Written testimony: Noelle Eckley Selin, Associate Professor, Institute for Data, Systems, and Society and Department of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology

I am Noelle Eckley Selin, Associate Professor in the Institute for Data, Systems, and Society, and in the Department of Earth, Atmospheric and Planetary Sciences at the Massachusetts Institute of Technology. I am an atmospheric chemist who studies how mercury travels in the air, how it behaves in the environment, and how regulatory actions can alter mercury exposure and human impacts. My recent research, as well as that of other scientists, can and should inform the evaluation of the Mercury and Air Toxics Standards (MATS) issued by the Environmental Protection Agency (EPA).

My primary area of expertise is modeling of mercury in the atmosphere and its cycling through the environment. I have been studying mercury for more than 15 years, and I developed one of the models, the GEOS-Chem mercury model, that is commonly used to calculate how mercury travels through the air, land, and ocean (Selin et al., 2007; Selin et al., 2008). While mercury is a naturally occurring element, human activities over history have increased the amount of mercury that is depositing to global ecosystems by about a factor of three since the year 1450 (Outridge et al., 2018).

Burning coal is a major source of mercury emissions into the atmosphere, both in the United States and globally. Once emitted, mercury travels through the air, changes chemical form, and can deposit both nearby and far away from sources, depending on its form. In water bodies, mercury can then be converted to the more toxic methylmercury, which accumulates via food chains. People in the U.S. are exposed to mercury primarily by eating fish, including both freshwater and marine (saltwater) fish.

Because of the continuing health and environmental risks posed by mercury emissions both here in the U.S. and worldwide, my research group has worked to better understand how regulations on mercury emissions can translate into changes in concentrations in the environment, human exposure, and health impacts. Recent policy efforts to reduce mercury emissions include the domestic Mercury and Air Toxics Standards issued in 2011 as well as the global Minamata Convention on Mercury, which entered into force in 2017 and to which the U.S. is a party.

Since the MATS standards were announced in 2011, we have been analyzing their potential benefits. In 2011, when the Environmental Protection Agency proposed the MATS rule, its Regulatory Impact Analysis did not fully assess the benefits of reducing mercury emissions for the entire U.S. population. The original proposal acknowledged that the agency had limited ability to undertake this quantification with the scientific methodologies and tools available at the time. EPA thus conducted a partial analysis of mercury benefits, quantifying benefits only for people who consume self-caught freshwater fish (recreational fishers and their families), and only for a subset of applicable health benefits (reduced IQ deficits). EPA calculated that these (partial) benefits amounted to $4-6 million per year.

My research group developed a new approach which enabled us to conduct a much more comprehensive analysis of the mercury-related benefits of MATS. To do this, we used emissions scenarios in which U.S. mercury emissions were reduced consistent with the requirements under MATS. We used a state-of-the-art atmospheric model to calculate the resultant change in mercury deposition in the U.S., and in the ocean. We used that information, along with data on current mercury intake and concentrations in the U.S. population, to calculate expected changes in exposure to methylmercury, the toxic form of mercury that people are exposed to by eating fish. We then used the best available information on the health impacts of mercury, including both IQ deficits and cardiovascular impacts (heart attacks), and, using a variety of economic techniques, quantified the expected impacts from the MATS standard relative to a case without these policies.

With this method, we were able to calculate the benefits of the MATS standards to the entire US population, rather than just looking at those who consume self-caught freshwater fish. (Giang and Selin 2016).

Our research found that when we considered a more complete subset of health impacts (IQ and heart attacks) and affected populations (consumers of self-caught freshwater fish and consumers of commercial marine and estuarine fish in the US market), the benefits of MATS turn out to be orders of magnitude larger than those estimated by EPA. Our best estimate was that MATS could yield cumulative lifetime benefits for individuals affected by 2050 of $147 billion (2005 USD, discounted at 3%). As we simulated these benefits over a 40-year period (2010-2050), this is equivalent to an average annual benefit of **$3.7 billion**.

Our estimates are much higher than EPA's for two key reasons.

1) Unlike EPA, we examined the impacts on the entire U.S. population, recognizing that people in the US eat both freshwater and saltwater fish, and fish caught both recreationally and commercially. Indeed, recent work has shown that more than 80% of methylmercury exposure to the US population comes from marine fish (Sunderland et al., 2018).

2) We included not only IQ deficits for newborn children, which was the only endpoint quantified by EPA, but also fatal and non-fatal heart attacks for adults, following the best available science identifying and quantifying the impacts of mercury. An expert panel convened by EPA concluded that scientific evidence of an effect was strong enough to incorporate these impacts into regulatory assessments (Roman et al. 2011).

Furthermore, our estimates do not capture all the possible impacts of MATS. In particular, there are four other important aspects of mercury emissions that should be taken into account:

1) **Other health impacts:** New research over the past several years has quantified impacts other than IQ decreases and heart attacks. Mercury can damage the immune system and reproductive system, and is a possible carcinogen. These effects are not yet easily quantifiable, but scientific evidence that they are occurring continues to grow.

