CleanLaw 47: Joe Goffman and Francesca Dominici Discuss Air Pollution Links to Coronavirus and Lack of Air Quality Improvements in Black Communities, August 25, 2020

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Robin Just: Welcome to CleanLaw, from the Environmental & Energy Law Program at Harvard Law School. In this episode, our Executive Director, Joe Goffman, speaks with Francesca Dominici, Professor of Biostatistics, Population, and Data Science at the Harvard T.H. Chan School of Public Health and co-director of the Harvard Data Science Initiative. They discuss her team's state of the art science that shows air pollution continues to be a public health threat and links air pollution with increased coronavirus death rates. They also discuss her team's recent study revealing that, even as air quality improved overall between 2010 and 2016, it did not improve in Black communities. We hope you enjoy this podcast.

Joe Goffman: Thank you so much, Francesca, for joining us for a second time on the CleanLaw podcast. We're making this recording in the middle of July and I know that you are insanely busy. I think we're all lucky that someone with your gifts is devoting them to making a contribution -- in fact, a tremendous contribution -- to taking on the problems we're facing now, both in terms of the perennial problem of air pollution and the immediate, even more vivid problems of the intersection of air pollution and environmental justice and the COVID-19 pandemic. What I think would be really interesting to hear you talk about would be three articles that you published recently. Reading them, I had a combination of reactions. I was both amazed at your ability to deliver complex scientific information that had up-to-the minute relevance and was actionable and yet, at the same time, I found the articles kind of distressing because, in a couple of cases, they delivered some really disturbing news about where we are as a society and where we are in our struggle -- if you can put it like that -- to combat air pollution.

Joe: Without further ado, I'm wondering if we could walk through your and your colleagues' recent work on the impact of exposure to fine particle pollution and the ill effects of COVID-19, and then talk about another article you and your team have recently posted on perhaps what is even more distressing: the fact that as air pollution has gone down in the last six years, or at least in the period of time between 2010 and 2016, exposure to air pollution in Black and low-income communities has gotten worse. And then I think we wouldn't be doing our job if we didn't talk about the EPA's recent proposal not to tighten the fine particle standard, which comes despite the fact that you and your team have done work that continues to demonstrate the harmful, even lethal, effects of PM 2.5 exposure among communities of people over 65 at levels below the current

standard. So, at this point, let me turn the microphone over to you and ask you to talk a bit about what your work has uncovered about the relationship between air pollution and COVID-19.

Francesca Dominici: Thank you, Joe, for your kind words. First of all, let me say now I know why I'm feeling exhausted. When I also feel demoralized, I think I should give you a call and talk to you.

Joe: As far as I'm concerned, you and I can have an open line. I'll tell you: there are ten different reasons for that. One of which -- and I think this is going to come through in our discussion -- a lot of the work that you do and your colleagues do on air pollution can be very abstract and very hard for the general public to connect to what is going on in their lives and in society, but your work now intersects with two things that everybody understands at a gut level: the ravages of COVID-19 across the country and across the world and the problems of racial and economic inequality. You've managed, in a very vivid way, to put a spotlight on both of those things using the very sophisticated statistical and epidemiological techniques.

Francesca: Thank you. I really, really appreciate. And I also have to say I am so grateful and so fortunate because I have a team of student and post-doctoral fellows and colleagues that are just amazing. I give ideas and I direct them, but really, this is really thankful to them and their hard work. It's amazing actually to see the degree of responsiveness and engagement I get from a lot of the students in the college, actually, at Harvard. They want to do this work and they want to make a difference. So that's really what keeps me going.

Francesca: Going to the work on long-term exposure to fine particulate matter and COVID-19 and mortality rate....That started as we were in the middle -- I mean, we're still in the middle of the pandemic, unfortunately, but as this....Back at the end of March, myself and my colleagues were feeling this level of high anxiety and thinking about how can we use our data and our skills to help. There were two things that we made an immediate connection. One is, two years ago, I had the privilege of being a member of a Ph.D. thesis committee of a student in the Department of Environmental Health, Jeong Jo Choi, that was mentored by David Christiani, who is a Professor of Environmental Health and also a pulmonologist at Mass General. In that work, the Ph.D. thesis looked at the relationship between fine particle matter, long-term exposure to fine particulate matter, and acute respiratory distress syndrome. Now, at that time, I of course paid very little attention to acute respiratory distress syndrome. I was told it was something really bad and, if you get, is going to kill you. But then, with COVID, it immediately became clear that COVID is a form of viral pneumonia and, actually, many of the deaths are caused by this acute respiratory distress syndrome. It's a multi-organ failure syndrome.

