SHIFTING SANDS: UNSOUND SCIENCE AND UNSAFE REGULATIONS – REPORT 1

20 May 2021

Zoom: https://us02web.zoom.us/rec/share/GtyomYWHoEzcT-pt_lG_uNzb2aPyTQ8BJkLmZI62fndbs2n_Euk-qggZmJFl0NhN.q8GCtl4lp4nUHCLj

YouTube: Shifting Sands: Unsound Science and Unsafe Regulations: Report 1

Presentation Slides: PowerPoint Presentation (nas.org)

Hosted by David Randall, Research Director, National Association of Scholars, a report co-author

Video Summary

Modern science suffers from an irreproducibility crisis in a wide range of disciplines, from public health to social psychology. Far too frequently, scientists cannot replicate claims made in published research. This poses serious questions to policymakers. How many federal regulations reflect irreproducible, flawed, and unsound research? How many grant dollars have funded irreproducible research? In short, how many government regulations based on irreproducible science limit America's freedom and prosperity?

On Thursday, May 20th, 2021, the National Association of Scholars launched its latest project, "Shifting Sands: Unsound Science and Unsafe Regulation." This first in a series of reports will examine how irreproducible science affects select areas of government policy and regulation governed by different federal agencies. This first report on $PM_{2.5}$ regulation focuses on irreproducible research in the field of environmental epidemiology, which informs the U.S. Environmental Protection Agency's (EPA) policies and regulations. It assesses scientific research that associates airborne fine particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$) with mortality, heart attacks, and asthma.

Over the last 40 years, the EPA has slowly imposed increasingly restrictive air quality regulations based on research sponsored by the agency. However, the scientific world's professional incentives reward exciting research with new, positive (significant association) claims—but not reproducible research. This encourages researchers, wittingly or negligently, to use a variety of statistical practices to produce research that blows wind into the sails of their careers with little regard for the reproducibility of their experiments. This conversation on how government agencies and public policy are harmed by the irreproducibility crisis will also include recommendations to bring public agency methodologies into alignment with the best available science by adopting resampling methods and transparent research.

Transcript

David Randall (DR): Welcome to the National Association of Scholars presentation on the report on *Shifting Sands*, our report on $PM_{2.5}$ components, statistical study thereof, co-written by: yours truly, David Randall, Director of Research for the National Association of Scholars; S. Stanley Young, who is the head of our Shifting Sands Project; and Warren Kindzierski, who teaches at the University of Alberta. *"Shifting Sands: Unsound Science and Unsafe Regulations*," Report No.1, Keeping Count of Government Science, P-Value Plotting, P-Hacking and $PM_{2.5}$ Regulation.

I am delighted to have as our commenters today Steve Milloy, Jay Lehr, and showing up in a little bit Donald van der Vaart, who are distinguished in in their various ways. I'm going to leave it when they speak if they can just do a sentence introduction as suits themselves, because I want us to get reasonably quickly to our actual report.

I will just mention to everybody listening, the structure is going to be this: I'll speak for a little bit -- no more than five minutes – then Stan Young and Warren Kindzierski will present together for the next 20 or so minutes. I'll have the last five minutes. We're then going to have 10 minutes of comments apiece from Jay Lehr, Steve Milloy, and Donald van der Vaart. There will then be questions and answers, perhaps moderated discussion. People who want to comment, please put in your questions in the chat or the Q&A buttons at the bottom of the screen; I will be selecting from them. If your questions aren't answered in time, please send them to me by email, randall@nas.org, and I will pass them on. Also this will be recorded and will be on the National Association of Scholars' YouTube channel. You will be able to look at this, and pass on a link to this to everybody else soonest.

I have a few credits just sent to me so I can introduce the people's titles:

- Warren Kindzierski (WK), report co-author, environmental engineer, Adjunct Professor in the School of Public Health at the University of Alberta, Edmonton, and a Contributor to the American Institute for Economic Research.
- Stanley Young (SY), report co-author, statistician, CEO of CGStat, Director of the Shifting Sands project, and a member of ACSH's Board of Advisors as well as the US EPA Science Advisory Board.
- Jay Lehr (JL), groundwater hydrogeologist, Director of Science at the Heartland Institute, and Senior Policy Advisor with the International Climate Science Coalition.
- Steve Milloy (SM), biostatistician, lawyer, journalist, founder of junkscience.com, and author of *Scare Pollution* (among other titles).
- Donald van der Vaart (DV), who I trust will be showing up momentarily, a chemical engineer and licensed attorney, former Secretary of the North Carolina Department of Environmental Quality, and currently a member of the USEPA Science Advisory Board.

I'm just going to go straight to my quick introduction of what is happening here. The background is, modern science suffers from an irreproducibility crisis in a wide range of disciplines, from public health to social psychology. Far too frequently, scientists cannot replicate claims made in published research. This poses serious questions about policy makers. How many federal regulations reflect irreproducible, flawed, and unsound research? How many grant dollars have funded irreproducible research? In short, how many government regulations based on irreproducible science limit America's freedom and prosperity?

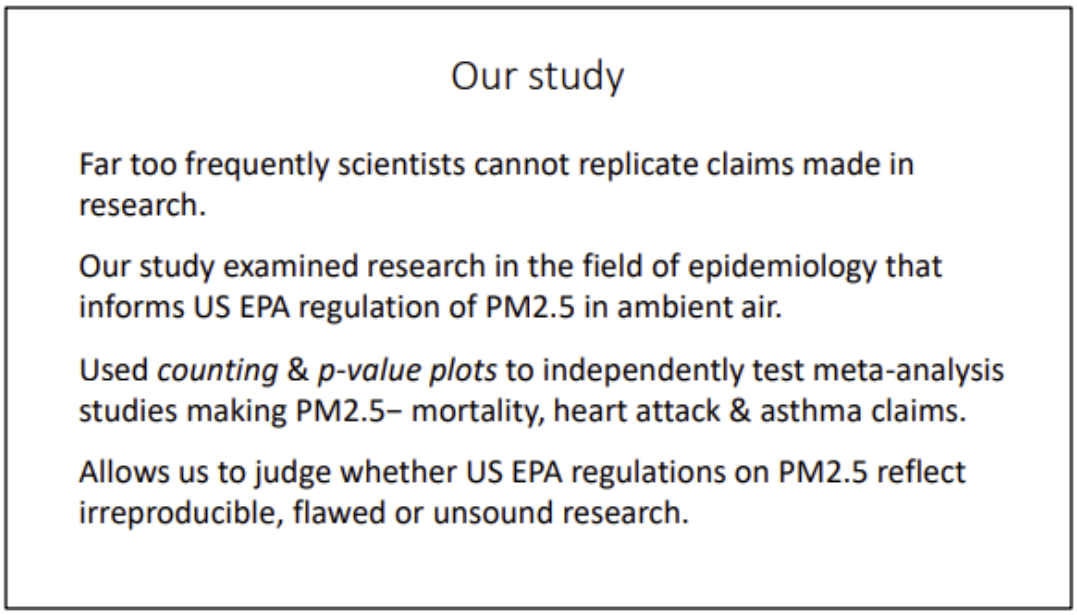
Our project, National Association of Scholars' *Shifting Sands*, examines how irreproducible science negatively affects select areas of government policy and regulation governed by different federal agencies. This first report on particulate matter 2.5 regulation focuses on irreproducible research in the field of environmental epidemiology, which informs the US Environmental Protection Agency's policies and regulations. It focuses upon scientific research that associates airborne fine particulate matter smaller than 2.5 microns in diameter – $PM_{2.5}$ – with mortality, heart attacks, and asthma. Over the past 40 years, the EPA has slowly imposed increasingly restrictive air quality regulations and has regularly updated these regulations. This requires the accumulation of data on both air quality and health effects, much of it forwarded by the EPA's sponsorship of research that would underpin their emerging regulations. The EPA have relied on statistical analyses to detect significant associations between $PM_{2.5}$ and health effects. However – and here we come to a big however – the scientific world's professional incentives reward exciting research with new positive claims, claims with significant associations, but they don't reward reproducible research. This encourages researchers – wittingly or negligently – to use a variety of statistical practices to produce positive – but likely false – claims.

Our report applies multiple testing and multiple modeling (MTMM) to assess whether a body of research has indeed been affected by such statistical practices. We use MTMM to control for experiment-wise error: the probability that at least one individual claim will register a false positive when multiple statistical tests are conducted. Conducting large numbers of statistical tests in a study produces many false positives by chance alone. We count the number of statistical tests and use a novel statistical method, p-value plotting, as a severe test to diagnose specific claims made about $PM_{2.5}$ in environmental epidemiology meta-analysis.

A meta-analysis is a systematic procedure for statistically combining data from multiple studies that address a common research question – for example, whether $PM_{2.5}$ is a likely cause of a health effect. *Our investigation provides compelling circumstantial evidence that the environmental epidemiology literature on $PM_{2.5}$ – specifically for mortality, asthma, and heart attack claims -- has been affected by statistical practices that have rendered the underlying research untrustworthy.* The EPA might not have regulated $PM_{2.5}$ at all if they had applied more rigorous scientific reproducibility requirements to research that they used to justify their regulations.

