Arden Pope 021507 Air Pollution Presentation Transcription
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00:32
Well that was a nice introduction. I hate to start talking and show you that I'm just a country boy. It might help if we turn the lights down just a little bit. What I am going to tell you is the truth the best I know it. And whether you like it or not, it is the truth the best I know it and uh…

1:00
So let's just start right away with what are we breathing ok because that's what you care about is the air pollution issue. What do we want to breathe? Well ideally we want to breathe pure air, which is essentially nitrogen and oxygen. That's what we want to breathe. That's pretty much what you are breathing here, right, but any place there's going to be pollutants. Some of the pollutants that are of biggest concern have to do with so2. Now when you are talking a cold fire power plant, our air is polluted with so2. Now this so2 is emitted from cold fire power plants and it oxidizes and forms fine particles, sulfate particles. I will note that while a lot of what is emitted from smoke stacks from power plants, especially cold fire power plants, a lot is emitted as gas, so2, no2, can oxidize and form what we call sulfates and nitrates particles.

2:00
We also pollute out air with co, with ozone, and co2 which isn't such a concern from a health standpoint. Co2 is of course a concern with the global warming issues which I'm not an expert on, but it is an important gas which we need to care about, so. What are we breathing? Well, pure air plus various gaseous pollutants plus particulate matter. Now particulate matter turns out to be a very, very important concern. It turns out that all particles aren't the same. I'm going to break down particulate matter into 2 types of particles. Coarse particles. Now then come primarily from natural processes. Windblown dust, crustal materials, etc. That's course particles. Frankly I don't find a lot of health effects from course particles. There is some, but not much. So when you are worried about cleaning up, if fact some of the early work I did, I really found good news and bad news.

3:00
And the good news was that it doesn't appear that the course particles really matter that much from a health perspective, but the fine particles matter a lot. Now where do fine particles come from? Primarily from burning things. Burning diesel, burning gasoline, burning coal, burning wood. You burn things and you get smoke. And smoke is made primarily of fine particles. Or you smoking cigarettes. The most serious part of smoking cigarettes is, they call it tar but what is it, fine

particles- combustion related particles. So these fine particles are more toxic primarily b/c they are small enough that they can enter deeply into your airways and get down into the alvior and bronchior region of the lungs. In additional to that, these fine particles are very complex, nasty, toxic stuff. So I'm going to focus a lot on fine particles and when you are dealing with power plants you're dealing primarily with fine particle emissions.

4:00
Sulfur dioxide and sulfur oxide emissions which particulate and form sulfate particles which are part of these fine particles. Then there is a lot of other air toxins which we don't have time to discuss in detail. Many of these toxins are found in the fine particles. Now, how big are these fine particles, what are we dealing with. Well, many of you may know this already but let me just quickly review, when you talk about particulate pollution, often you hear the words PMTM. PMTM is particulate matter which is less than 10 micrometers in aerodynamic diameter. Alright, very, very small particles. Then if you start talking about PM 2.5, you are talking about particles that are less than 2 ½ micrometers in diameter.

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To help put that into perspective, a human hair, now human hairs come in different sizes, but an average human hair is approximately 60 micrometers in diameter. So if you take a cross section of a human hair and put a human hair on it, it would be about that size (diagram). A pm 2.5 particle would be about that size (diagram) although most of them are much, much smaller. So these are extremely tiny particles. If you were to…. Uh, here are some actual fine particles, from the ambient air, magnified. Now to give you a feel on how big this is, the entire width of this slide is only about 25 micrometers. So the entire width of the slide is less than ½ the width of a human hair. And now you can see that there are particles of all different sizes and shapes. These very biggest particles are barely or actually not quite 2 ½ micrometers. The largest majority of these particles are very, very tiny particles.

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Now to give another idea, here are some actual soot particles. These are the kinds of particles that come out of a smoke stack of a power plant, cold fire power plant. And they come in different shapes and sizes and in fact, most of the particles, the primary particles that are emitted are ultrafine particles. They are extremely tiny. And you are looking at them. See them? These are actually clusters of what we call ultrafine primary cluster particles. But they aggregate together and form particles of different sizes. This particle is about…. Well, these are all less than 1 micrometer in aerodynamic diameter. So these are the things, and I remind you again, particles come in all sorts of different shapes and sizes. But these eini tiny

weenie particles that you are looking at down here, these are primarily soot particles and a real concern.

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Now, you can't see these with a naked eye. These are electron microscope particles or images, but if you pollute your air, yeah, it will look like that, right? There's Salt Lake City. You are not looking at individual particles, you are looking at ugly polluted air with these particles. Ok now, I think it was today or yesterday maybe, and this is actually a slide of Severe Valley- I'm not an expert in this area or even in any of the issues you are dealing with but uh, can you get ugly polluted air in this valley? You emit pollution in the valley, its going to get bad during inversions. I don't know, I wasn't here, I don't have any monitoring, but you can certainly see that there is an inversion layer here. You can certainly see that the conditions in this valley are such that you emit pollutants into it, you are going to trap… it will get polluted.

8:00
Now, Brigham Young in 1860 was giving a lecture to the Mormon pioneers. And some of the Mormon pioneers were running off looking for gold and he says, you know that's not a very smart thing to do. And for a number of reasons. And he says, you know what the most valuable asset we have here in Utah is? The single most valuable physical asset we have. What did he say? Clean Air. That's exactly right. He said that good, pure air is the greatest sustainer of animal life. He said we should cherish it. He then argued that we should not suffer the soil, the air and the water, in our Utah valleys to become polluted. Well, let's talk a little bit about air pollution science. The epidemiology. I don't know where it starts. But at least one good place to start in sort of the modern era of air pollution would be in a place called Muse Valley Belgium.