Francesca: So, then, I started thinking, hm. I'm wondering if there is a link between exposure to air pollution and COVID. And so we developed and linked and organized so much data, because that's what we do. We develop new methods for data science and apply to several hundred million observations to look at the health impact of fine particulate matter. And so I quickly approached my Ph.D. student, Zhao Hu, and junior faculty member in my department, Rachel Nethery, and I said, "What can we do with the available data to think about whether or not there is a link between fine particulate matter and COVID-19?"

Francesca: We had already data on long-term exposure to fine particulate matter for all the United States for the last 20 years because that's… through our collaboration, this is data that we developed. We have previously developed machine learning approaches to estimate exposure to fine particulate matter. We have data on socioeconomic status. So we have many data sources. I'm also extremely grateful to the Johns Hopkins team because they have developed this dashboard where you can download the daily number of total deaths for COVID-19 at the county level. So we pretty much put a lens on that and worked nonstop to gather and link the data. We decided not to look at COVID-19 cases or the spread of the disease just because, first of all, there was too much uncertainty in the data. There is still uncertainty in the number of deaths, but I also felt that the number of deaths were standardized with respect to the population size were a little less susceptible to the different testing practices.

Francesca: So we developed a specific hypothesis, which is whether people that are living in geographical areas that are exposed to fine particulate matter becomes more vulnerable and have a higher risk of death of COVID-19 after they contracted the virus. There are a lot of biological possibilities to this hypothesis because, based on the multiple studies we have done, there is strong evidence all around the world that suggests that, when you're exposed to fine particulate matter for a very long time, they penetrate very deep into your lungs. They start an inflammation system. They can get in your bloodstream. And so I would expect that, if you contract the virus, then it makes you less resilient to fight the virus and therefore, you have a high chance of that. The statistical analysis is, in a certain way, as sophisticated as it can be to disentangle the different confounding factors and many challenges in the data, but at the same time, I would say also simple because, unfortunately, the COVID-19 mortality data is only available at the county level for all the United States.

Francesca: So we did the analysis. We did as many as possible sensitivity analysis and robustness check that we could. We found that, if you compare two counties that, let's say, are as similar as possible with respect to socioeconomic status, population density, stage of the epidemic, access to healthcare, percentage of people smoking, you name it, you try to compare two counties that are as similar as possible. Pretty much everything we can measure. The county that has one

microgram per cubic meter higher level of fine particulate matter in the last 10 years experienced an increased mortality rate for COVID-19 that ranged between 8% and 11%. These estimates of relative risk has been changing a little bit because, unfortunately, we are still in the middle of the epidemic. So we are actually re-running the analysis almost every week because, again, unfortunately, we are still getting deaths.

Francesca: We... Picked up by the news in a very crazy way, actually. To be honest with you, I wasn't even prepared for that. This is a very preliminary study. I think the study has...One of the main limitations, as I said, is this is all ecological data. They are aggregated data. It could be subject to different types of confounding. But we made it available. We made the code available. I think what has been really rewarding to me is that...this is something I always wanted to accomplish, actually, which was really to start a movement. To start a movement all around the world of looking at this question. Because by posting the data and the code, then the next thing happened is, in England, they're doing a similar study. In the Netherlands, they're doing a similar study. In India, they're doing a similar study. And so I think this is actually...as science progresses, I think especially in the context of data from a pandemic that tends to have all kinds of issues...I think that ultimately consistency of evidence across many places is something that we need.

Francesca: I call this a very evolving area of research. I am very proud of the work. I think we have done the best that we could considering the data that we have. But clearly more needs to be done. I think that -- I was actually quite happy that it's playing an important role because it seems to me pretty unwise, to put it mildly, that we are not lowering the National Ambient Air Quality Standard at the time of a pandemic that is affecting our lungs. So that's a nutshell about the COVID-19. The work is under review. We actually have a university-wide data science working group on COVID and the environment. There is so much work coming out of this group. Again, it's mostly by students. I think the most important aspect of this...and the scientific rigor of this work will increase conditional to our ability to access better data, individual-level data. So that's something that we are fighting for. We'll see what will happen.