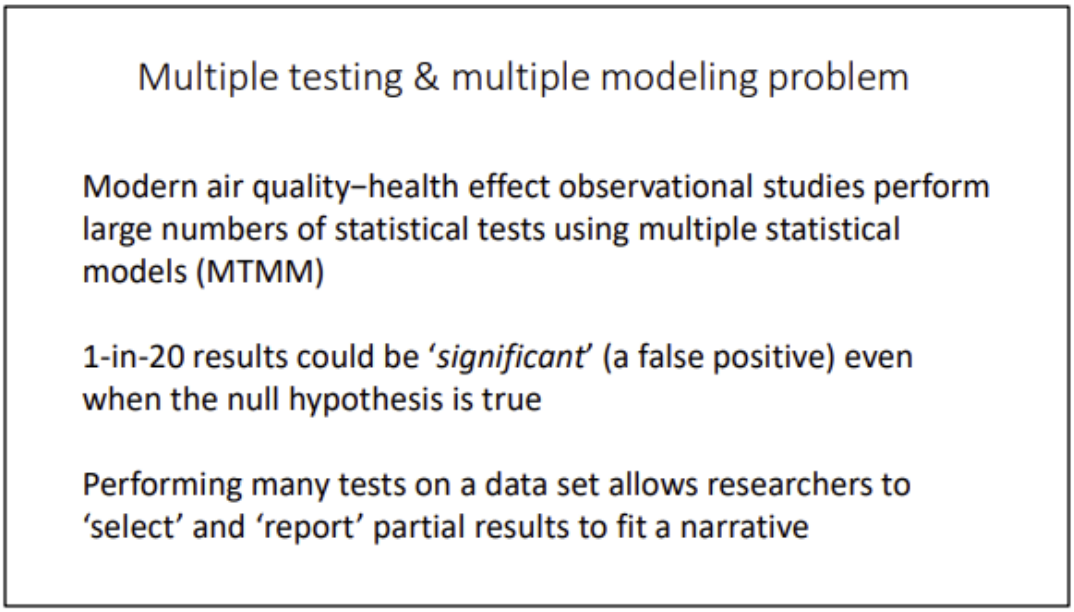
That's where I'm going to stop with the introduction. I'm now going to hand it over to Stan and Warren.

WK: I'll walk you through the first part of our study and then we'll let Stan follow up. I want to expand a bit about the two techniques that we used in our study.



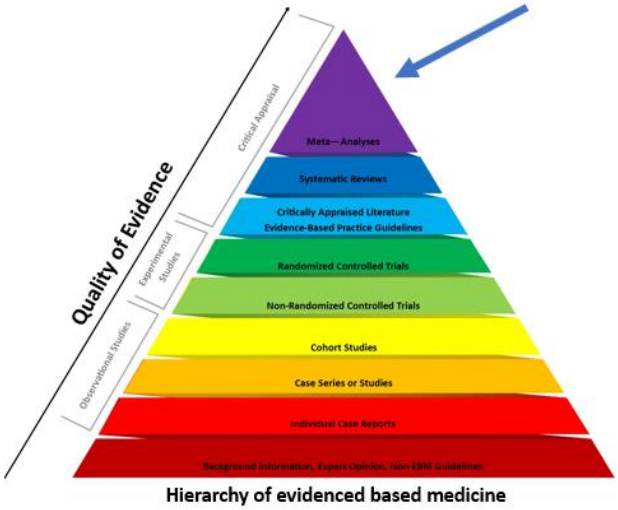
One of them was counting. We were interested in understanding the number of statistical tests that epidemiology studies actually perform when they do air quality health effect analysis. We looked at that for three types of claims: $PM_{2.5}$ mortality, heart attack, and asthma claims.

The other aspect was p-value plots. We took the risk statistics from the epidemiology studies. Those are mostly relative risk or odd ratio values, along with their confidence intervals, and converted them into p-values. Then we ordered them from the smallest to largest value and plotted them against the integers 1, 2, 3, etc. That is a p-value plot. That plot allows us to look at the characteristics of the distribution of values used for meta-analysis.



David has previously talked about the "multiple testing multiple modeling" (MTMM) problem. I'll just re-emphasize that what we're going to see is epidemiology studies perform huge amounts of statistical tests. Given that one in every 20 tests could be a significant or false positive result, even when the null hypothesis is true, what we can get is large numbers of false positives when large numbers of statistical tests are performed. Performing many tests also allows researchers to select specific results that allows them to fit a narrative.

Meta-analysis



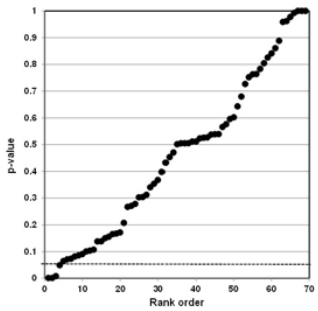
A bit about meta-analysis – David talked about what it actually is. If you look at the image on the left, it involves searching literature for studies that that indicate or have similar statistical values that are of interest. The example that I'll give is looking at a meta-analysis of whether some Factor A causes Disease B. You can search the literature, identify literally thousands of studies which have to be screened and reviewed. After that process, typically some number – perhaps as low as 10, perhaps as high as 200 – studies are selected for quantitative analysis and the meta-analysis.

On the right-hand side, we see that within the medical community, this meta-analysis process is held in quite high regard. A typical team for doing a meta-analysis might involve five to fifteen scientists, and they could complete one of these in about a week. About 5,000 meta-analyses are published annually.

Getting back to p-value plots, what do we expect to see? There are two types of behaviors that we would expect from a p-value plot. One of them conforms to the null hypothesis – that plots on the left, and that is the evidence of no association for whatever factor and disease you are investigating. That indicates a 45-degree line, which is exhibiting randomness in your p-value data. These data should be randomly distributed from a within the range of zero to one. Plotted by rank order, they show a 45-degree line, approximately.

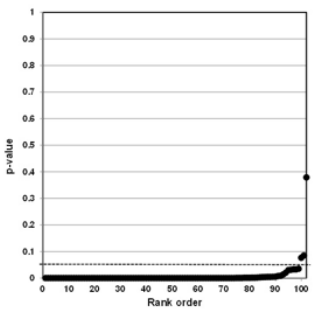
p-value plots – examples of expected behavior

Null hypothesis



(i) elderly long-term exercise training–mortality & morbidity risk (n=69)

Evidence of a real effect



(ii) smoking–squamous cell carcinoma risk (n=102)

On the other hand, the alternative hypothesis that supports evidence of a real effect should show most of your p-values – very small, less than 0.5. There may be a couple of stragglers on the end, on the right side. Those very possibly could be false negatives. But these are very distinct distributions of data behaviors, and p-value plots outside of what you see here should be regarded as suspect.

(1) Orellano et al. 2012 – air quality & mortality

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Review article

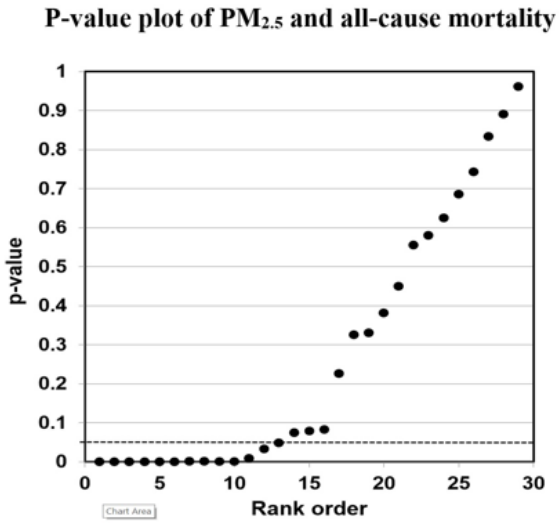
Short-term exposure to particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), and ozone (O_3) and all-cause and cause-specific mortality: Systematic review and *meta*-analysis

Pablo Orellano , Julieta Reynoso , Nancy Quaranta , Ariel Bardach

Claim... *"study found evidence of a positive association between short-term exposure to PM10, PM2.5, NO2, and O3 and all-cause mortality, and between PM10 and PM2.5 and cardiovascular, respiratory and cerebrovascular mortality"*

What did we see? Well, we looked at a number of meta-analysis studies. The first one we're going to talk about is where they studied four air quality parameters and looked at a variety of mortality endpoints. This particular study identified almost 2,500 electronic records from which they screened over 1,600. They ultimately selected 196 for quantitative analysis.

(1) Orellano et al. 2012 – severe testing



- The p-value plot clearly departs from expected behavior – it is bilinear; it breaks into 2 lines.
- This data set is a 2-component distribution.
- As to causes; we see issues such as publication bias, p-hacking, HARKing – well-cited problems in scientific literature – as possible explanations for small p-values

If we look at a p-value plot for their data – we're showing it for $PM_{2.5}$ and all-cause mortality – there are 29 statistics that they used for their meta-analysis. So there are 29 dots here. What we see is a two-component distribution. This conforms neither to the null hypothesis or to the alternative hypothesis. Evidence from this type of analysis should be regarded as suspect.

Another meta-analysis that we explored was that of air quality and heart attack. This is looking at short-term exposure – it really is inferred exposure – to six air quality parameters and "myocardial infarction" or heart attack. The claim that was made is that virtually all the air quality parameters except ozone were associated with myocardial infarction (MI).

