**Introduction**

The field of preventive epidemiology involves the identification of potentially modifiable risk factors that contribute to the burden of disease within human populations. Environmental epidemiology, in particular, considers the effect of environmental exposures — chemical or otherwise. Scholars warn that conditions of cumulative chronic toxicity pose an acute risk to the wellbeing of humans and our living environment (Naidu et al., 2021; Vineis, 2018). In fact, it has been estimated that human activity releases chemicals at a rate of 220 billion tons per annum (Cribb, 2016). As a result, exposure to low levels of pollutants has become an inevitable peril of daily life, so understanding the health effects of such exposures is especially timely. The quantification of such risks through environmental epidemiology studies can prompt critical regulatory action.

Studies concerning chemical pollutants in environmental epidemiology have historically focused on elucidating the effect and mechanisms of exposures to a single pollutant. However, humans are invariably exposed to numerous complex chemical mixtures which together contribute to the progression of adverse health outcomes. Therefore, risk assessments of single pollutants likely fail to capture the true consequences of these complex exposures (Heys et al., 2016). Assessing mixtures of chemicals can also have more direct implications for public health interventions. The United States Environmental Protection Agency (U.S. EPA) currently passes regulations for individual pollutants. In practice, though, regulation occurs by controlling the source of pollution, which is responsible for the production of a whole mixture of chemicals with specific joint effects on human health. As a result, the National Academies of Science has advocated for a multipollutant regulatory approach, which is likely to be more protective of human health (Committee on Incorporating 21st Century Science into Risk-Based Evaluations et al., 2017).

Hence, there are clear practical motivations for the development of studies and methodologies that examine the health effects of exposure to co-occurring chemical mixtures, hereafter referred to as exposure mixtures. However, expanding the focus of analysis from one exposure to multiple exposures introduces unique statistical challenges. In addition to a common issue of small effect sizes and small sample sizes present in most exposure analyses, multiple exposure analyses must also contend with high-dimensionality, collinearity, non-linear effects, and non-additive interactions amongst exposures (Yu et al., 2022). [MORE ON EXPOSURES]

The classic multiple linear regression framework fails to capture the true effects in this setting. In the past few years, a wide variety of statistical methods have been developed to overcome these challenges (Gibson et al., 2019; Yu et al., 2022), which have been accompanied by a host of comparative simulation studies for general mixture scenarios (e.g., Hoskovec et al., 2021; Lazarevic et al., 2020; Pesenti et al., 2023). However, there is not yet conclusive guidance about the ability of these methods to conduct inference on non-additive interactions between exposures.

The goal of this thesis is to explore the theory of emerging Bayesian regression techniques for quantifying complex interactions between environmental exposures. [clarify goals]

In an age where anthropogenic actions have radically reshaped the earth, humanistic inquiry can offer critical insights into our place within a rapidly evolving environment. I begin in Chapter 2 by contextualizing this thesis with a brief overview of cultural and social understandings of the topic of environmental exposures. Chapter 3 provides background on several Bayesian methods for analyzing exposure mixtures. Chapter 4 assesses the performance of these methods for conducting inference on non-additive interactions using a simulation study based on X. Chapter 5 explores an application on X data [TBD]. I conclude with a discussion of the implications of this work for the future study of complex interactions in exposure mixture studies.

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