Joe: You mentioned that the timing or the juxtaposition of what you're discovering in terms of air pollution and COVID with the decision, or at least the proposal, by the EPA not to tighten the NAAQS standard is probably a good thing to talk about next. Particularly because it seems as if you really made a concerted effort to respond to an objection that some of the scientists particularly Tony Cox, Scott Pruitt, and now, Andy Wheeler recruited to raise objections to or advance a new and ultimately more restrictive approach to looking at the causal relationship between pollution and health effects. It seems to me that, when we were proposed not to tighten the standard, he explicitly and implicitly relied on the claim that the science...suggesting a tighter standard was uncertain. But your

paper really seems to take that on and really, at least to my eye, refute Cox's claim that the causal inference test hasn't been passed here. I'm wondering if you could elaborate on that a little bit.

Francesca: This is, I would say, a pretty multi-phased and complex discussion. A few key points. I think it's unfortunate that the EPA Trump administration has been using the argument of lack of causality as an argument to dismiss the enormous amount of epidemiological evidence on the link between air pollution and health. I think, before the Trump administration, the process of whether or not lowering the National Ambient Air Quality Standard has been based on a consistency of evidence, which to mean the context of observational data, where you can never really assess causality, isn't the best possible approach. To review for a moment now: let's assume for a moment that, absent the pandemic, what the EPA has always done is to use thousands and thousands and thousands of studies that consistently report evidence of a link between short- and long-term exposure to fine particulate matter and mortality. When we published our paper in 2017 and we had this conversation, Joe, the paper in the New England Journal of Medicine, that was a very influential paper because we analyzed 60 million Americans. Again, they raised this criticism. They said, "Well, the statistical analysis on that paper and also in all of the other papers is based on traditional regression model and the traditional regression approach cannot make statements about causality and therefore we don't have enough evidence and therefore we should not lower the standard."

Francesca: So I personally think that...even though I'm very proud of the work we just published last week on causal inference model to look at causality...and we can talk about that in a second, but I think in general, when you are trying to assess a link between an environmental exposure, whatever it is -- air pollution, radon, asbestos, you can name it -- in using observational data, there is not a single bulletproof statistical method that's going to give you the right answer. It just doesn't exist. Because the data are messy and the data are observational. You can not randomize people to breathe high pollution level or low pollution level as you can do in a randomized trial. So my position on this is that the closest way you can get to causality is, again, consistency of evidence across many studies, across sociobiological studies, and across epidemiological studies.

Francesca: I can say all of this. I also thought that there is a very extensive and rich literature on statistical methods that allow to make statements about causality from observational data. There is a very broad literature, very prolific literature, in statistics. Don Rubin, who is a professor of environmental statistics, introduced the idea of the potential outcome framework. So then I said, well, if it's really that this is the line of attack, that we haven't used methods for causal inference, well, we're going to do it. Now, it wasn't that easy because the data...we wanted to build on the paper we did in 2017. And so to give you an idea of the data, we are

talking about 570 million observations. Trying to develop and apply very sophisticated statistical methods of such a giant dataset...it wasn't easy. But we were able to achieve that.

Francesca: The general idea is the following, which is actually...just to try to communicate that as easy as possible. When you are trying to analyze observational data on air pollution and health, you always have these issues of confounding. Basically, when you take two geographical areas, one is high pollution level, another one is low pollution level, these counties are also different with respect to many other factors. Generally, the counties that are more polluted are the counties that have more people in poverty; there are people with lower socioeconomic status, access to healthcare. And so whenever you try to analyze these data, you always come across a challenge that you need to differentiate and distinguish the effect of pollution on mortality from all these other factors. If you do a regression model, you basically make a mathematical assumption of how you're going to adjust for this confounder. And so the criticism with this regression model is that if the mathematical assumption about how you eliminate confounding is wrong, your results will be wrong.

Francesca: The methods for causal inference, and again, I'm talking about hundreds and hundreds and hundreds of papers in the statistical literature in the last 20 years, what they do is, instead of relying on very specific assumption of a statistical model, they somehow match and find counties that are basically similar to each other with respect to all of these factors and then compare these counties. Basically, the only difference between these counties are the high level of pollution or low level of pollution. So because we have data for all the US, and actually we have data for every zip code in the United States for the last 20 years, we have enough of each data to say, for example, if I take one zip code that has a high level of pollution, I'm going to find another zip code that is absolutely identical to this zip code with respect to as many variables as I want, except the zip code has a low pollution level. So then the only difference between these two units is one is polluted and one is not.

