The Health Effects of Nuclear Radiation

Cambridge Forum, 4/12/89

Alice Stewart: If everybody in America realized that they probably killed off more of their workers from creating bombs than they've certainly killed off any foreigners, they might look at the story very differently.

Welcome to Cambridge Forum. In our series on preventing nuclear war, the issue now is health effects of nuclear radiation. I'm Herb Better, director of the Forum and a Chaplain of Harvard University. Our speaker is Alice Stewart, M.D., the world renowned epidemiologist whose landmark findings link the use of prenatal x-rays to childhood cancer. Her research in social medicine was long done at Oxford University where she founded the Oxford Survey of Childhood Cancers. She now works as a senior research fellow at Birmingham University. Much of her research challenges the commonly held belief that there are no significant health effects from low level radiation. Welcome to Cambridge Forum Dr. Stewart.

To understand why there is a quarrel about whether or not it is safe to use radiation, I think you have to have some idea in your

head about what radioactivity is. It is of course, a natural form of energy to which we are all exposed. And today, you can actually measure the intensity of the radiation as accurately as say you could measure temperature. Unfortunately, unlike temperature for which we can have say a fairly wide range of benign situations -- it doesn't matter whether it's a little too cold or a little too hot or about medium, and only in the extreme situations of very great heat or very extreme cold can you, as it were, not live. Unfortunately, radioactivity is a harmful force, a malign force, even at its very low dose levels.

The principle is this: that the energy, if it meets with a living cell, is now about to split the smooth mechanism of a cell, the molecular mechanism of the cell into its component parts and they struggle to get back again and then trouble arises. Now, any of you can afford to lose a cell; any living structure, anything from a tree to a man. So that doesn't matter very much. But unfortunately, in causing this damage you can produce a mutation. The cell will go on living, but it'll now have acquired different characteristics as a result of having disturbed the nucleus of the cell. And this is the trouble with radiation and it only needs one such cell to be created and to survive to form either a totally abnormal human being if it

happens to be a germ cell, or in the case of a body cell, to be the starting point of a cancer.

→ 8 — genetic damage — pass. of sowing bad seeds into human gene pool

Now of course one mustn't imagine this happening very often. It's a very rare event and in most cases the event that you're afraid of, namely that an abnormal cell will continue to survive and cause a cancer, is a very rare event. But the fact that it can occur just from a single cell, puts the whole danger of radiation into a different category from say getting far too hot or too cold. And it is this question, whether in practice the cancer risk comes right down to the single cell or not, that is I think the argument for today.

There are various ways in which you can try and discover whether it's dangerous, all of which have got to face the following difficulties: The types of cancer caused by radiation are indistinguishable from naturally occurring cancers. And to give you a single figure -- 20% of people in a given population can expect to die from cancer. So you're going to have a situation in which you've got the natural disease, you've got to distinguish the extra cases from the naturally occurring ones.

The next trouble is that if you -- the interval between receiving the radiation and getting the cancer, instead of for instance, if

your child is exposed to getting the measles and you ought to know whether the child is going to fall ill, it'll all happen within 17 days or not at all. You've either had the trouble and you're going to have the illness or you've escaped. Now the quiverant time for knowing whether anything has gone wrong as a result of the radiation, ranges from less than 2 to more than 50 years. So you see, you're in trouble about whether knowing that there's going to be a subsequent event.

And then the third difficulty is that we're all living with the natural background radiation, so how are you going to distinguish between what might have come from that and anything you've added.

Well you can see that there would be in theory, these two ways in which you might tackle the problem now that we are in the stage of being able actually to make extra radiation, one is to find a high dose situation and study it.

In natural life you're never going to come across a lot of radiation. It's always going to be at the low levels. But of course we've been able to make bombs and we've actually dropped a bomb on Hiroshima and Nagasaki and we've had a survivor population there, known to of been exposed to a large dose and

has been followed over time and to see what was the late effect from the cancer.