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Now I don't have a slide of Muse Valley Belgium but it was an industrial valley in the 1930's. They had a severe temperature inversion. Lots of people got sick. Some died. Then we move here in 1948 to Denora, Pennsylvania. This is actually, Denora, Pennsylvania is about 28 miles south of Pittsburgh. This is an artist rendition of what it would have looked like in 1948. And there is the Monotony Heler River **???**… there's this bend in the Monotony Heler River and you have Denora that sits right there. They had some mills, a steel mill, a zinc mill… I can't remember what all was there. Then they had cold fired barges that went up and down the river.

10:00

And in October of 1948, they had a severe air pollution episode- an inversion that trapped all the air pollution in between the bluffs and the hills on both sides of the river. It just got terrible. That's a picture of the town, at noon, at mid day, in Denora, Pennsylvania. This is October 29, 1948. Approximately ½, Approximately ½ of the community became acutely ill with respiratory and cardiovascular aliments. Deaths shot up. Doctors and morticians could not keep up and often became ill themselves. The fire department personnel went around administering oxygen to aliening residents. This was absolutely a terrible situation. The concern was, man, if you had something like this happen in a big city, thousands of people would die. 4 years later. London. 1952. Mid day again in London. Terrible pollution.

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Where's it coming from incidentally? Burning coal. Both places, primarily burning coal. Terrible pollution and in fact if you simply plot the deaths relative to the pollution you can see that episodes start at right here at about the 4th day of December 1952. Air pollution shot up, smoke and sulfured oxide. Again, this is primarily coal related pollution. It stayed up for about 5 days, look what happened to deaths. They went up and then they actually stayed up for about 2 weeks. There's a lot of debate as to how many deaths were really due to this 5-day air pollution. The low ball number is about 4,000. High numbers about 12,000. Somewhere between 4 and 12 thousand deaths due to that air pollution episode.

12:00
After theses episodes, there was no doubt that at least at high enough levels of air pollution, this air pollution cause disease and death. Alright. And because this was so apparent in the UK and in the US, public policy changed. No longer did we follow the policy of lassie faire with regards to air pollution. Uhhhh, let somebody pollute all they want. No big deal. We learned that in can have serious consequences. And so, in the United States and in the UK, we had public policy that largely eliminated the so called killer fog episodes. But they didn't eliminate air pollution by any means. This is uh, this is Salt Lake City in 1939. Uh, air pollution is quite bad. Uh, as you can see. Well, let's go back to our Utah Valleys for a minute.

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By the time that got into the 1900's, it became clear that we did not follow the admonition of Brigham Young. Our valleys were becoming highly polluted. This brings us to Utah Valley. I moved here… I was a professor at Texas A&M, came up to BYU, uh, was not acquainted with the air pollution problems that existed, but they did exist. It turns out that Utah Valley, could be severe, right, but Utah Valley served as a fantastic place to study. You have the mountains surrounding the, the, the, the, the, you know the community in the middle of the, of the valley. You

know, many of you are familiar with Utah Lake and the lake mountains to the west and the Wassach **???** mountains here to the, to the east. And it turns out that, the winter inversions as you know, trap the local pollution and this results in a natural test chamber to study air pollution.

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And because its largely a Mormon population, because it is largely non-smoking, there's a number of reasons it's an excellent place to study. Another reason at least in the late 1980's and early 1990's, was it had a very large source of air pollution. The steel mill- Geneva steel. Now most of that pollution again is coming from where? Coal. Now they are not burning it from power. They are cooking it in their coke ovens for a coking operation. Ok, you are looking at fine particulate air pollution right there. There's a little steam coming off of that. They would argue back then that that was all steam. It wasn't. It just simply was not true. The PM10 on this day, there is no fog here either by the way, this is all particle pollution, about 150 micrograms per cubic meter.

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Very, very ugly pollution. On really bad days, oh no, this is an average day, here's the steel mill. You can see the skiff **???** of pollution. Uh, this was sort of an average day in the 1980's. On real bad days, you had to get up above the aversion to even take a picture. And again, this… and there's the steel mill down there. In fact, see that thermal bubble above the smoke stack. And this is classic smog, a combination of fog and smoke or smog, ok. So you are looking at both humidity, fog, and bad pollution. In fact the pollution is 220 micrograms per cubic meter on that particular day. And um, and again, there's the steel mill. Now remember, there are real people down there. Breathing that stuff. Then the question is, does that harm you.

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Now, I actually came… I wondered that myself, is this really causing problems. And I sort of came a few years before the steel mill shut down for 13 months due to a labor dispute. And then reopened under new ownership. And this provided… not only do we have a natural exposure chamber, we now have a natural experiment. Ha ha, pretty neat idea. So, I retrospectively collected um, hospitalization data for Utah Valley and guess what I found? When the steel mill shut down it was dramatically cleaner and there was dramatically fewer pediatric respiratory hospital admissions. Now, this lead to all sorts of problems and denials and this and that and the other. Now let me tell you up front, I never published a paper that wasn't in a top scientific journal, medical journal and that wasn't peer reviewed by scientists.