(2) Mustafic et al. 2012 – air quality & heart attack

JAMA

Main Air Pollutants and Myocardial Infarction

A Systematic Review and Meta-analysis

Hanrije Mustafic, MD, MPH
Patricia Jabre, MD, PhD
Christophe Caussin, MD
Mohammad H. Murad, MD, MPH
Sylvie Escolano, PhD
Muriel Tafflet, MSc
Marie-Cecile Périer, MSc
Eloi Marijon, MD
Dewi Vernerey, MSc
Jean-Philippe Empana, MD, PhD
Xavier Jouven, MD, PhD

Claim... *"all the main air pollutants, with the exception of ozone, were significantly associated with a near-term increase in MI* [heart attack] *risk"*

(2) Mustafic et al. 2012 – severe testing

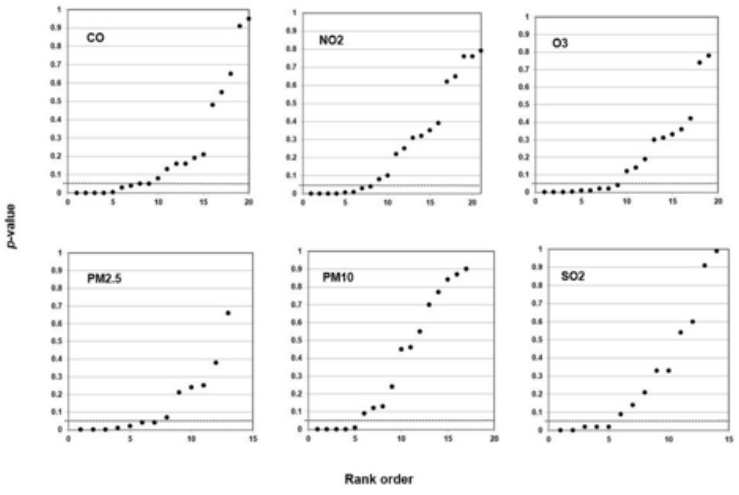
counts

Counts of the number of statistical tests in 34 studies

Statistic	Space1	Space2	Space3
minimum	8	8	240
lower quartile	23	64	2,496
median	36	256	12,288
upper quartile	109	1,024	58,368
maximum	540	16,384	4,587,520

note:
minimum = minimum count
lower quartile = 25th percentile count
median = 50th percentile count
upper quartile = 75th percentile count
maximum = maximum count
Space 1 = Outcomes x Predictors x Lags
Space 2 = $2^{Covariates}$
Space 3 (number of statistical tests) = Space 1 x Space 2

p-value plots



We're showing you two results from our analysis on the left, or counts. On the right are p-value plots. We'll look at the count table first, showing you the statistics for 34 individual studies that were included in their quantitative analysis. I would point you to what's highlighted in red – that's that median or central tendency estimate for the number of statistical tests. On the far right-hand side is the total. So this particular group of studies, the median was over 12,000. That is a tremendously huge amount of statistical tests with a lot of possible false positive results.

If we look at the right, I'll just draw your attention to the lower left plot, that's $PM_{2.5}$. Here again we see a two-component distribution. If we kind of stand back and look at all of the air quality parameters, they all show two-component distributions. Here again, evidence from these analyses should be regarded as suspect.

- Counts are summarized on LHS – the median count of statistical tests was over 12,000 from 34 base studies that we reviewed.
- We counted *outcomes*, *predictors*, *time lags* & *covariates* (where appropriate) to estimate numbers of statistical tests.
- The p-value plots – RHS – show no resemblance to expected behavior.
- All of these plots show data sets that are 2-component distributions.
- Their claim should be regarded as suspect particularly with large numbers of statistical tests conducted in their base studies.
- We see similar causes – publication bias, p-hacking, HARKing – as possible explanations for the small p-values

The third meta-analysis we looked at was related to air quality parameters and development of asthma. What was looked at here was inferred exposure to air quality early in life, and asking the question "Is that associated with the development of asthma later in life?" This particular analysis only looked at two air quality parameters: nitrogen dioxide (NO_2) and $PM_{2.5}$. This is somewhat surprising because they certainly had information on all six, yet they only chose to analyze two. Then they made a claim that their results are consistent with some sort of effect of outdoor air pollution.

(3) Anderson et al. 2013 – air quality & development of asthma

Air Qual Atmos Health (2013) 6:47–56
DOI 10.1007/s11869-011-0144-5

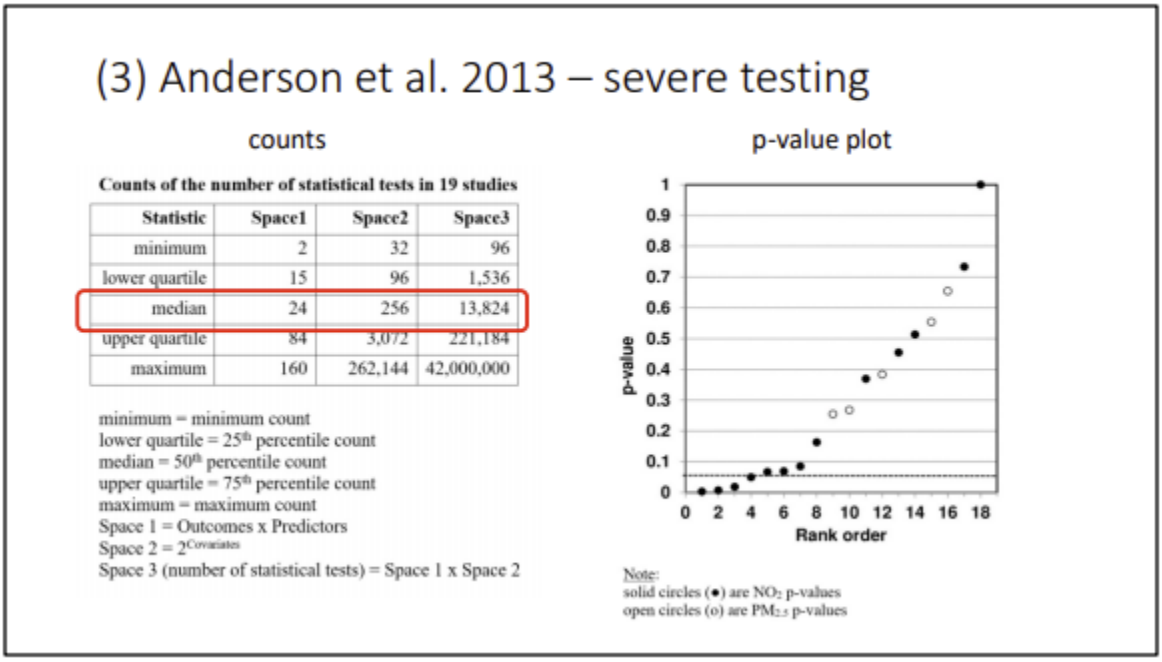
Long-term exposure to air pollution and the incidence of asthma: meta-analysis of cohort studies

H. Ross Anderson · Graziella Favarato · Richard W. Atkinson

Claim... *"results are consistent with an effect of outdoor air pollution on asthma incidence"*

This particular study started with over 4,000 electronic records. After screening and review, they were interested in identifying individual population cohorts. That would allow them to combine these cohorts and look at the overall effect. They identified 17 population cohorts that were present in 24 scientific publications. We picked 19 of those

publications and analyzed them. We look at the results on the left of the counts. Again, I point you to the what's circled in in red. That central tendency – or median number of counts in this case – was almost 14,000 statistical tests as the average among these 19 studies. Again, that is a huge amount. Lots of opportunity for false positives.

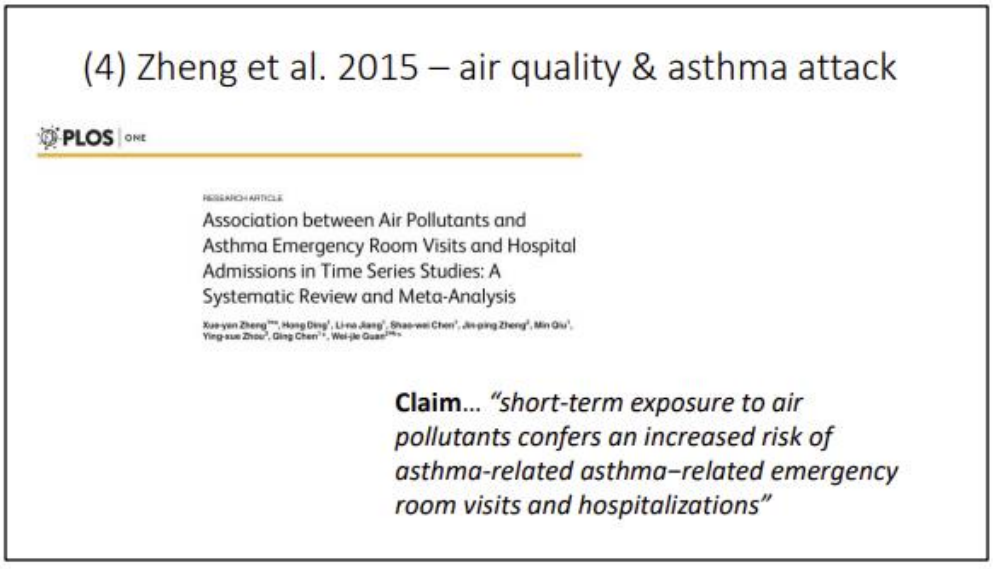


On the right side, we look at a p-value plot. These researchers combined their results for nitrogen dioxide and $PM_{2.5}$, so we did the same thing, exactly as them. The black dots represent nitrogen dioxide; the open circles represent $PM_{2.5}$. If we focus on the black dots, we see a two-component distribution, which deviates from the expected behavior that I showed you previously. So the results for NO_2 should be regarded as suspect.