Francesca: We used two standard regression approaches. The traditional regression approach and then we used three different methods for causality inference. We analyzed all of the data that was published in 2017 in the New England Journal of Medicine and then we also updated data up to 2016. The bottom line is there is evidence of a causal link between long-term exposure to fine particulate matter and mortality, but what is even more disturbing is that this relative risk is even higher, actually, if you look only at the people that be living in geographical location at a level of fine particulate matter below the current National Ambient Air Quality Standard. So, results that we published in the past were not sensitive to the choice of the statistical method. If you used a method that tried to assess question of causality, you still find a strong relationship. And the relationship is

even higher -- this relative risk of mortality is even higher in areas that are in attainment with the National Ambient Air Quality Standard.

Joe: That was a great explanation because, in the article, you basically asserted that your latest work had actually bridged what was posited as an unbridgeable divide between the causal inference methodology and these epidemiological or statistical methodologies. Certainly, that really was a great explanation of what you meant, or what you and your team meant, when you wrote that you had essentially or bridged or perhaps exposed as a false dichotomy or false dilemma between those two different approaches. If I have my dates right, I think the comment period on the proposal not to tighten the PM 2.5 NAAQS is still open. So I'm assuming that, if not you, then a number of people will be providing expert comment that reflects exactly what you and your colleagues have developed and what you just explained.

Francesca: I know they did. The journal was kind enough, actually...I think the deadline was June 29 and the journal was kind enough to post the article on June 26 to allow people to comment on it.

Joe: It seems to me in reading part of the proposal to leave the NAAQS in place, some of the arguments that were made there and some of the work that was cited, this paper seemed like, if you will, a direct riposte to that that should make it extremely difficult for the agency to maintain its position were it of a mind to be open-minded about the science. The other thing that you and your team have zeroed in on -- and in some ways, for those of us who have worked long in terms of advancing air pollution policy, that is maybe the most distressing -- is your work revealing that while, generally, we're seeing, or saw in 2010 through 2016, reduction in air pollution and, generally, the improvement of air quality -- that benefit seemed to have not only been unevenly distributed, but maldistributed in precisely, if you will, the worst possible way, which is areas or communities that are dominated by white populations are seeing the benefits, but low-income communities and communities with Black populations are not seeing those benefits. If I read the work correctly, it was mostly observational, but obviously, completely sophisticated and well-founded, but the real challenge for policymakers is how to take the observations and translate it into policy action. But I guess before we get there, it would be vital to hear you describe the work in that paper and the conclusions you reached.

Francesca: This has been really a different type of work for me, which has opened my mind and that's why I love what I do so much, because I get to learn from my colleagues all the time. I'm not considering myself an expert on data visualization, but this was really something where we want to not only do some statistical analysis, but I felt that, in the context of environmental justice and this context of environmental injustice, it was important that rather beyond doing sophisticated analysis to work

as hard as we could to visualize it. We need to see it. I wanted to be able see it. This was a work led by a post-doctoral fellow at the Harvard School of Public Health. He likes to be called AJ. His name is super long on the paper. Also in collaboration with ESRI, which is the Environmental Science Research Institute, which is more sophisticated research into geographic information system.

Francesca: So this is what we did. As I mentioned, we have now daily measures of fine particulate matter for one kilometer to one kilometer grid for all the continental United States from the year 2000 to 2016. My colleague Josh Schwartz has been estimating these levels, but also there are other colleagues around the world that make this data available. And then we have census data. What we wanted to do is, first of all, we just visualized what everybody knows, which is, in the last 20 years, the level of pollution, the level of fine particulate matter in the air, has been going down in this country. Also, by the way, thanks to a rigorous process that the EPA has always had, informed by science, and thanks to the Clean Air Act. Then, what we wanted to do is asking the question as whether everybody was benefiting of this reduction in fine particulate matter in the same way; whether or not we were addressing also racial and income inequality in terms of how much pollution you breathe; whether we were the same, whether we were doing better, and whether we were doing worse. What the paper does, we both did a statistical analysis where we tried, we calculated over time the degree of inequality in exposure with respect to the mean over time. But we also visualized it through different animation.