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That's just the way I do the work. I'll present it, but that's just the way I did the work. I did it then and I do it now. And that's uh, that's going to continue. I ended up, around that time b/c there was so much controversy, that I started working with a group at Harvard. And we conducted a whole series of studies through the late 80's, 1980's through the sort of mid 1990's- a whole series of studies using Utah Valley as our natural exposure chamber. And we published these in a whole series of journals, but in essence I'll just tell you what we found. Exposure to the find particulate pollution in Utah Valley was associated with increased hospital admissions, increased respiratory symptoms, reduced lung function, increased school absences, and increased respiratory cardiovascular deaths.

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Now these early studies were considered by many to be landmark, you know, ground breaking studies. And they were being used, in fact, used to a large degree to set the national ambient air quality standards as well as international standards. Now there were other that were highly critical of these studies and it became quite controversial. And uh, you know, these kind of battles occur locally, they occur nationally and they occur internationally. Alright. Just as a few examples, uh, you know the New York Times ran several articles about this, you know, "Utah Mills Lies at Heart of Fight For Air Pollution Control", I think it says. It's been cut off. Wall Street Journal, "Provo, Utah Provides Combatants in Clean Air Fight." I've cut off the pictures. Very, very controversial stuff.

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Well, I was a bit ambivalent about the controversy… you guys are sort of involved in your own local issue here, right? But hey, I wanna tell you, human lungs are human lungs. Whether you're from here, whether you're from Missouri, whether you're from Stubenville **???** Ohio, or Denora, Pennsylvania. You breathe particles. I mean we do studies with rats but humans still beat rats, don't they? We know what they are about… human lungs. The controversy was big but I was a bit ambivalent about it. I became very, very interested in understanding how can air pollution really influence the health of our lungs as much as it seems to. And so rather than get too caught up in the controversy as a scientist, I said, hey, there's a lot of this public policy debate that highlights the importance of understanding this. I want to go on and understand it even more. And I was particularly interested in not only what the short term day to day changes in air pollution does to our health, but I really wanted to know what does long term chronic exposure do to our health as well.

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So, I actually took a leave from BYU and went out to Harvard in 1992 and 1993. And I had already been working with this man. This is Douglas Dockery, who if you read the literature his name shows up all the time as well. And Frand Spiser **???**. And they had conducted a study, had been doing what is called a prospective cohort study where they had prospectively followed up, 14 to 16 years, they followed up over 8,000 adults who had lived in 6 U.S. cities. And they monitored pollution- TSP, PM10, PM2.5, sulfate particles, aerosol acidity and various gases pollutants. And after I got there a short time, they asked me if I would be willing to analyze these data. So I had nothing to do with actually designing this study. But I did analyze, analyze the data for them.

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And to just to sort of give you a feel of, of, of how this works, there were 6 cities, as I mentioned, the study was designed to include 2 highly polluted cities, that was Stubenville **???**, Ohio and Saint Louis, Missouri, to very clean cities, that was Topeka, Kansas and Portage, Wisconsin, and two cities kind of in the middle, sort of average polluted cities, that was Kingston Harrimon **???**, Tennessee and Watertown, Massachusetts. And then what we have here, is we have on this horizontal axis, time not **???** is the time of enrollment and then the subsequent years is the year of follow up. On this vertical axis is the probability of survival. So you can see here at the time of enrollment, 100% are alive. That was in fact one of the conditions of enrollment. And then you can see as we follow them over time, these survival curves, these are just unadjusted survival curves, you can see they splay out don't they.

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And, and what, what this is saying is basically that those in the more polluted cities are dying more rapidly than those in the cleaner cities. Now there is not statistical analysis about what is going on. This is just sort of the data. Uh, doing more sophisticated statistical analysis is hard to explain in any group. But we can do very, very complicated statistical adjustment on this, on mortality. So now were adjusting for age, sex, race, body mass index, occupational exposures, smoking history, etc. And then calculating the adjusted mortality risk for each of the cities and plotting them over PM2.5 air pollution. Ok. Look at that! This is a great ratio. So this is basically, think of this as the elevated risk of dying over air pollution.

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And in fact that association looks to be so straight and so clean it looks like we cheated. Doesn't it? We didn't. We didn't. That's what it really looked like. Another way to present these data would be to, to, to present what we call adjusted risk ratios, so now we are adjusting for age, sex, race, body mass index, cigarette smoking, etc. And then looking at the effect of air pollution relative to

some other real big bad risk factor. How about cigarette smoking. Ok, so here's cigarette smoking. I don't want to offend anybody. But what does this say about cigarette smoking? It says that smoking 25 pack years, being a current smoker who smoked 25 pack years at the time of enrollment of this study, had double the risk of dying versus a never smoker. 8 times the risk of dying of lung cancer. 2.3 times the risk of dying of cardiopulmonary.

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What's this say about cigarette smoke? It says that it's dumb. If you want to live a long healthy life, don't smoke! But you don't want to put your mouth on the end of a tail pipe regularly and breathe bad air pollution. Right? What does this say about breathing? Well, look at this, 1.26 if you live in Stubenville **???** vs. Portage. So this is the relevant range. It's sort of like smoker vs. nonsmoker. Polluted city vs. clean city. 26%, we see this as just stunning. Think about this for a minute. In a community, in a community that has smokers, how many smokers, how many people smoke now in cities? Well about 25-25% in an average city smoke adults. Alright. So this says that of those 25%, their risk of dying is increased by 100% but across the community, the whole community of adults, there's about a 26% excess death.