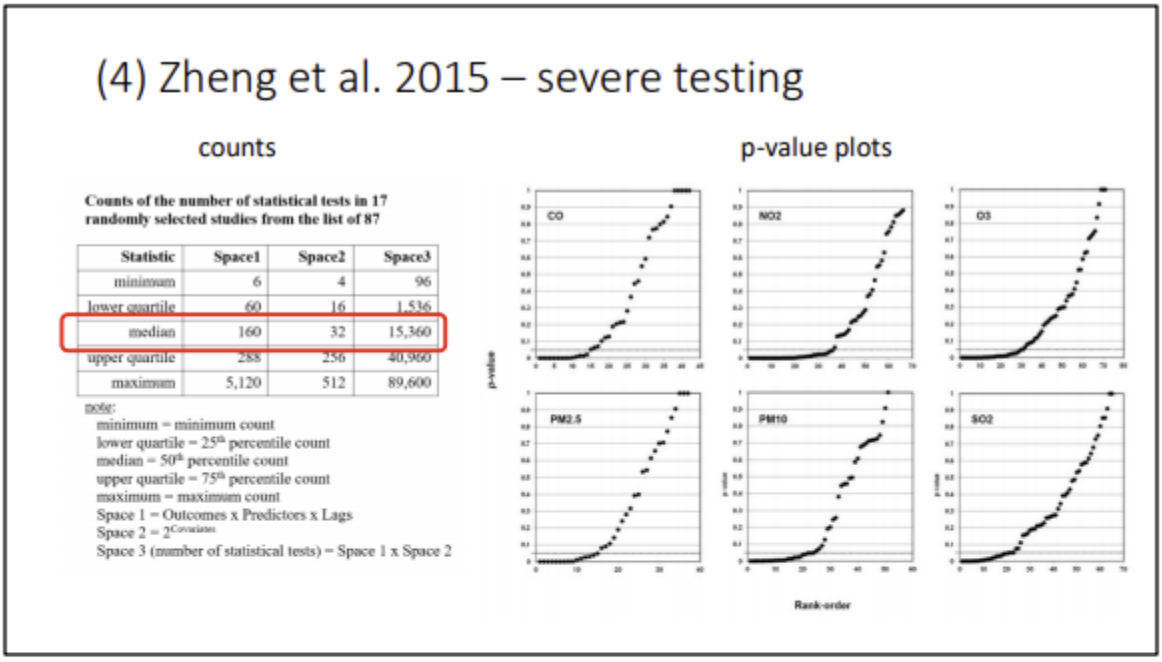
More interestingly, if you look at the open circles, they plot as a near 45-degree line, providing virtually convincing evidence of a null effect for $PM_{2.5}$ versus development of asthma.

Stan, I will let you take over.

SY: I am going to talk about another study on immediate induction of asthma by a group of Chinese researchers.



A lot of the meta-analysis studies are coming out of China. It's basically a computer game. You don't have to have many resources other than computers and time. They claim “short-term exposure to air pollution confers an increased risk of asthma-related emergency room visits.”



- Counts on LHS – the median count of statistical tests was over 15,000 from 17 randomly-selected base studies that we reviewed.
- A point to make here… it appears to be typical to perform over 10,000 statistical tests in an environmental epidemiology study.
- p-value plots – look at the lower left plot for PM2.5, we can see many small p-values stacked up below .05 & we also see many p-values exhibiting randomness (>.05)
- All of these plots show data sets that are 2-component distributions.
- Their claim should be regarded as suspect.
- Again, publication bias, p-hacking, HARKing are possible explanations for the small p-values

There were 87 studies in this in this trial. We took a random sample of 17 of those studies to get a sense of how many statistical comparisons were made. As Warren said, you look at the red boxed-in area – a median number across these studies is 15,000 tests. You should do a little bit of mental arithmetic. There's a 5% chance of a statistical false positive. If you multiply 5% times 15,000, you have a veritable flood of potential false positive results.

Turning now to the p-value plots, we've got the six components: carbon monoxide (CO), NO_2, ozone (O_3), $PM_{2.5}$, PM_{10}, and SO_2. You see this string of p-values very close to zero, and then you see the nice 45-degree line. We're calling this Mixture A. An agent can't be both causing and not causing asthma, so we're in something of a dilemma here. We've taken the position that the random p-values, those on the 45-degree line, are probably telling us the truth.

Publication Bias, p-Hacking, HARKing

Outcome reporting bias: significant results are selected among study outcomes to be published.

Redundant publication bias: significant results are published in more than one paper.

There are various reasons how researchers can get small p-values unrelated to the nature of the of the item under study. There's publication bias, p-hacking, and HARKing. Publication bias is quite simple. If you look at a lot of tests and you find a p-value that supports your narrative, you go ahead and attempt to publish. On the other hand, if nothing you look at among those that sea of p-values supports your narrative, you do a simple thing – you just push that study to the side and don't bother to publish. It's called publication bias.

P-hacking is just a pejorative term for computing lots of p-values. With many questions available, you can compute thousands of these things. P-hacking is computing thousands of them and then picking off the few p-values that support your narrative.

HARKing is kind of interesting. Hypothesis after the results are known. You have a large data set, you p-hack – you compute lots of p-values. Then you construct a narrative hypothesis. Your stated hypothesis is based on actually looking at the data. It's like shooting fish in a barrel. Both p-hacking and HARKing are disreputable practices, but they're widely practiced.

Redundant publication bias…there's several ways to think about this. If you have a cohort study and you compute thousands of tests – you can compute for heart attacks or COPD or whatever – there's the thing of the trade calls salami slicing. You can write a paper for each one that you want to do, and so multiple studies can come out of the same data set, and the same massive statistical analysis.

Bunnies in the sky

The Statistical Crisis in Science

Data-dependent analysis—a "garden of forking paths"—explains why many statistically significant comparisons don't hold up.

Andrew Gelman and Eric Loken

I like this one. "Bunnies in the sky" is a metaphor for a random sighting given many opportunities. If you're just goofing off and not having much to do, you look up in the sky and say, "What do I see? Do I see an elephant? Do I see a bunny rabbit?" Most people would say bunnies in the sky is completely random. That's the way to think about p-hacking. There's a sea of p-values and you just pick off the ones that look good. This photographer saw a bunny in the sky and he took a picture.

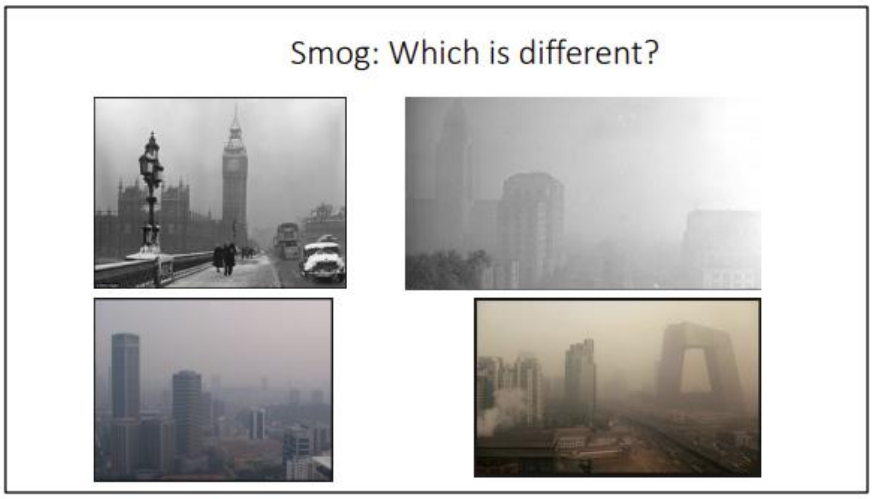
Let's run an epidemiology study!

10-sided dice simulation:
$PM_{2.5}$ causes X

Work Sheet Stan Young, Simulation

MedCondition	YoungFemale	YoungMale	OldFemale	OldMale
1. Angina	.384	.660	.836	.067
2. Arthritis	.190	.251	.098	.451
3. Asthma	.205	.830	.258	.086
4. Cancer	.493	.641	.903	.491
5. C. Bronchitis	.810	.968	.076	.782
6. CHD	.599	.384	.290	.149
7. Emphysema	.100	.861	.107	.999
8. Heart Attack	.747	.543	.622	.158
9. Liver Disease	.183	.334	.596	.466
10. Stroke	.479	.013	.004	.999
11. Thyroid D.	.851	.935	.415	.042
12. Diabetes	.554	.654	.354	.772
13. H. LDL	.537	.383	.475	.900
14. L. HDL	.188	.618	.967	.293
15. C React Protein	.943	.910	.251	.750

I like to teach graduate students. I like to get them into the mindset of randomness. In the upper left-hand corner, you see red, white, and blue – very patriotic – dice. You see a 0, a 4, and a 6. So that would be a p-value of 0.046, just less than 0.05, so that's a statistically significant roll of the dice. I made up a worksheet listing 15 possible health effects that could come from air pollution or air poor air quality, and I added "Young Female," Young Male," "Old Female," "Old Male." There's 60 blocks in here, so I rolled the dice 60 times, and I wrote in each little square the resulting simulated p-value. I've marked in red three of them – 0.013, 0.004, and 0.042 – so we have three significant results. If I were into the p-hacking publication game, what I would do is write three papers, and I would discard all these p-values that did not obtain statistical significance.



- Upper left, London Smog 1952. Increase in daily deaths.
- Upper right, LA 1948.
- Singapore (lower left), Beijing (lower right) have heavy smog and no report of increased daily deaths.

This is a great set of pictures here; I'll walk you through it. Over on the upper left, we have London during the London Fog or Smog of 1952. This was a cold weather inversion. It's in November, December. The inversion lasted for a fair number of days. At the time, many of the people in London were heating their houses with coal fires in their little stoves. The SO_2 percolated up into the sky. The inversion didn't let it get swept away by wind, and they ended up with this very, very thick pea soup: smog. Analysts subsequently checked the daily deaths during this period of time. There were an increased number of deaths relative to the same contemporary time associated with this London smog.

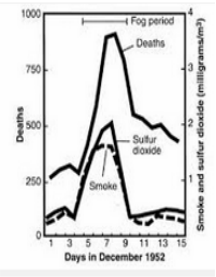
On the right, we have upper right we have Los Angeles in 1948. California at that time had smogs – that's actually where the name "smog" came from.