Francesca: The concerned story...I think, Joe, you read the paper and I'm glad because that means we explained it clearly. You described the results exactly right: that from the year 2000 to the year 2016, even though the levels of pollution in the air have been going down, the areas in this country that still have high pollution level are predominately the areas where the Black population lives. Let me give you just a quantification for a moment. If you take our country in the year 2010, and let's say you only look at geographical areas with pollution level above eight microgram per cubic meter, which is in attainment, but I would say high levels of pollution. Among the, I would call it the polluted air in this country, in 2010, you will see that approximately 50% were areas that were predominately populated by the Black population and 50% that were predominately populated by the white population. In a certain way, in 2010, we still have a good percentage of zip codes that were high polluted, but it was kind of an equal distribution between the Black and the white population.

Francesca: If now you fast forward, in 2016, among the zip codes that are still above eight micrograms per cubic meter -- there will be fewer because, as I said, the pollution level has been going down, but among the polluted area, now we have 75% of the area that are populated by the Black population and only 25% of the ones populated by the white. If you actually look at the even more polluted zip codes --

let's say that you only restrict attention to the zip codes that have a pollution level above 10. These are very polluted. Well, in 2010, the great majority of very polluted zip codes in the US were -- actually, almost 93% -- are areas predominately populated by the Black population versus 10%. The progress is uneven. It's not progress that addresses...we're not cleaning the air in an even way for everybody. As the pollution levels are going down in this country, as we have a smaller number of geographical areas that are polluted, among the ones that are polluted, they are predominately populated by the Black population.

Francesca: Very similar story is true for the Latino. As you can imagine, for example, the most polluted zip codes are the ones in California and they are all concentrated in the areas where it is predominately populated by Hispanic. And similar story is from the different income group. Although what is interesting is that the disparity in air pollution exposure is much more prevalent and stronger among racial community than among income group. The other striking finding that is very clearly visualized in the paper that surprised me: the levels of fine particulate matter over time for the areas where the Black population with the higher socioeconomic status consistently has been breathing higher level of pollution in this country in the last 16 years -- consistently higher pollution than a white population of the lowest socioeconomic status. The richest Black population breathes higher pollution level than the poorest white consistently in the last 16 years. You can see it. This is not about fancy statistics. You can see it right there.

Francesca: I was expecting to see differences. I was not expecting to see the racial inequality and the divide to become bigger over time. I think my guess, we haven't studied that, is that as the pressure to clean is stronger, people try to find ways to continue to pollute in areas that don't have the ability to fight against and so, clearly, here is the new power plant that is coming up in the under-served community. We just posted the paper on the archive and submitted for publication. We'll see, but I think that speaks to the fact that there is something structurally wrong...I'm not saying purposely, but there is something structurally wrong in how we are implementing regulation. I think we need to look at the system so then we are not cleaning the air, but we are cleaning the air equally and evenly for everyone.

Joe: That was an astoundingly clear and astoundingly disturbing description of what you've observed and how it presents. I hate to lure you into the world of policy when you might not want to go there, given the very strong foundation you keep fortifying in terms of the science, but as you know, the Democrat who's running for president, Joe Biden, has been vocal, particularly recently, about including in his policy proposals a really strong focus on environmental justice. It's mostly in the context of clean energy and climate, as you know, but if he were to be elected and we could take him at his word that he would prioritize in his administration addressing precisely problems like this -- indeed, precisely this problem -- what

would your advice be from the point of view of what the federal government under a Biden presidency could do about this? I know that his proposal borrowed something from the Inslee proposal to do more detailed mapping of the effects of pollution and climate change. I'm guessing that there is a lot of expert judgment that would support that as an important first step, but is there anything that you've observed that policymakers with their policy hats on should be focusing on to address this problem?

Francesca: That's a great question, Joe. I have to say this is something I'm learning very, very quickly. Because, to be honest with you, I am a data nerd.

Joe: Yes. That's exactly the right word. It's not surprising, but something this precise is really unnerving.

Francesca: Yeah. What has been really an enlightening experience for me is just because the work on COVID got so much press attention, I started to work with Senator Booker on his bill on environmental justice and working with his staffer. Actually, I have been talking to them. It's been very hard work, but great work because, for the first time actually in my career, I was so pleased to see that they are saying, well, we are releasing a new bill on environmental justice. We want it to rely on science as much as possible. We need you to tell us exactly what everything in your data means and what we can do about it. And so this is a process of learning, of mutual learning. Actually, this is what is important because I think we never had enough conversation between policymaker and politician and scientist that bridges this gap. Because, for example, I said, "Well, I think clearly we have a problem in how air pollution regulations are enforced and how states achieve attainment, but I don't know all of the nuts and bolts of the current process. So I can't tell you how to fix it if I don't know...or if we don't know together."