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Well how many people in that community breathe? This was stunning. This suggests that in an average community, the effects overall on the population is roughly comparable to smoking- and that's ignoring the fact that the kids breathe too. It's not just adults. We are familiar with this man, Clark Keith, er uh, Clark Heath. He was a, with the American Cancer Society and they had this big cohort that they had been following. 1.2 million people that they had been following. It's called the American Cancer Society Cancer Prevention Study II cohort. They had this big old cohort that they had been following. So we contacted him and said look it, would you collaborate with us and let us use your data, we will link air pollution data to it. So we will link air pollution from 151 U.S. Metropolitan areas with risk factor data for over ½ a million people in their cohort that lived in the communities for which we had air pollution data.

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Alright. And then analy.. now incidentally that paper I probably should have mentioned it, this, this, this paper was published where? New England Journal of Medicine. Top journal in the world, medical journal in the world. You didn't ask where we published this, American Journal of Respiratory, Critical Care and Medicine. This is the journal of the American Thoracic Society and Lung Association (???). It's the top journal in thoracic medicine in the world. And let me just tell you what we got. Well, with cigarette smoking, those are the results for cigarette

smoking. They look about the same. Cigarette smoking still not very smart, right? What about air pollution? Wow. Not quite as big as we saw in the 6 cities study but it's still there.

27:00
What this means very, very succinctly is, that your risk of dying of all causes goes up by 17% if you live in a polluted city versus a clean city. Your risk of dying of cardio pulmonary, respirator and cardio vascular death, goes up by 31%. Crazy. Now, when we publish these papers, this was back in 1993 and 1995 when we published these, we thought well, this would help reduce some of the controversy over the health effects of air pollution, this is pretty clear, very clean studies. It didn't. The controversy seemed to reach the scene **???** shortly after this. Um, after these 2 papers came out.

28:00
Uh, the journal Science had an article come out, "Showdown Over Clean Air Science." Industry and environmental researchers are squaring off over studies, these studies were primarily the Utah Valley studies and these 2 studies I just showed you, the ACS and 6 cities studies, linking air pollution and illness in what some are calling the biggest environmental fight of the decade. Now in fact, the science was not fought over as much as what? Who actually pays the cost of air pollution. Now, for example, Business Week ran a big article called "Tiny Particles, Big Dilemma." And what did they emphasize? They emphasized uncertainties in regards to the science in terms of the health effects. And the enormity, and they are big, the enormity of the costs associated with controlling the air pollution. Um, and in fact, the estimated annual cost of pollution control may be as high as 10 billion dollars per year.

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But of course on the other hand, consumer groups and environmental groups are, are arguing that what we really be understanding is, is that the costs of air pollution are being born by society, i.e. all of us that breathe and that these costs can be very, very large. And um, and in fact the estimate, the annual benefits of pollution control have been estimated at greater than 100 million. That's a fairly conservative estimate. In the United States, it's probably around 3-500 million dollars. Alright. Now it turned out that in the early 2000's, the controversy of, the of, of, of, of, of, the air pollution science dampened quite a bit. In fact the Harvard 6 Cities and the ACS study were being called secret science, junk science. I mean remember they were published in the top peer reviewed medical journals. There's nothing else you can do as a researcher.

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How could it be secret? We just published it. But they were being highly criticized. We ended up, we ended up turning over our raw data files, now, now it's a little bit tricky to do this. You can't turn over data from these cohorts because you actually sign… before you can do a study like this, you have to have what's called IRB approval. Institutional Review Board for Human Subjects. They will always require that you have a consent form and the consent form will always have a confidentiality agreement in it. So we have confidentiality agreements with everybody that participates in this, as well as the states that give us their death records. So um, we can't turn this over to anybody so we ended up setting up a situation where we could turn the analytic files so that they could be audited by an independent group. And that lasted for several years.

31:00

But in the year 2000, an extensive reanalysis of the Harvard 6 Cities study and the American Cancer Society Study, a, a, a, a complete reanalysis of that was conducted and reported by the Health Effects Institute in the year 2000. In essence they got the same answers we got and actually, they found that the results were more robust than I would have ever dreamed of. Remarkable set of results. In addition, in the year 2001, the U.S. Supreme Court actually ruled unanimously in favor. Basically there were lawsuits that were brought up over the standards that were based on these studies. And the lawsuits argued 3 things. One, that the science was junk. Couldn't be relied on. Number two, that in order to set the standards, there should be, the cost associated with clean up ought to be considered. And three, that the EPA overstepped its, its, its legal bounds.

32:00

That actually Congress had to set these standards, not bureaucrats. Alright. Well, it went to district court, the district court… U.S… federal court I should say not district, federal court, uh, District of Columbia if I remember right, they argued, no the science is great. They said, no, the clean air act requires that you look at costs, aft… you set the standards and then you look at costs in terms of how you implement them. And the 3rd issue they said, uh, there is a problem. Maybe you've overstepped your bounds. So the standards were knocked down. It was appealed to the U.S. Supreme Court. The Supreme Court ruled on all 3; science was good; (…. My fingers here. Laughter. You know where we are going right. Laughter.) Uh, they ruled in our favor, that helped a lot. And then, the 3rd thing that happened is, we went back there and we said now (???), after all of this controversy, and over the years, there were 8 more years of follow up with the American Cancer Society Study.

