND denote none of the PAHs were detected.

- Studies are in progress at Meharry Medical College in reducing health disparities caused by environmental exposures in the context of a public health exposome.
- The exposome is an exposure paradigm, which is a universal exposure tracking framework for integrating complex relationships between exogenous and endogenous exposures across the lifespan from conception to death. (Figure 2).
- The exposome model has guided the development of a bioinformatics infrastructure that supports the assessment of exposure characteristics on personal and population level health outcomes.

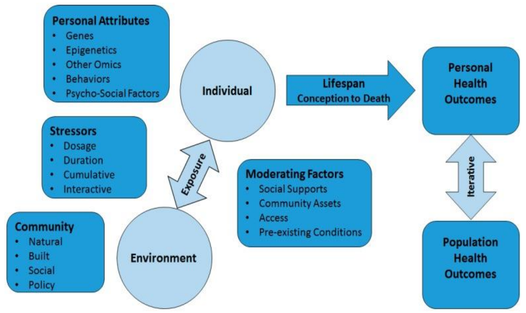

Figure 2: Public Health Exposome Conceptual Model (Juarez *et al.*, 2014).

Summary

- Findings from our work at Meharry could be integrated in medical education curricular offerings in primary care training on the impact of environment on health outcomes of patients, health services consumers, community, and population health.
- Information dissemination is the key to reduce/prevent exposures to toxics using the following modes:

  Individuals and communities
  - ➢ Raise awareness
  - ➢ Increase knowledge
  - ➢ Change attitudes and behavior

  Societal and environmental change
  - ➢ Education of public, policy –makers, decision makers and planners
  - ➢ Enhance the knowledge and skill set of educators
  - ➢ Introduce new curriculum that lays emphasis on potential risks to the community from chemicals and adopt strategies for prevention

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Acknowledgements

Our research was supported by funding from the HRSA grant UH1HP30348, NIH grants 3P20MD000516-07S1, G12MD007586-29, and EPA grant G17D112354237. This information or content and conclusions are those of the authors and should not be construed as the official position or policy of, nor should any endorsements be inferred by HRSA, HHS, NIH, EPA or the U.S. Government.