2) **Duration:** The main estimates in our 2016 paper also do not fully take into account the long time frame that mercury lasts in the environment. As an element, mercury does not degrade, so mercury that we emit today continues to cycle in the environment for decades and even centuries (Selin, 2009; Obrist et al., 2018). Mercury can accumulate in the soil and below the surface in the ocean, and can return to the atmosphere to affect people in the future, just as mercury emitted in the past continues to affect us today. This re-emitted mercury can then deposit to waterbodies and become methylmercury, continuing to affect human health. The mercury model we used in our 2016 paper did not simulate its long-term impacts; simulating these requires tracking mercury for decades or more as it moves through the land and ocean. We did, however, estimate how our result would change given these effects, and found they would increase our overall estimates by about 30%. Our ability to quantify the long-term impacts of mercury in models has improved since 2016 (Selin, 2018, Angot et al., 2018). Taking this into account, we found in subsequent work that delaying the implementation of global mercury reductions by five years would decrease the impact of policies by an average of 14%. In other words, a reduction in mercury delayed by 5 years would have to be 14% more stringent in order to have the same effect, due to the continuing impacts from mercury emitted during the delay and subsequently re-emitting to the atmosphere (Angot et al., 2018).

3) **Highly Exposed Populations:** Some population groups in the U.S. are especially exposed to mercury, particularly subsistence fishers and tribal communities (Perlinger et al., 2018; Angot et al., 2018).

4) **Additional benefits:** Our estimates only address the direct benefits of mercury reductions. The benefits of the rule from reducing air pollution from particulate matter are likely to be substantial as well, and these were also quantified by EPA. In related research, my group has quantified particulate matter benefits for a number of different policy proposals other than MATS. For example, for several policies aimed at reducing carbon dioxide, we found that particulate matter related benefits can exceed the cost of regulations (e.g. Thompson et al., 2014). For impact and cost-benefit analysis to be accurate, it is important to take into account all of the potential consequences of regulations, intended or not, both positive and negative.

In 2016, EPA issued its "Supplemental Finding That It Is Appropriate and Necessary To Regulate Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units." The EPA recently proposed to reconsider this supplemental finding, and to determine that it is not "appropriate and necessary" to regulate mercury emissions from power plants under Section 112 of the Clean Air Act. In support of its revised finding, EPA asserted that the monetized benefits of the rule are in the range of $4-6 million. As summarized above, this estimate is not consistent with the best available science.

In 2016, I submitted a public comment on the proposed supplemental finding, together with other mercury researchers who were then part of my research team at MIT.[1] In that comment, we provided scientific evidence that supported EPA's determination that (1) formal, monetized benefit-cost analysis is not the preferred approach for weighing the advantages and disadvantages of mercury policy, and (2) even if a formal benefit-cost analysis approach is used to evaluate MATS, benefits related to mercury alone are substantial and likely to outweigh its costs. In support of (1), we noted in our comment that benefits to human health that are difficult to quantify in regulatory benefit-cost analysis may be large, and that aggregating benefits for the entire US can obscure the fact that some communities bear significantly more burdens than others. Relevant to (2), we provided information on our 2016 analysis estimating $3.7 billion/year in lifetime benefits of MATS.

I also submitted two additional public comments in 2019, along with other researchers, urging EPA to incorporate the most up-to-date scientific information in its consideration of its "appropriate and necessary" finding. Together with mercury researchers at Harvard University and across the country, we emphasized that the scientific literature has developed significant new evidence since 2011 quantifying the benefits of regulating power plant emissions.[2] In another comment, with coauthors of studies estimating the impacts of regulations on mercury deposition and exposure, we reiterated our argument that MATS benefits are substantial and likely to outweigh costs, and presented recent research that emphasized its differential impacts on sensitive populations such as tribal communities (Angot et al., 2018; Perlinger et al., 2018).[3]

In conclusion, the assertion by EPA that the MATS standards result in $4-6 million in mercury-related benefits to the U.S. is out of date and incorrect. The best available scientific information suggests that the mercury-related benefits that can be quantified are orders of magnitude more than that – in the billions of dollars. Unquantified benefits, as well as the benefits from reducing particulate matter, would make that number even higher. EPA ought to take into account the best available scientific evidence in developing its regulations. Mercury continues to pose risks to the U.S. population, and it remains appropriate and necessary to regulate its emission.

Attachment:
Giang, A. and Selin, N.E., 2016. Benefits of mercury controls for the United States. *Proceedings of the National Academy of Sciences*, *113*(2), pp.286-291.

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[1] https://www.regulations.gov/document?D=EPA-HQ-OAR-2009-0234-20544
[2] http://clinics.law.harvard.edu/environment/files/2019/04/EELPC-MATS-Cost-Reconsideration-Comments-FINAL.pdf
[3] http://web.mit.edu/selin/www/EPA-HQ-OAR-2018_0794_Giangetal.pdf

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