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So we took advantage of that 8 years of follow up and I was collaborating with a group from the University of Ottawa, the American Cancer Society, New York University School of Medicine and we published in the journal of the American Medical Association, the largest and most robust study of lung cancer, cardio pulmonary mortality and long term exposure of fine particulate air pollution. The bottom line is this, air pollution goes up, the risk of mortality goes up. Now here's the dirty little secret, there is no safe threshold. Look at that. It goes up in a near linear fashion. It's all due to cardio pulmonary. What do I mean by cardio pulmonary again?

34:00
Respirator and cardio vascular disease. It's all due to cardio pulmonary and some lung cancer. Again, what's the dirty little secret? There is no safe threshold. I don't know where you are at in this valley right now. Apparently, there's no decent monitoring so it hard to know, but you're pretty clean. You know, you are way down here somewhere. But if you get dirtier, what will happen? This evidence suggests that your risk of mortality will go up. Now, how much I don't know. It depends on how much dirtier it gets. But again, there is no safe threshold. We know that. Now, are there standards? The EPA has a standard. The EPA standard for long term exposure is 15 micro grams per cubic meter. Draw a line up through there and what do you see? There's no **???**. If there was a threshold this would be flat then would go up at 15.

35:00
It just simply doesn't, ok. Well… Again, most relevant. What do I know about sever**???** county **???** ? Not very much. What do I know if… I do know that you have pretty clean air right now, don't you? What do I know if your air pollution gets worse? Its likely to increase your risk of cardio pulmonary disease of death. Ok. How much? I don't have the information to answer that question. All right, let's move on just a little bit farther. Let's go to L.A. really quick. (Laughter) Ha ha, you don't want to do that. If we go to L.A. it's really bad. Look here at San Bernardino and Riverside. We did another study using that ACS cohort, but we just took the people that lived in L.A. and we did GIS coding based on their residence and then put them how bad the air pollution was and

36:00
the bottom line is, it seems like we underestimated the effects of air pollution in the previous study. If you have better information on exactly where they live, that is more special resolution with regards to your addresses, you can do a better job of analyzing these data and you see… by the way, just this month, New England Journal of Medicine, Miller et al., just this month, post menopausal women, this was the women's health study. Now they did this study, primarily not to look at air

pollution, but to look at hormone replacement therapy and things. But the women were there that then followed up, uh, they knew where they lived. They linked them together and said let's see if we can get the same results as the 6 Cities or ACS study. And you know what? They didn't. The effects were way bigger than what we estimated in the ACS study.

Audience Member Question: Is there any study on children… the birth age?

37:00
Yeah, there's studies on children. Children are har… I've done a lot of study on childrens but they are day to day studies, they are not long term studies. And uh, and you clearly see effects in children. Those are the 1st studies I did. There's a study by Traci Woodruff and others that nooks specifically at post-neonatal infant mortality- so, looking at infant mortality. They see an effect very similar to what I showed you at the ACS study. Not quite as big as what we see with the women's health initiative. These studies not only found that air pollution was causing health effects, respiratory health effects, but they showed that there are effects associated with our heart. And I won't go into all of the details but I'm going to do a little bit if that's ok. With regards to heart, it turns out that you know, for example I published a paper in the journal of circulation, this is the Journal of the American Heart Association, and the associated press ran this, this, this, uh, this, this news release-

38:00
"Air Pollution in US Cities Causes Twice as Many Deaths from Heart Disease as it does from Lung Cancer and other Respiratory Ailments." Can this really be true? Is it biologically plausible? If so… now by the way, what am I doing now? I'm shifting gears a little bit. The evidence, the epidemiologic evidence, the observational evidence is so compelling now, I'm no longer going to argue that we need to study to see if air pollution hurts our health. It does! Now we are changing, we want to know why. How can breathing particles actually increase your risk of dying of heart disease. We found effects of fine particulate pollution on the lungs. We see pulmonary inflammation, reduced lung function, increased respiratory symptoms, accelerated progression, uh and exacerbation of chronic obstructive pulmonary disease. This makes sense! The lungs are the target organ of air pollution, right? This is biologically plausible.

39:00
But, just recently, there's this great study from California, you asked about children, this is just as spooky as I'll get at. I don't know that you want to hear it.

Audience Members: Yeah, we do. We do. Absolutely.

They, they are in California, that 12 cities in California with different levels of air pollution. They enrolled a whole bunch of children. Thousands of children at about 10 years of age. And then they followed them prospectively, 10 to 18, and every year they measured their lung function. Now that's the most important time for lung function growth. And what they wanted to do is see, do children living in more polluted cities have deficits in lung function growth. And what did they find? Yeah, they did. They did. This was actually published in the jour, the New England Journal of Medicine in 2004. These are the 12 cities. This is FED1. That's forced expiratory volume in one second, one of the most important measures of lung function.

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This is the percent of the children that had less than 80% of predicted FED1. And what you can… and this is PM10, er, PM2.5 pollution. Look at that; you live in a more polluted city more of the kids have deficits in lung function. Yeah?

Audience Member Question: Excuse me ??? May I ask a question?

You may.

Audience Member Question: Now what you are saying with this is that, the children in these most polluted cities, is it the full capacity of the air sacs, I mean compared to the children in the cleaner cities, the lungs don't maybe get their full growth?

The lungs are not developing as much as they would if they were living in clean cities. Doesn't that tick you off? Yeah, it does. I am not going to go beyond what the study says I'm going to be speculating at that point, but I do know, I do know this Gauderman and John Peters, I do know the principal people here. And I know, I know this man, David Bates. He's one of the premier pulmonologists in the world. He actually died just a couple of months ago and I was asked to go up and speak at his funeral.