This is an excellent way of discovering about late effects of radiation, provided what happens from radiation at the high dose is the same as what happens at the low dose. I've explained at the very beginning that you can kill cells and you can also mutate them. Cancer will be mutation, cell death, and I said when it's just one cell it doesn't matter. But if it's a whole string of cells and you're going to destroy the tissue, then you're going to have a different story on your hands and you will in fact, you can kill people with radiation. And some of the survivors from Hiroshima, you have to ask yourself, whether in fact they only had the late survivors, whether all the deaths had occurred earlier or whether there were any delayed deaths from non-cancers.

Well the judgment has been that there has only been that there was only the late effect of radiation and that therefore you could take the risk estimates that came from the A bomb survivor and translate them back and be able to say, now supposing you want to have nuclear power or you want to use some more weapons, you will at least be able to tell the workers who are going to keep at the low dose, how much extra cancer they're going to get.

And the answer from that type of exposure is rather optimistic. It says that yes, there may be a little trouble, but it's going to be very small.

Now that was the situation until in fact, the records of the men who were working in one of your nuclear weapons production plants in Hanford in the state of Washington were actually came to be examined. What had happened was that Hanford started work in 1944 and had been going forward and we were now at say 1964, when somebody thought that it would be a good idea to collect together the records of the workers and also ascertain how many workers had died. Now you in the United States are in a rather what we in the epidemiologists call a good position. You have a social security number which will enable a working population to identify deaths that have occurred long after the man has left the industry. And by using that technique of tracing deaths and linking them with the actual radiation received while at work, a project was started in this country in 1964. It said, go back, backlog all the radiation doses of workers at Hanford, find out who has died and who hasn't, put two and two together and tell us whether there has been any danger from the small doses of radiation that these workers were getting.

Well, how small were they? There were some very strict regulations that said that no man was to receive more than 5 rems per annum. It sounds like a nice, small amount of dose. Certainly you could have a 5 rem dose to go and have an x-ray examination. It would have to be a fairly long one like a barium ..., but it would be possible. So it would be a fairly low dose if spread over a year. And sure enough at Hanford the regulations had been very good and this dose had never been exceeded. So it was confidently expected that there would be no trouble because that was what had been forecast from the follow-up of the A bomb. But when they came to look at the records, they said, here we are, none of these men have had more dose than they've allowed, but they've actually had something like between ten and twenty times as many, as much cancer as would have been expected on the basis of the A bomb study.

So then the cat was in the fire. And you have only one other test case. Was a mistake made (on either side)? Was a mistake made through the A bomb survivors or was there a mistake made through the workers? And there's one sort of umpire in this situation. And this is where we came in with a very unlikely sort of umpire and it was in England we had more or less by accident discovered that a single x-ray taken shortly before birth was sufficient to increase the risk of an early cancer

death. Now how did that happen? It was way back in the 50's when the leukemia death rate in the world was increasing at an abnormally fast rate. We can look back now and know that nothing very bad was happening. All that was happening was that people were being able to live longer as a result of antibiotics and therefore a whole group of people who had been liable to die from infections had died without you're realizing sometimes the reason why they had died and one of the reasons was leukemia. But nobody knew that at the time. And one of the things that was clear was that young children were experiencing this increase more than anybody else. And so it was thought to be a good idea to go to the mothers of the children who had died of the leukemia and see whether they had a collective memory about what had happened to their children that might help to solve the whole problem of the worldwide increase in leukemia. And this is the so-called Oxford Survey of Childhood Cancers that did begin by just taking approximately 500 leukemia deaths of children, matching them up with 500 other forms of cancer and 1,000 live children and having one outstanding finding which was that both groups of dead children -- those who died from leukemia and those who died from solid tumors, had in fact been x-rayed more often than the live children.

That was way back in the mid 50's which is earlier than this time I've told you about in 1964 for the workers study here. Nobody believed us. And so we went on and we managed to include in this study in Britain, all children who died from 1953 onwards. And we were steadily working away with this material until you can come to the present day and say that's it's been proven beyond doubt that a very small dose of radiation in this context does have the bad effect that I described. That a single x-ray, a very small dose, is sufficient to increase the risk of a cancer death in the case of children ~~in~~ sometime in the next 15 years.

