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Response to "Comment on 'Impact of air manganese on child neurodevelopment in East Liverpool, Ohio' by Haynes et al. (2018)"

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We appreciate the opportunity to respond to comments regarding our study (Haynes at al., 2018). The comments by Bailey et al. (2018) focus on the size of airborne manganese (Mn) and the use of Mn bio-markers.

Bailey et al. (2018) claim that our research used hair Mn as a surrogate for air Mn; however, this is entirely unfounded. Our research did not claim that hair Mn was a surrogate for air Mn. It is a well-recognized axiom in environmental health research that reliable bio-markers of a toxicant are by far a better measure of exposure than indirect assessment of the toxicant in environmental media. Our study investigated the association between Mn in children's bodies (hair) and a measure of child IQ.

Bailey et al. (2018) stated that the biomarker levels "…do not suggest a potential for adverse health effects." The support they offer for this claim is an attempt to mislead the reader by implying that the levels of Mn in hair were low. Indeed, we cited three (3) other studies of very heavily exposed cohorts with hair Mn that exceeded the East Liverpool cohort; however, this does not imply that the values measured in the hair of East Liverpool children were low as there are no national pediatric population comparison values for hair Mn.

Bailey et al. (2018) state that our research "…did not consider the respirable fraction (PM10) of Mn particulates…" Actually, we did note this distinction, but since longitudinal PM10 data were not available at time of our publication, we presented the data that were available (total suspended particulate, TSP) and compared it to the United States

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Conflict of interest
None.

Environmental Protection Agency (USEPA) Reference Concentration (RfC). This comparison was not without precedent as, in another study of airborne Mn in East Liverpool, both the Agency for Toxic Substances and Disease Registry (ATSDR) and USEPA scientists compared TSP Mn levels to the USEPA RfC and ATSDR Minimum Risk Level (MRL) (Colledge et al., 2015).

Bailey et al. (2018) state that ATSDR has developed "…the most scientifically supported toxicity criterion…" and conclude that "…there should be no concern for associated adverse health effects." This is a surprising statement given that the ATSDR's recommendation for East Liverpool was the following: "The exposures in this community represent a public health hazard and should be mitigated as soon as possible to reduce harmful exposures" (ATSDR, 2016). The Pennsylvania Department of Health agrees as they made the following statement following public concern about Mn blowing across the state line from East Liverpool, Ohio into Pennsylvania, "…long term (chronic) exposure to manganese at the detected concentrations has the potential to harm people's health" (PA DOH, 2016). Similarly, the USEPA filed an action "… against S.H. Bell Company alleging that emissions of ambient manganese from its facility located in East Liverpool, Ohio and in Ohioville, Pennsylvania present an imminent and substantial endangerment to public health…" (USEPA, 2018). The EPA has also indicated the Mn standard has the highest priority for reassessment (USEPA, 2015). The World Health Organization (WHO) guideline for Mn (WHO, 2000) is 0.15 μg/m^3, below what Bailey et al. (2018) state is the current level of respirable Mn in East Liverpool at 0.2 μg/m^3. Thus, in contradiction to Bailey et al. (2018), the ATSDR, USEPA, and WHO recommendations align with our study findings. Moreover, based on our nation's history with lead exposure limits, an exposure standard does not necessarily mean that it was established to protect public health, particularly pediatric health (Centers for Disease Control and Prevention, 2012).

Bailey et al. (2012) conclude that we provided "…no reliable evidence for the conclusion that hair Mn is negatively associated with child IQ…" Not only did our study find a statistically significant association, but so have many other studies in the U.S. and abroad (Haynes et al., 2015; Menezes-Filho et al.,2011; Riojas-Rodriguez et al., 2010; Bouchard, 2011; Wright et al., 2006). Even using the most conservative statistical model including multiple biomarkers effect estimates are aligned with the core model used in our study that investigated the associated of hair Mn and child IQ after adjusting for demographic and socioeconomic factors. Coincidentally, our report was awarded the NIEHS Paper of the Month for November 2017 (Environmental Factor, 2018a) and NIEHS Paper of the Year for 2017 (Environmental Factor, 2018b).

In summary, the comments by Bailey et al. (2018) which focus on the size of Mn particles and the exposure standard demonstrates that they completely missed the point of our research. Our study demonstrated that higher levels of Mn in children's bodies were negatively associated with child IQ. Therefore, children in East Liverpool are exposed to Mn levels that are too high, regardless of how the air Mn levels compare to a national standard.

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