41:00
I got to give a good Mormon talk at a, at a scientific funeral, right? Laughter. Ok, I don't, I don't know. A lot of fun. Actually here, this is the James Gauderman and John Peters, interestingly enough, there were 2 speakers at his funeral, John Peters was the other one. Um, now I'm not involved with this study, but it says, these are some good men. And there's some women involved too. These are good people doing these studies. Now the reason… another interesting things is, just last month, just last month in the Journal Lancet, now Journal Lancet is the top medical journal in Europe. The 3 best journals in the world in medicine are New England

Journal of Medicine, Amer… Journal of the American Medical Association and the Lancet. This was crazy, they took another slice of these data and rather than look across communities with pollution they said let's look at how closely they live to highly, to very busy roadways.

42:00
And the bottom line was, is the closer you live to a road, the less your lung development is as a child. Ok, you don't want me to tell you anymore, so I am going to move on. We've also found that PM affects blood markers of systemic inflammation and oxidates stress **???**. Things like, syratic protein **???**, pro inflammatory mediators, etc. Now this is a little bit more of a stretch, but if your lungs are inflamed, if you get pulmonary inflammation of the lungs, it's not too big a stretch to think that you would get systemic inflammation. Here's a crazy one though. By accident, I was looking at a whole different other hypothesis. But by accident we saw that there was changes in cardiac rhythm associated with, with air pollution. So I stated doing more work, started doing what's called cardiac autonomic function measures.

43:00
Basically this involves multiple 24 hour ECG monitoring for people and then analyzing the ECG tracings for literally millions of heartbeats. What did we find? Air pollution effects cardiac autonomic function and cardiac rhythm. Uh oh, this is even more annoying. If you get inflammation, effe… you can get effects on the blood vessels. And if you get effects on blood vessels, you get effects on heart and brain. You get ischemic heart disease, things like MI's or Myocardial Infarction, or heart attacks if you will. And you get increased cerebral vascular ischemia, which will include these ischemic strokes. Now, this is what I have been most interested in, in my research over the last few years. And so, I, I, Dockery and I published just last year this big review of the literature in trying to come up with the pathophysiologic pathways.

44:00
Now I know this is too complex to discuss, but what it says is, that breathing air pollution doesn't just influence your lungs, it influences your whole body including blood, brain, vascular… vascular and your heart. Now just for fun though, let's talk about air pollution and atherosclerosis, you want to? Just for a minute? Because atherosclerosis kills more of us than any other thing, doesn't it? About 35, 40% of us really die of atherosclerosis is the U.S. atherosclerosis is what causes most of these strokes, it's what causes most of the heart attacks. Many of our heart failure deaths are really due to initial ischemic heart disease, heart attacks, that damaged your lung, I mean your heart, and then you die later of heart failure. So a lot of our deaths, the underlying pathophysiology is atherosclerosis.

45:00
Now atherosclerosis is really a progressive disease of buildup of fatty plaques in the artery walls and these plaques are incased in a fibrous cap and sometimes those rupture and when those rupture you'll get clotting and sometimes… and that clotting is what will precipitate the heart attack or the stroke. You with me? Now, what does this have to do with air pollution? Well, it turns out that we've already learned that fine particulate exposure is a… results in pulmonary and systemic inflammation. We also know that blood lipids, cholesterol, really influence atherosclerosis. But not just cholesterol, inflammation influence… a combination of high inflammation and high blood lipids is deadly. That's why a lot of us take Statins. When you take a Statin you are taking not only something that lowers your cholesterol, but lowers inflammation- they're effective anti-inflammatories. Ok?

46:00
Bottom line is, is fine particulate exposure results in systemic inflammatory response, which increases the progression and destabilization of these atherosclerotic plaques. Ok now, is there any evidence of this really happening? The answer is yes. There is a series of studies done by Stephan van Feden, James Hogg and others that found in rabbits, these are genetically altered rabbits that are prone to develop atherosclerosis. And then they experimentally exposed them to fine particulate exposure and found clear evidence of accelerated progression of atherosclerosis plaques with greater vulnerability to plaque rupture. Another stud just last year, in 2005, by Son et al. This came out of a group at, uh, New York University Medical School. They took a bunch of rats. These were hyperlipidemic rats. These are rats that naturally get a lot of atherosclerosis. Ok?

47:00
And they took the rats and they split… I said rats. I don't mean rats. They're mice, ok? They're mice. Doesn't make much difference but… yeah, rodents. [Laughter] Hyperlipidemic rodents. Wouldn't you want to be one of those? They took ½ of them and they fed them a normal chow diet. They took the other ½ and fed them a high fat chow diet. And then of both groups, ½ of them got filtered clean air and ½ got about 100 micrograms per cubic meter of PM2.5, 8 hours a day, 5 days a week for 6 months. Now 100 sounds kind of high and its high for here. But its environmentally relevant, it was 100 in, uh, it was 100 in Provo and Orem (???) a few weeks ago. So these are environmentally relevant. This isn't cramming particles down their throat. This is normal particles [**inaudible**] 8 hours a day.