Lower left we have Singapore. Singapore is an interesting story. It's right across the Sumatra Strait in Indonesia where they do a lot of slash and burn. The smoke will come across the Strait and inundate the city for fairly long periods of time. The right is the iconic building in Beijing. We have three cities here, all of which have been subjected to smog attacks. There are no reports in Beijing, Los Angeles, or Singapore of associated deaths. I've attempted to get data sets from these people and getting data sets is a whole different game.

But London, there's no statistical doubt that there was an increase of deaths. Now it's an etiology question but I think that's related to the SO_2 producing acid, eventually killing generally weaker, older people.

The etiology

London 1952



Nemery, B., Hoet, P. H. M., Nemmar, A. 2001. The Meuse Valley fog of 1930: an air pollution disaster. *Lancet* 357, 9257: 704–08. https://doi.org/10.1016/s0140-6736(00)04135-0.

Zu, K., Tao, G., Long, C., Goodman, J., Valberg, P. 2016. Long-range fine particulate matter from the 2002 Quebec forest fires and daily mortality in Greater Boston and New York City. *Air Quality, Atmosphere, and Health* 9: 213–21. https://doi.org/10.1007/s11869-015-0332-9.

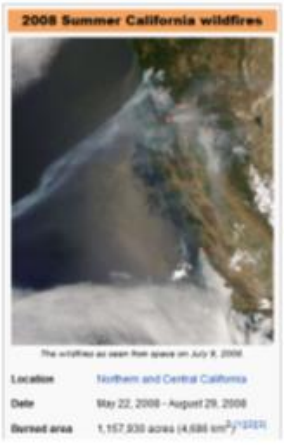
But here's more on that. Nemery in Lancet, 2001, he went back and looked at the Meuse Valley event. In Meuse Valley, not only were there increased deaths due to a temperature inversion and smog effect, they actually had autopsies on the people that died. Some of the people that died (there were also cattle that died) were subjected to autopsy. Interestingly, the hearts of these people were absolutely fine. No problem there, but the lungs were what they termed "blown out." They surmised or inferred that there was acid in the air that led to this.

Let's talk about what happens when you have a smoke attack. Through the wonders of satellites and so forth, on the left we have wildfires in California. We're looking at the south coast of California. You can see the smoke. Then if you look towards the right-hand side of the smoke signals, you can see red. Those are massive forest fires. In this picture you can see four or five forest fires, each giving rise to plumes of smoke. The lower plume of smoke that goes down and then to the left – that's covering the Los Angeles area. That's the South Coast Air Basin.

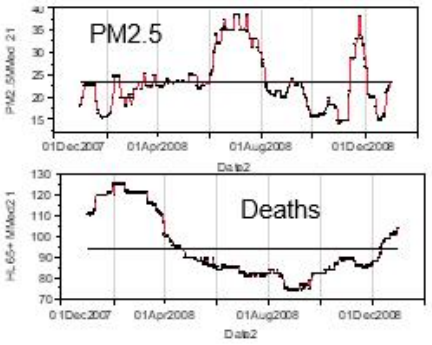
On the right in the upper panel, you see $PM_{2.5}$ in parts per million, and you can see it daily going up and down and bouncing around. All of a sudden, just before August 1st, you see a spike. $PM_{2.5}$ is going up on the day that we have the satellite picture, so we have a picture and a record that $PM_{2.5}$ is going up.

Natural Experiments

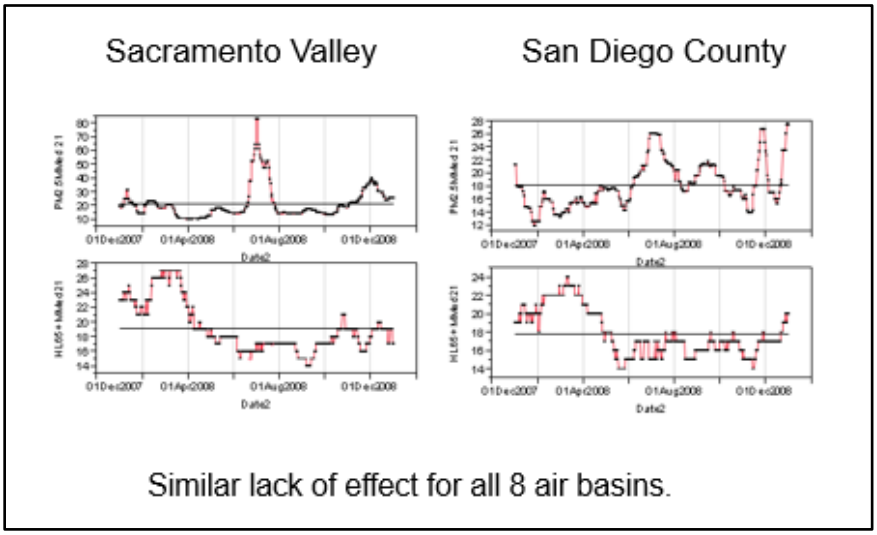
Wildfires



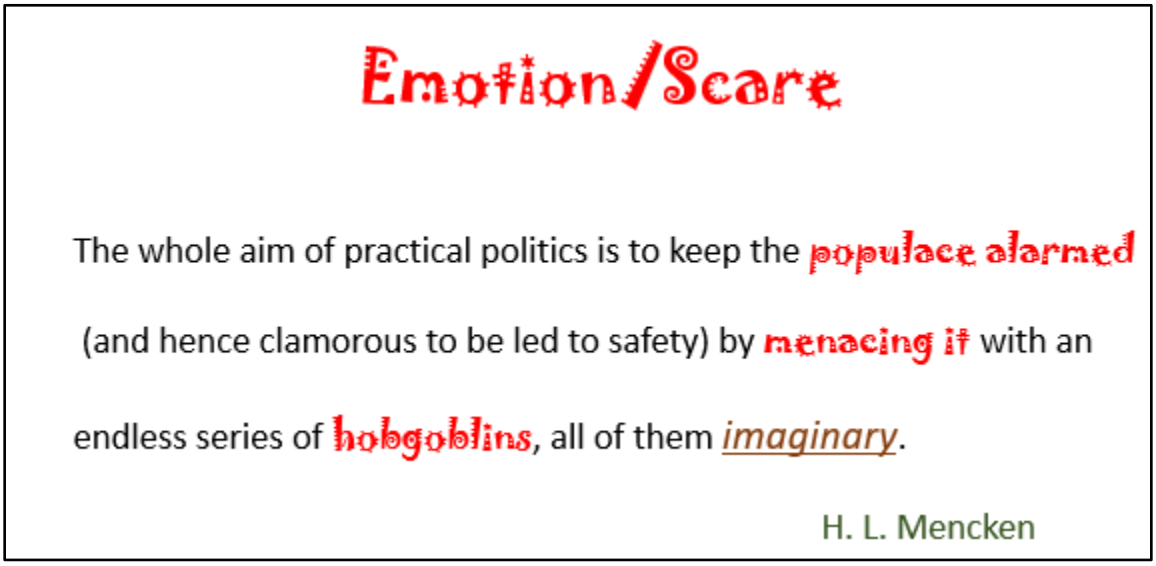
South Coast, 2008



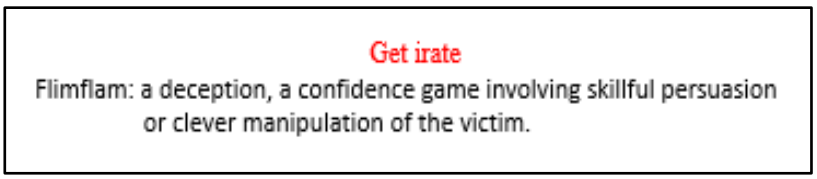
Deaths in the United States – particularly Los Angeles – are cyclical. They're higher in the winter and lower in the summer. So as you look at the daily deaths – anywhere from 70 to 130 deaths per day – you can see the deaths going down towards the summer. During this peak $PM_{2.5}$ level, you really don't see anything going on with deaths. Likewise, when you get over to December, you can see the $PM_{2.5}$ going up, and you really don't see deaths going up either. Now there's some sophistication of taking out weather effects and lags and things like that, but we think this is a fair representation of air pollution: $PM_{2.5}$ increasing and daily deaths unaffected.



This was pretty much universal across the California data set. We have the Sacramento Valley – $PM_{2.5}$ increasing dramatically. We have satellite pictures – I didn't show them here – and you see not much going on with deaths. San Diego, again a peak in $PM_{2.5}$ and daily deaths largely not doing anything.



I'm going to end with a sort of a political statement I've written in a funky font to bring the message home. The top says, "Emotion and scare." Human beings have genes that control emotions, and they have other genes that are rational thinking kinds of genes. Almost always, in a push, emotion will overcome the thinking genes. It takes a while for the thinking genes to come back in. "The whole aim of practical politics is to keep the population alarmed (and hence clamorous to be led to safety) by menacing it with an endless series of hobgoblins, all of them imaginary." H.L. Mencken wrote in the 30s and 40s – he was a muckraker, a very popular newspaper person at the time – and he was saying even then that if you want to control the population, you basically you scare the hell out of them and then they'll do what you want.



I leave with a "get irate" comment. "Flimflam" is a deception, a confidence game involving skillful persuasion or clever manipulation of the victim. We're pretty much on the side that air quality is not causing deaths, it's not causing asthma, it's not causing heart attacks. Researchers following the incentives that are in place are writing papers based on bunnies in the sky, very carefully written to entice the editors to publish their papers. Emotion tends to overrule sensible thinking, but I think H.L. Mencken had it right. So we're supporting Mencken's strategy of pointing out other things.