Francesca: So we are actually working hand by hand to understand how currently...I know at the very high level, and Joe, probably you know more than I do, that when the standards are revised and lowered, the states are asked to implement the state implementation plan, where they will say, I'm going to do X, Y, and Z to meet the standard, but the degree to which they are specifying about what they're going to do about vulnerable communities, it's unclear to me. What the data are saying is that we have to overcorrect. In a certain way, what that means is that not only that you are not allowed to pollute more in this community, but you have to go to the extra ten steps in this community to clean the air in this community more than you do in the privileged community. It's about actually reversing a trend. Again, none of this is surprising. It's just that I think with COVID, we realize how the inequity to healthcare and the inequity in health and the inequity of being affected by COVID and the inequity of breathing polluted air is really devastating in our country.

Francesca: So going back to you, I don't have the answer because it's actually...the answer will be a result of many months of hand to hand work between policymakers and my science team. It's so interesting because they are looking at how currently environmental justice is implemented in this country. They come back to us and say, okay, but can you give us this data point? Can you give us this other data point? But then if we do this, what will happen? It's actually scientific collaboration between policymaker and scientist because the reality is it's never a single, simple answer. It's about a process, and it's about a process of mutual learning, and a process of collectively trying to do the best thing. As we know, right now, we are not in that situation.

Joe: The question I asked you in particular, as a scientist, was probably almost unfair, but what's really striking is that, certainly under the Obama administration, the EPA worked with information and worked with the commitment to address environmental justice and really tried to navigate the existing legal authority that the agency had and to navigate the fact that the rubber meets the road not just in the rules that the federal agency writes, but in the way the rules are implemented by states, and really tried to focus on elevating the process tools that different communities had and elevating the informational tools that communities had in engaging with how implementation decisions are made. What feels at least like a breakthrough in your work is the level of sophistication and precision and clarity of the information your team provided about this phenomenon. About the fact that what everybody knows about the structure of society, what everybody's well-informed intuitions were coming into this, can really be revealed by work that's being produced in almost real time with the level of precision that your team provided. And I think that the suggestion you made, which is don't just try to compensate on the process level, but really make it part of policy to address the problem that you and your team and others of course have so vividly revealed, is really where we need to go next. But I don't think we could have gotten there or can get there without your work.

Francesca: Thank you. I think you're very generous. It's actually interesting that what we're trying to communicate is...this is why I think...for people that are listening to this, I hope I will engage them and interest them to study data science and statistics. Because the concept here is actually the first concept we teach in every data science and statistics class, which is when you're looking at data over the population, you should not only look at the mean or the average, but you need to look at the spread. You need to look at the variability. At the variance as well. That you show inequalities about...Don't just look at the mean because the average is saying that the clean air is going down, but that does not mean that everyone is breathing cleaner air. It's one of the fundamental concepts of statistics.

Joe: I think, Francesca, you've done just an amazing job of describing eloquently the power of the tools that you use from a scientific perspective and the

methodologies you use. It's amazing what a great job you've done making it all so engageable even to people who aren't expert in the field. And, of course, the results of your work are so compelling and absolutely vital for the public and policymakers to understand and to be able to help people not only understand the results but understand the underlying science as well as you and your team do is just priceless. So I think we're lucky to have you on as a guest, but the world is lucky to have you and your team doing the work you do.

Francesca: Thank you, Joe. You're really, really generous. Again, I think these are words for the entire team. From students and postdoctoral fellows that are facing tremendous amounts of uncertainty about their future from home and in different time zones, I am so grateful to them and privileged to learning from them. Because as I explain things to you, they explain things to me in the same way.

Joe: Well, I'm guessing that they're all highly self-motivated in their own right, but also derive a certain amount of inspiration from working with you. As much as I enjoy what I do for a living, talking to you makes me...oh, I don't know...envy what you do not only for a living, but as a vocation. I can't thank you enough because I think in talking to me you really imparted a sense of that on top of also explaining some really important observations we as a society need to act on.

Francesca: Thank you again.

Joe: Thank you.

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