48:00

Look at this, these are cross sections of the aortic heart. Look at these atherosclerotic lesions. Well, you can see, huh, high fat chow is not as good as normal chow, right? But you can also see, polluted air is not as good as clean air. It's that simple. Now, we can't do these kind of studies on humans. We can't sacrifice them to look at their arteries, right? But humans expose themselves to high fat chow diets and fine particulate pollution by polluting the air they breathe. And so, we can do some natural studies, observational studies- let me just show you a couple. This is Paulo Saldiva. He's a pathologist at University de Sao Paulo. I've worked with him over the years. He actually had access to tissue samples from autopsies of people that died of violent causes, primarily auto accidents in the Sao Paulo Brazil region. Ok?

49:00

We could go back and trace, find out where they lived, how much air pollution they were exposed to and we could even look at their lungs look at a score called anthracosis- this is how many black carbon particles are in lungs. Bottom line, more pollution, more inflammation. Another example. This is another pathologist. John Godleski at Harvard. He and I and some other colleagues went back and took the American Cancer Society data and took the cause of death off the death certificates and tried to look at the patterns of mortality and air pollution to see which pathophysiologic pathways they fit. And they fit the pathway of, you breathe air pollution you get pulmonary inflammation, you get systemic inflammation, you get accelerated atherosclerosis and you die of ischemic heart diseases. Look at this woman, great woman. She was the 1st full professor of medicine in the country of Switzerland.

50:00

Great lady. Ursula Ackermann-Liebrich. And you know Kunzli. I used to teach with them at the University of Bozen, Switzerland in the summers. I did some studies looking at air pollution and mortality in 3 Swiss cities. This, this nino **???**, he went to, he ended up going to University of Southern California, the Keck School of Medicine. He's a pulmonologist. But he got some data in California where you do ultrasound measures to look at athero… subclinical measures of atherosclerosis. It just simply looked at them over different quartiles of PM2.5 exposures in California. What does he see? Well, he's not sacrificing humans and looking at their arteries, but he is doing the next best thing, doing ultrasounds. And wow. Ok, I'm almost done. Jeffery Anderson, he's a cardiologist. He and his, eh, I, I mean, I, he's a group that works up at LDS Hospital. And they, they actually treat, this is a real doctor, he treats patients and everything, ok.

51:00

He has this, he has this, um, this, this registry of patients that they've been treating and I can go back and I got with him and his group and could link air pollution data with the times when they're getting their ischemic heart disease events, primarily, um, heart attacks and unstable angina. And what did we find? We do this, this fancy analysis I was all excited to do. They had, you know, 13 thousand almost well defined followed up cardiac patients who lived on Utah's west edge front. What did we find? 1 or 2 days of exposure to air pollution increased their risk of having one of these ischemic events. What was even more interesting is, is that we have angiography so you can take these angiograms of the hearts, maybe some of you have had one, ok, and you can actually look at the arteries in the heart and you can look and see if one of them are occluded or have one of these atherosclerotic lesions in them.

52:00

And what we found is, is that these effects were much bigger in individuals that had at least one coronary artery with an atherosclerotic lesion in it. Ie: air pollution seems to increase the risk of rupturing of these, of these lesions. What could cause that? We know. Ok, right now, this study is not done. That's my wife right there, by the way. Lovely lady, isn't she? That's a research participant. We are now trying to look at vascular responses to air pollution using this brand new equipment we just were able to get from Israel, where we hook them up and we can look at vascular responses to a challenge, occluding one of the arms, and see if that changes when they are exposed to air pollution versus when they are not. It should. If this is true, if what I've shown you already is true, this is probably what will happen. Do I know the answers yet? Uh uh, no, we're not done. Day after tomorrow doing another set of… ok now, I don't want to present this information as an alarmist.

53:00

This is not chicken little, the sky is falling bad news. May it is a little for you. For us in the waschetch **???** front, it's a little bit good news because why? Cuz we are cleaning up our pollution somewhat. What does this tell us? This tells us that our efforts to clean up pollution have real significant impacts on improving out health. What's the bad news? If the inverse is true, well you know what it is I don't need to tell you… and there's plenty of evidence that suggests that if you clean up your air pollution it helps. For example, the 6 cities study that I showed you before, that I did back in 93. Well there's been another 8 years of follow up and what's amazing is, is in many of those cities… all of the cities in fact, of the 6 cities study, have cleaned up since then. Especially the most polluted city, Stubenville. Look at that. It went from that much pollution to that much pollution and look what happened to the risk of dying. It went down!

54:00
But even in the more moderately polluted cities, the air pollution went down and their risk of dying went down. And even in our cleanest cities, these are cities now roughly about where you're at. Even in the cleanest cities, look what happened. Air pollution went down risk of dying went down. Now, Severe county **???**. This is the best one I got for you. Just turn the arrow the other direction. That's probably what will happen, you know, something like that. Just turn the arrow the other direction. Aye, you're not going to be Stubenville. Thank heavens. Ok, its not going to be that bad. Probably won't be as bad as St. Louis or Kingston, but its going to be something like this, isn't it? I don't know how bad it will be, but that's, that's the best evidence we got. Here's a fun study. There's a copper smelter strike back in the 1960's and 70's. back then, copper smelters were omitting a lot of s02.

55:00
What does a stil… what does a… a… a cold fire power plant emit? A lot of s02. Now, the strike happened and a dramatic 60% reduction in sulfate particles, particles that come primarily from emitting s02 and then it forming sulfate particles. 60% reduction in sulfate particles over about an 8 ½ month time. So we went back and collected all the mortality data you could collect, analyzed the data as sophisticated as you can, I won't go into the details there, and what did we find? That during that strike, mortality was 2 to 4 percent lower, after controlling for everything else. Now I know that's not like dead bodies everywhere. but 2 to 4 percent, that's good news if you can clean it up.