That's the end of my presentation.

DR: Thank you. I'm going to speak briefly by way of a conclusion of our presentation, then we'll have our commenters present. Basically the conclusion: the EPA has failed to require that research justifying regulation be subject to MTMM tests such as ours, or even to make key data sets publicly available. Failures that undercut confidence in their personnel's professional capacities as researchers and as regulators. These failures suggest more broadly that the standard procedures of epidemiology are insufficiently rigorous. These failures also suggest that current EPA policy – both in general and with regards to $PM_{2.5}$ regulation – failed with sufficient severity the research used to justify regulation. The EPA's negligence is self-serving, as it increases its regulatory power at the expense of citizens and freedom.

We offer recommendations – I may not read them all – intended to bring EPA methodologies up to the level of "best available science" as per the mandate of the Information Quality Act.

- Adopt resampling methods – multiple testing and multiple modeling (MTMM) – as part of the standard battery of tests applied to environmental epidemiology research.
- Rely exclusively on meta-analyses that take account of endemic biases, including questionable research practices procedures: HARKing and p-hacking.
- Redo the EPA's assessment of base studies more broadly to take account of these biases.
- Require pre-registration and registered reports of all research that informs the EPA's regulation. That's not a panacea – people can game pre-registration and registered reports, too – but it'll get rid of a certain amount of flimflam.
- Require public access to all research data used to justify the EPA's regulations.
- Place greater weight on reproduced research – reproduced, not reproducible – for informing the EPA's regulations.
- Constrain the EPA's use of weight-of-evidence to take account of the irreproducibility crisis.
- Report the proportion of positive results to negative results in research that the EPA funds.
- Certainly consider increased funding to investigate direct causal biological links between substances and health outcomes.

There are more in our report, but that's a fair number of them. We've subjected the science underpinning EPA $PM_{2.5}$ regulation to a serious critique, and we believe the EPA should take account of this critique as it reforms its regulations. But we care even more about reforming the procedures the EPA uses in general to assess science, and in reforming the procedures used throughout all federal agencies that use "best available science" to inform their regulatory policy.

Government should use the best science whatever the regulatory consequences.

Scientists should use the best research procedures whatever the result.

Those principles are the twin keynotes of this report. The best science and research procedures involve building evidence on this solid rock of transparent, reproducible, and reproduced scientific inquiry, not on shifting sands.

That's my conclusion. Jay, Steve, which of you would like to speak first?

JL: I cannot help but be a cheerleader for this amazing report. I don't know that I have read 98 pages about science this good since 1970. I want to recommend everybody listening in, now or later on YouTube, to obtain a copy of it. I say 98

pages because that's how long the actual narrative is, and then 50 pages of appendix. I can't say that I absorbed them quite as much, but this report is the most important report I've read 40 or 50 years.

I'm the oldest person in this webinar or seminar, and I go back to the beginning of where the problem began, because I was doing science during the Eisenhower Administration, and I am aware how we got into this fix. A fellow by the name of Vannevar Bush was President Eisenhower's Science Director, and he was so impressed – and properly impressed – with the government's creating the atomic bomb around 1945 at the end of World War II, which ended World War II – he decided that government research was the way to go. And he talked Eisenhower who's [missing words] public at the end of his terms that "beware of the technological complex taking the nation in the wrong direction," but he went along with Vannevar's recommendation to research organizations within, essentially taking away the bulk of research from private industry and placing it in the hands of the government. All the problems that are reported so well in this report – and I'll go over each of them very, very briefly – are the result of government writing research they were sure the government wanted, not necessarily, and also ensuring that the results [missing words] the government believe they should count.

There are seven or eight major sections to this fabulous report. Malleable research plans – which is to say you alter your research to fit, that you'll come out with the conclusions that the government looking for. Legally inacceptable data sets – I mean, this is going on, where the directors of EPA in the last few terms have in front of Congressional hearings said they could not give up their data sets because it was legally defensible that they would be opening up things for inspection that shouldn't be. Their methodology was opaque, and they wouldn't admit to it. Their algorithms that they would not admit to – sheer insanity. The lack of sharing of science.

Then we've had in the last 10 years undocumented data cleansing. Go back any 10-year period with the NASA and NOAA. You look at their data, you'll see it changing over time. They figure out ways to change the data. They've done it with buoys in the ocean, charting ocean temperatures. They've done it with air quality and NASA. It's sheer insanity. You just see the data changing and some cockamamie reason for why it changed.

What we've heard here from Warren and Stan are clearly flawed statistical methods. The p-values, the p-hacking – we're seeing it all the time. You've heard mentioned the publication bias – they hide consistently negative results. In research, a negative result is every bit as important as a positive result, but today's researchers are taught to put aside results that don't fit their hypothesis. It's absolutely crazy, and now we have political and disciplinary groupthink. We're seeing this every day with the "critical race theory" and the whole "woke" situation. We're seeing professors fired for not going along with the administrative view.

Reproducibility is what science is about. I'm one of the few people who actually knew Albert Einstein, at least sort of. I was a freshman at Princeton in 1953, and Albert Einstein and I passed each other on the street two or three times a week. He was going to his office at the Advanced Physics building, and I was on my way to class. We had a nodding acquaintance. We knew each other. I was 17 years old and we didn't chat, but he was famous for saying in response to a book published in Germany – a hundred German scientists who did not agree with Einstein's theory of relativity. When the book was presented to him, he said, "You know, they didn't need a hundred. All they needed was one to prove me wrong" and the facts of reproducibility disappeared. If you can't reproduce a result, it's simply not a good result.

Now this has also snuck into all of our science societies. Just about every science society that I've ever been involved with – at least half a dozen – have put out rulings that they are confident that man is impacting the temperature of the earth. The problem there is, these rulings are put out by the boards of directors of these agencies. They do not poll the members of the agencies. The people that get to be on the boards of directors of agencies get there by going along, agreeing they all become a liberal progressive mindset. And they're virtually all wrong. This is true of just about every science society today and it's really [missing word].

I am very familiar with Stan and Warren's work on $PM_{2.5}$ and more with Steve Milloy, who will speak next. He did a three-year study that of the fraud perpetrated by EPA on the PM studies in laboratories, on people, and the data in California. It reads like a detective story, and I strongly recommend that people read that book. But if they don't want to read the book, they can email me and I'll send you my review of the book that surfs over the high points and of course calls it one of the best research books one could ever read. It's exciting to read. As I said, it's like a detective story, but it really bears out everything that Stan and Warren have said previously.

If there's only one thing that isn't mentioned enough in the report *Shifting Sands* is the idea of the Precautionary Principle. The Precautionary Principle comes up in so many studies where even when the writers and researchers

admit they don't have really solid evidence, but they figure “better safe than sorry.” “Better safe than sorry” is absolutely a terrible thing.

One of the areas I’ve been deeply involved in for over 30 years is the LNT, the linear no-threshold on radiation – the idea that a single atom of radiation could cause cancer. The result that a man got a Nobel Prize for that and his research is totally fraudulent. Ed Calabrese – the world's leading expert in radiation toxicology – has been writing papers about it. His papers are very complex, and he always asks me to rewrite the paper for public consumption. I just rewrote his latest work and it's published this very week at cfact.org.

So I’m very familiar with this, and I just think this *Shifting Sands* project is the best thing I’ve read. It gives me such optimism that there's a way back, that we may get out of the mess that science has dug itself into for all the reasons that are mentioned in the report and have been mentioned by Stan. I cannot recommend the report too highly. I think if we could get more people to come aboard, recognizing these problems and slowly solving them…it may take us a generation, because we've raised a generation of academic scholars – and I use the term “scholars” loosely for the people who write reports committing the scientific sins that Stan and Warren have described, and I’m sure that Steve Milloy will build on what they said, and what I said.

In closing, one last point is that “consensus” – I brought it out with Einstein and 100 people consensus – has no place in science. It was brought home to me by Michael Crichton in a lecture he gave in 2003. Crichton was a doctor who never practiced and wrote novels using science. He gave a lecture in 2003 at Caltech explaining that consensus was something of criminals and politicians. When everybody agrees, Michael Crichton said, “Watch your wallet.” That's one thing that could be mentioned even more than it is in in this report. Consensus has no place in science. The idea that 97% of scientists believe in global warming is so absurd. 97% of no group agrees with anything. That should be thrown out on common sense. That's probably one thing that was not emphasized as might have been in the report, but I cannot recommend it too highly. That's all I have to say.

DR: Thank you so much. Steve Milloy, would you be so kind?

SM: Thanks for having me. You know, back when Stephen Colbert was doing comedy, he coined the term “truthiness,” and I think Warren and Stan’s report *Shifting Sands* does an excellent job of showing the “statisticalness” of the $PM_{2.5}$ scare. I just want to provide some context for this whole issue. No one's really talked about it yet. About 10, 11 years ago, Obama EPA Administrator Lisa Jackson went to Congress and testified that one in five deaths in America are caused by $PM_{2.5}$. Then the Obama Administration proceeded to use $PM_{2.5}$ to destroy the coal industry and issue climate regulations.

The scare has really only gotten bigger since then. Earlier this year there was a Harvard University study that came out claiming that $PM_{2.5}$ from smokestacks, tailpipes killed 8 million people worldwide every year. That's about one in seven deaths, so you know if this was true, there should be bodies all over the place. Eight million people a year – that's a lot more than COVID has killed. When EPA was going after the coal industry, I challenged…I’ve been working on PM for 25 years. I’ve never seen anyone killed by $PM_{2.5}$. I asked the EPA, challenged EPA, “Show us the bodies. If one in five deaths in America is caused by $PM_{2.5}$, show us a body.” They never did, because they can't.

Now $PM_{2.5}$ is the most potent regulatory weapon that EPA has. EPA's three basic points with $PM_{2.5}$ is that breathing $PM_{2.5}$ kills people, any inhalation of $PM_{2.5}$ – even one molecule – can cause death, and that death can occur virtually instantaneously or after decades of inhalation. Just that last part – either kill you instantly or 60 years from now – that should already start to raise questions in your head – how is that possible? In a nutshell, EPA describes $PM_{2.5}$ as the most deadly substance known to man. If you look out your window, you may be having blue sky today, like I am. In America, the average amount of $PM_{2.5}$ in the air is about 10 micrograms per cubic meter. EPA says that that air is deadly.

I know that we have much time here, I want to keep everything short. I’m a statistician by training, and I was very interested in in the statistics when I first started working on $PM_{2.5}$. I have a background in epidemiology, and the EPA's epidemiology was never very convincing. It was always just weak associations built on really lousy data, and then manipulated like Stan and Warren have shown. If you think about what EPA and environmental advocates say about $PM_{2.5}$ is really silly. As the Obama EPA Administrator testified to Congress, just breathing outdoor air in America, that “kills 570,000 people per year,” yet smoking only kills 400,000 people per year – 440,000 – how is that possible? Because the smokers are also breathing the blue-sky air. There's something that doesn't add up. That's another one of those things that should make you ask questions about $PM_{2.5}$.

EPA claims that there are three lines of evidence that support its claims that 2.5 kills: the epidemiology, which is studies of human populations; toxicology (usually studies of whether in animals); and then clinical studies. As I said, the epidemiology has never been very good. I sued EPA once over some of its $PM_{2.5}$ work. EPA admitted in court that the $PM_{2.5}$ epidemiology does not show causation between inhaling $PM_{2.5}$ and death. Because that's true, EPA went to other techniques to try to show that $PM_{2.5}$ killed, including toxicology studies where they exposed animals to extremely high levels of $PM_{2.5}$ for extended periods of time, and also, believe it or not, clinical studies where they've exposed human beings – elderly people, sick people, elderly sick people, asthmatics – to extremely high levels of $PM_{2.5}$ for extended periods of time, hoping to see something bad happen to them. That's a whole other story that is worth going into, but we're just going to stick with the results for now.

So in all the hundreds (if not thousands) of toxicology studies done with $PM_{2.5}$, no animal has ever died, no matter how much $PM_{2.5}$ they were exposed to. In all the clinical studies EPA has done with $PM_{2.5}$ in its various forms – everything from diesel exhaust to wood smoke to whatever particles they could pull out of the air – they've never caused any harm to anybody. Never caused a single cough or wheeze in asthmatics. Never killed anybody, obviously. So the notion that $PM_{2.5}$ causes death or asthma or heart attacks or whatever is not really backed up by any sort of biological evidence. That's important because these statistics show that there's a mathematical relationship between two events – breathing air and dying, for example – but even if you have a correlation, you still need to have biological plausibility to support that. While EPA does offer many biological explanations, in fact, none of these really work out. You can't find any place in the real world where $PM_{2.5}$ has ever harmed anybody.

For example, coal miners work in conditions with a lot of $PM_{2.5}$. Outdoor air has 10 micrograms per cubic meter $PM_{2.5}$. Until the Obama Administration came along, coal miners could inhale 2,000 micrograms for an hour shift and do that their entire career. And guess what? Coal miners live longer than average workers, so the $PM_{2.5}$ is not having an effect.

Another example – my favorite – is smoking or marijuana. With tobacco or marijuana – it doesn't matter. What smokers are inhaling is $PM_{2.5}$ particles, and they're inhaling them very deeply. EPA says that a single particle of $PM_{2.5}$ can kill you, and there's also 10 micrograms per cubic meter in the air, so over the course of an hour, you'll inhale 10 micrograms of $PM_{2.5}$. But a smoker will inhale *40,000* micrograms of $PM_{2.5}$ in just the time it takes to smoke a cigarette. Someone who smokes a marijuana joint can inhale *100,000* micrograms of $PM_{2.5}$ in just a few minutes, and of course no one has ever died from a single cigarette or a marijuana joint. In fact, we prescribe marijuana joints to sick people – the very people EPA claims should be dying from $PM_{2.5}$. They don't.

Stan brought up, and I think this is very important: the incidents of deadly air pollution that occurred in the 20th century. There were three. Stan pointed out the Meuse Valley in 1930 in Belgium. Stan didn't mention this one – Donora, Pennsylvania, 1948, and then there's the London Fog. All three of them – although EPA typically blames them on $PM_{2.5}$, in fact that is wrong. All the research done at the time, contemporaneously, shows that that was wrong. Stan mentioned all three incidents had weather inversions trapping the air. The local industries and coal burning did not stop, just filling the air with sulfur particles, making the air acidic, concentrating it. That is the cause of the deaths.

The way you can prove this is you look around today, you can go on the internet, you can google air quality in cities in India and China where some of the worst air occurs, and there are no deaths there. The PM levels can be very high – outdoor average in the US is about 10, in India and China you can reach 1,000. According to EPA, there should be a lot of deaths, but there aren't. Why is that? Well, it's because although the PM levels are very high, the sulfur levels -- what would make the air acidic and deadly to breathe – those are always very low. We've done a very good job of controlling sulfur pollution.

I commend Stan and Warren for a terrific report focusing on the statistics. There are a lot of statistical shenanigans that have gone on with $PM_{2.5}$ over the years. I encourage people to also look at the real-life claims. There are no real-life claims, because $PM_{2.5}$ doesn't kill anybody in the real world.

I'll just leave you with this thought. $PM_{2.5}$ was the Obama Administration's very potent regulatory weapon. During the Trump years, we were able to tamp that down, and we even got the EPA independent Science Advisory Board to basically say "What EPA claims is $PM_{2.5}$ science is just really nonsense," but now we have a new Administration and they're going to go right back to claiming $PM_{2.5}$ is killing 500,000 Americans a year. So I think this is going to be an issue of growing importance over the next few years, and I encourage everyone to get involved, learn about it, because it's really going to affect our lives. I'll stop there.

DR: Thank you so very much. I don't believe we have Donald van der Vaart, so I'm going to go to some of the questions and I'm going to again encourage everybody who is listening – if you have questions, please submit them either to chat or Q&A.

I'm just going to address a pair from Chris Boocock. The first one I'm going to answer myself and the second I'll pass on to Warren and Stan. The first one is "Re the papers that your presentations critiqued. Have you offered the authors a right to reply?" That's actually something I just want to mention. This report is not alone. This report is presenting the papers which Stan and Warren have been presenting in professional journals. Everybody has a right to reply to a journal; it's just sort of standard operating procedure. So yes, of course they have a right to reply. Every scientist has a right to reply. If they were to actually get in touch with us and say "Hey, we also want to mention something on your website" – Sure, love to, that'd be great, we'd love to have a forum and a debate on this. I don't think they're particularly going to bother, because they already have the normal professional ways of doing it, but hey, love to.

Your second question: "Can the panel comment on systematic review approaches such as GRADE?" and they have passed on a link to something from the BMJ. Stan and Warren, do you have any comments on GRADE and systematic review approaches?

WK: Perhaps I can answer that. Stan and I published a review in Critical Reviews in Toxicology. One of the questions from the reviewers was directed to those type of protocols. GRADE is one of over two dozen protocols that can be used for those types of analysis. Stan, if you recall, all of them are silent on the multiple testing bias, so in fact while they assist meta-analysis and systematic review researchers in some aspect, they do not address the multiple testing bias.

SY: There's a 2000 paper, I think in JAMA, which is the bible for reporting meta-analysis and observational studies papers. Long, pretty detailed, quite good as far as it goes, but as Warren says, there's absolutely no mention of multiple testing and multiple modeling (MTMM). So there is a either a systematic blind spot or an unintentional blind spot, particularly in the area of epidemiology, but also psychology and many areas where multiple testing and multiple modeling (MTMM) is off the table.

Now if you go into clinical trials – and there's a crazy thing here – I gave a lecture at the FDA. The FDA is absolutely adamant about controlling for multiple testing in randomized clinical trials – long protocols, careful, great stuff – but I challenged the people at the FDA. I said, "You're controlling multiple testing in the case of randomized clinical trials, but even in a randomized clinical trial, when you look at side effects – and there could be hundreds of side effects – you are absolutely silent on multiple testing." I am absolutely sure if someone did the research, they would find drugs that were pushed off the market based on multiple testing across hundreds of side effects. So the FDA itself is schizophrenic on this. On the one hand, yes, they pay attention to multiple testing, but on the other hand, no, they don't. I'll go out on a limb here – it's sort of self-serving in case of randomized clinical trials for efficacy. They don't want to clear a drug that doesn't work. Well, drug companies don't want to clear a drug that doesn't work, either. On the other hand, side effects can be deadly to the marketing and use of a drug, and they should be equally rigorous on the side effects. They should use techniques that are standard in the literature and SAS Institute and all that. So there's a lot to be upset about in terms of this multiple testing and multiple modeling.

DR: Thank you. Another question which I'm going to push a little bit – this is from Richard Belzer. "2020 provides a natural experiment of sorts on conventional $PM_{2.5}$ methods versus COVID mortality. This may be useful for creating a competitive etiology $PM_{2.5}$ or COVID." Frankly, the question is a little obscure to me, so I want to just push it a little bit. 2020 did because of the COVID thing actually have a significant effect on pollution and so on, which would allow interesting data to be coming in. When are we going to get all the data from 2020 such that we can actually start making interesting analyses from that data as it emerges?