Audience Member Comment: Particularly if you were one of the 2%.

Yup! And I would suppose we are talking about that range something here. Ya know, I don't know. I can't, I don't know. But you know, this sort of…. And I throw that in there just for that.

56:00
Ok now, while I say that I am not an alarmist, I'm not a polyanna **???** either. Air pollution really does have health effects. This is, this is uh, uh, a street in Beijing. Remember that study. Kids live closer to cities… (**garbled**) closer to air… you live there, you commute in that, if you're a kid your organs aren't going to develop as well. It's that simple. We have serious challenges all over the world with our air pollution. I am proud of any group that will make an effort to follow the admonition of Brigham Young. And, and encourage you to be aware that there is value of having good, clean, pure air. The greatest sustainer of animal life. I think that will do it. Thanks.

57:00
Standing ovation.

Awww, sit down, sit down. If you do that, I'll take my tie off.

Audience member: Go ahead. But then you'll have to go through some more slides.

Nah, I'm done with slides. Any questions?

Audience Member Question: Could you revisit and sum up again the connection, uh, the comparison between cigarette smoking and living in a polluted area.

Cigarette smoking is worse. Breathing cigarette smoke is like going out… well what we know is this, is the main reason it's worse is because the amount of, of particles that you are feeding your lungs, is huge. But if you were to go, and you know, put your mouth over the end of a tail pipe and take long drafts of a diesel truck on a regular basis, I'm quite confident the effects would be that large.

58:00
It's just simply a matter of, of exposure. Does that make sense? The, the effects of air pollution in a dirty city appear to be roug… for cardio vascular disease, appear to be roughly the same as living with a smoker. So its roughly the same as breathing environmental tobacco smoke or passive cigarette smoke in a home where you have a spouse that smokes. And there's been a lot of studies like that and in fact, the increased risk is roughly the same. So, we gotta… we have to be honest about it. It's not, it's not nearly as big as smoking, but it's, it's as big as living with a spouse that smokes, something like that to help put it into context.

Audience Member Question: Is the dispersion on the smaller particles much harder **???** effective that a bigger particle.

Yes. Absolutely. In fact, that's one of the, one of the reasons, b... because they are so small and we measure their, we measure their size by aero dynamic diameter, meaning, really what that means is how quickly they settle out.

59:00
And so basically, the smaller they are, the more, the longer they remain suspended in the air. And, and it turns out that coarse particles, particles greater than about 10 micrometers, they fall out, I mean big particles land on your head and kill you right, uh, you know, but particles that will be in the air, large particles, they can get as large as maybe 80 to 100 micrometers, but the real tiny ones, these that I was

showing you, they'll remain suspended in the air for a long time. You know, weeks or months even.

Audience Member Question: So that would include the whole valley. I think there's a lot of people who think if they live a couple of miles away, they won't suffer.

No, no the, the, the, the, the sad thing about any poll… first off, I don't want to say something I don't know anything about

1:00:00
But you take an emitter, I don't know how much this mill will, er this uh, uh, uh, uh, this power plant will emit, but you take, you take emissions, you put them in a smoke stack and stick them up high and what you're doing is actually reducing the impact on those that are close and spreading the impact out over many, many more people. And um, and so, those, you know, yes, the whole valley will be effected. Not just the valley, the whole state.

Audience Member Question: The, some of the folks, uh, uh went back east to Cumbland **???**, Maryland to a un, cold fire plant that was used in the same circular air bed. You look at the statistics for that particular county that that's in. The mortality rate is the 1/3 highest in the state of Maryland.

Yeah, I mean I can't, I don't know the specifics, I've never even been there, but I do know, I mean one of the interesting things is, there's a study published in the Journal of Science in 1970 bu, um, Lave **???** and Seskin **???**.

1:01:00
And what they showed was is that using 1960's, um, data for air pollution and census data for age, sex, race, this sort of thing, and then mortality data, they showed that, uh, fine particulate pollution goes up, mortality rates go up. We completely dismissed those studies. Hardly anybody believed them. They've been resurrected a bit after we've done the 6 cities and ACS studies because we're getting essentially the same result. But now in studies that are much better done, because we are following up cohorts, and now we can control for individual differences in age, sex, race, cigarette smoking, etc. So, if the data are consistent, the evidence that we have is consistent with the story your telling me… [video cut]

… And it's really nice to build them where the population isn't very big, fewer people exposed, not enough numbers to do good studies to be honest. Uh, if they build it here, I won't even bother coming down and counting the dead bodies.

1:02:00

And uh, there may be people in this community that they would rather have the pollution and the, what did you say, 70 jobs or whatever it is… [inaudible audience comment]… yeah, I mean I'm not, I'm not arguing… [garbled]… That's something I can't come into this valley and say. I can't show you what the studies are, but I just don't know. [video cut]

But I have always believed that you go by the signs. You don't, you don't exaggerate the effects, you don't underestimate the effects. You just say what they are and you make a decision. And I have no, I have no qualms with saying that a community, you know the Richfield area, this, this valley, you need to have a feeling of what the real effects are, the risks are and you need to make decisions as to whether or not that's what you want in your valley. You live here. You make the decisions. Alright? It's not me. I live in Springville. Now do I want that plant in Springville? No.

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