SY: Yes, conversations are always turning to COVID now as expected. It's a hot topic right now. There were very early studies, a thing called the Case Fatality Rate. A person has COVID – do they live or die? Very early study said that the case fatality rate for COVID was essentially not much worse than common flu. One can make a case that there's been an explosion of scientific effort in this area. Then I've even seen papers where people said, "It's a combination of COVID and pollution" and so forth. So the COVID bandwagon is pretty big, and it will take three or four years for the smart guys to figure it out. Right now, I think the vast majority of what we're reading in the COVID area is pretty questionable. The CDC data is even questionable, so let's try and stay with air pollution, because we can do that right now.

DR: Another question from Anne Andis: "How can federal agencies be held accountable for accurate, honest, non-biased policies and guidelines?" I'll just slip in with my own pet answer. This was one of the recommendations I mentioned: constraining weight of evidence. That is, in effect, weight of evidence gives regulators I would say the arbitrary right to determine the scientific information you can use and what you can discard. What we need, I believe, are more detailed and more transparent regulations governing the use of regulatory expertise, mentioning one, you have a standard rule given for including or excluding scientific information, and then a requirement for each to give a rationale for why you included or excluded. Simply forcing regulators to explain their rationale won't cure everything, but I think would be a significant improvement on the status quo. That's my immediate answer. Everybody else? Stan, Warren, Steve, and Jay?

SY: Let me say I've made recommendations on observational studies. A simple recommendation would be to separate the data set building from the data set analysis. Right now, one team of scientists does both, so they have a stranglehold over the construction of the analysis data set. Then more often than not, maybe 90% of the time, they will not release their data set. This is a recipe for mischief. What regulators could do is contract the building of data sets and making them public, and if they wanted to contract someone to analyze those data sets, they could do that, too, but to have both the building of the data sets and the analysis of the data sets in one set of hands I think is not a good idea.

The other thing that would make it even more fun is that the people that build the data set create a holdout data set which is not made public. Anyone writing a paper could write a paper, publish a paper, but they would know that this Sword of Damocles was over their head, that there is a holdout dataset. And the Sword of Damocles is not just for the researcher – it's also for the journal, because the paper would be published and then the holdout dataset would be brought forward. So there's room for embarrassing the editors, too, and I think they are part of the problem.

DR: Warren or Steve, do you have answers, too?

SM: To the question "What can we do about this," that's a great question, but I don't really have very good news for you. During the Trump Administration, we tried to do something about it. We – the Trump Administration – issued this science transparency rule. As soon as President Biden was inaugurated, environmentalists went to court and had a judge invalidate the rule, and the Biden Administration refused to defend it. All the rule required was – not even required, just sort of recommended – that data be made available to independent researchers for verification.

I've spent 30 years working on these issues, and the reason I got trapped into doing this for 30 years is because I've just been astounded by the dishonesty. Dishonesty is rampant in science today, especially government-funded science. The only way you can fix this – I mean, you can fix it hypothetically and if you have lots of people acting in good faith, yes, you can fix that, but we don't have that today. There's so much dishonesty going on. I'm afraid the only way to fix science is to get the government out of it, and that's just going to take a change of government.

DR: Thank you.

JL: Steve, would you tell everybody the title of your book? I know you don't like to be self-promoting, but what's the title of your book?

SM: It's called *Scare Pollution: Why and How to Fix the EPA*." It came out in 2016.

JL: Thank you.

SY: I will say it's a very fun and interesting book. I'll second Jay. It was a fun book to read and it pointed me in lots of interesting directions. My work is rather technical. His work is very accessible, and it's a fun read. I gave it to one of my friends – not a technical person – and he was enthralled with the book. He thought it was great. So I highly recommend the book.

SM: Thank you, Stan.

DR: A question which is a little off the mainstream of our own report, but I still want to do it. "I'm Michael Gorski. Would you wish to comment on the unproven assumption of the linearity of effect with dose as opposed to MPA 2.5 and ionizing radiation dose, LNT? About a threshold in dose-effect dependence. Biology is never linear, especially over a threshold effect [missing words] borderline. Please comment." I will mention that Peter Wood of the National Association of Scholars has indeed commented on this in 2015, so we have been commenting on this as an

unwarranted assumption. There's a lot of good work by Ed Calabrese and others. I guess my first question would be to Stan and Warren: does MTMM in particular speak to this particular dose issue?

SY: I will jump in where angels fear to tread. The low-dose linear extrapolation has been around for an awfully long time. It's been questioned by serious scientists since its beginning. We did a study. An epidemiologist sent me the dataset and another statistician and I, the three of us worked on this dataset for radon. It's highly regulated. They make you clean out your basement, put in air filtration, and so forth and so on. What we discovered was that not only was low-dose linear a bad model for what was going on, but natural exposure to this rock actually improves health. The substance is in asbestos mines and things like that, and if you're exposed to very, very high levels, it causes lung cancer, but at low, natural levels, there's actually a protective effect. There's a whole area biology, sort of squirrely biology or whatever, but I think it's right that you have hormesis.

One reason that cells do better is that they're actually challenged. They don't want to be challenged too much, but we showed quite convincingly that low levels of radon are actually protective against the lung cancers which occur at very high levels. So this whole business of what's happening down at low doses is extremely important, and the simple-minded low-dose linear is disastrous in terms of policy.

In case of protecting against ozone, it's disastrous in terms of protection. Radon is actually protective. I have a couple of papers on that. You put them out in the literature and poof – nobody pays attention, but it's out there, and low-dose linear is a scientific, mathematical crime.

SM: Someone mentioned Ed Calabrese before. Ed Calabrese has an excellent series of papers exposing the LNT as a product of scientific fraud. Point one. Point two, it's true that a high enough dose of radiation will kill you or give you cancer. From that high dose they basically draw the line down to zero, and so any exposure increases the chance of both. That's the sort of science fraud of it.

But going back to $PM_{2.5}$, although we know that high levels of radiation can kill you or cause cancer, high levels of $PM_{2.5}$? There's no there's no death from $PM_{2.5}$ that you can even draw that line down to zero with. That's how bad $PM_{2.5}$ "science" is.

DR: Thank you. We've also published Ed Calabrese in *Academic Questions*, the National Association of Scholars' fine journal, which everybody should join as a member, if only to be able to read Calabrese and other wonderful writers, and indeed on science regularly. Some wonderful articles by John Staddon recently, for instance, which everybody should be looking at.

I am looking at these various questions. "What is the "best science"? How does one determine the "best science?"" I will again give an immediate partial answer to that. There is this government term in the laws – "best available" – and in effect, one of the fascinating things is how precisely do you define "best available science" for which every single agency of course will have its own bureaucratic definition.

The NAS's own crusade is to redefine best available science to mean "transparently usable," and ideally reproduced. Some of the initiatives in the Trump Administration in effect were trying to upgrade the definitions of "best available science." So I would say – purely practically and legally – "best available science" is how do we precisely define what procedures you use? There are more spiritual yet idealistic definitions possible. Do other people want to comment on "best available science?"

JL: I'd like to say mathematical models is never "best available science." Mathematical model creates its own data. It's gotten crazy that we base regulations, ethical science, on a math equation that people believe simulates nature, which is almost never correct. Models are good for testing variables. Sensitivity testing. They are never good for coming up with an answer on which you develop science policy, and yet it's done all the time now.

SY: I will second that. I've seen papers where the measured levels of $PM_{2.5}$ on the ground are put through a massive modeling system, and then the level of $PM_{2.5}$ is projected on every point in the United States. The number of knobs that are on those models has to be pretty large, and it's based on questionable data. The sensors for $PM_{2.5}$ are typically put close to sources of $PM_{2.5}$, and so you have a very biased sampling system for the base numbers that go into this multi-knob model. It is entirely crazy.

While we're on data, one way to fix this is make sure that the datasets that are being used are publicly available. One of the things of science is that if you make a claim, others should be able to check your claim. There are just too many

ways that science is done that you can lay out in detail exactly sort of how to do it. But if the data sets are made available – and there is a law, the Data Quality Act, that at least from a legal point of view would require that paper and data that are used in those papers by regulators should be made public. That as far as I can tell has been totally ignored. I've gotten data sets from people in the air quality area, and almost invariably they got it wrong one way or the other, but I could not show them up and wrong without access to the data. So the fact that the EPA and the government is not routinely making data available is one of the big factors that messes up the whole thing.

DR: Thank you. It is now 3:29, so I'm going to say we are closing our fine session which is supposed to end at 3 30. Thank you so much – one, to my colleagues, Stan and Warren, thank you so much to Jay and Steve for agreeing to comment and for providing wonderful comments. Thank you to Chance for arranging all of this in the deep background.

I just want to repeat a number of things. First off, this is one of four reports which are going to be done in *Shifting Sands*. You will see our faces again at various points over the next several years as we do the second, third, and fourth reports on different subject matters.

Two, this will be on the NAS YouTube channel within 24 hours. Please type National Association of Scholars – we are not the rapper NAS with whom we are often confused on Google searches, although I'm sure we could do a good rap if we tried hard. If you have questions that weren't answered, please send them to me, David Randall, at randall@nas.org, and I will be glad to forward them to everybody – panelists, questioners, commenters.

I think that probably covers it. Thank you so much to the audience for coming and listening. Our report is on our website, nas.org – look for *Shifting Sands*, it should be fairly easy to find it. You can read this, you can download it, it's available, and we know you'll pass it to all your friends and give it in Christmas stockings.

Thank you very much and I think I will say the end, goodbye!

Transcribed by Kathryn E Kelly, DrPH MEd, NAS Life Member and President of the National Association of Scholars' Nevada Affiliate. The transcript has been slightly edited for clarity in written form. Please send any corrections to layton@nas.org.