So this is where I stand today to say to you, to try and answer questions from you as to why there has been a quarrel, who was wrong on the studies, either the A bomb survivors or the workers and where do we think the truth lies.

Thank you very much.

Questions:

Your research on fetal x-rays has more or less led to their discontinuation now, has it not?

That is true. Having found that the x-rays weren't safe, I don't know that that was the reason why the doctors stopped because I must tell you that only about 1 in 2,000 of these x-rays ever goes wrong. It was a very small effect. But fortunately for those small babies, a new method of examination has been invented called ultrasound and that has managed so that you have non-ionizing radiations now as a means of at it were, looking inside the womb. The particular hazard of the prenatal x-ray has disappeared.

You made a reference to a study that you did of the atomic bomb survivors of Hiroshima and my understanding is that you found that when you consider the total effects, the long term effects, that as many as ten or perhaps more times more death resulted from radiation than has been indicated previously. Is that correct?

No, not quite. I have had no direct access to the A bomb survivor data until very recently. But I worked up a theory that because there was this difference between Hanford and the Oxford Survey and the A bomb survivor study which had been allowed to set the standard, there must be something wrong with the interpretation of the A bomb survivor study. And after thinking about this for some time, I decided that it could have happened

in the following way: The impression left by the deaths, the mortality experience of these people who were collected together five years after the bombing, the mortality experience was that only cancers had shown any sign of being dose related. All the other causes of death (about 80% of other things) seemed to be occurring at the same level for the people whose estimated dose was zero or close to zero and the people whose estimated dose was over 300 rads.

So the conclusion drawn was that there had only been the cancer effect. But you see, there would be a way in which you could get a flat rate looking normal, would be a bad effect and a good effect cancelling one another out. Well at first sight you couldn't possibly have a good effect from a bomb, but you can if you're merely looking at it from the point of view of the deaths. If you succeed in killing off a whole lot of people out of your society and you selectively kill off the weaklings, you should be left with the other people who are stronger. They survived, they've been strong enough to survive the debauch, then you should from now onwards have had a below normal death rate. And not only lower than normal because they were stronger and so on, it should have been dose related the wrong way. The strongest people should have been the people who were most exposed. They had the biggest risk of dying at the beginning.

So I said to myself, why did they not have that? And of course it's very easy to produce the answer and it says that perhaps there was another effect to the radiation that wasn't showing so obviously as a cancer. And knowing that one of the tissues that is most sensitive to radiation -- your blood and the blood forming tissues, and what does the blood do other than provide you with a means of breathing? It prevents you from getting infections. It is the seat of the immune system. Now what was it that had enabled people to survive the debauch? It was by having a superior immune system. But supposing the price of survival had been that they had damaged their immune system? You would appear to come back to normal. But in fact, there would have been two effects. In other words, you now have three effects of the bombing. You'd had the selection effect which should have left everything upside down, you had the marrow damage effect which would cancer that out and everything would look lovely till you looked at the cancer story and then you saw the effect everybody has recognized, namely the cancer effects of radiation.

What are you saying about the positive value of nuclear radiation?

I don't myself think that it's the appalling threat the people seem to think it is. But it was the industry that didn't like our finding which said that about 5% of these workers were dying as a result of their work. They wanted the figure to be zero. Well, if it gives 5%, you better know about because first of all you could bring a bit of pressure to bear on the situation like you found with the prenatal x-ray. There may be an alternative to some of these x-ray uses. Don't use them too often. Be economical with them.

Dr. Stewart, many people in the nuclear industry, especially after there's been a small accident at a nuclear reactor, announce that that amount of radiation being released in exposed the public is comparable to background radiation and therefore we shouldn't worry about it. Is it true that we don't need to worry about background radiation?

Background radiation is not necessarily as harmless as it seems to be. Anything that is shared by everybody in a population will naturally seem normal. But you must realize that we know very little about the causes of cancer. And in theory, quite a lot of the cancers could be coming from background radiation, but you can't study this because the situation is so uniform. But in fact, it has been studied through the Oxford Survey. What

happened there is because we got this gigantic population of children who are probably the most sensitive to radiation, we've been able to compare the levels of childhood cancers in different parts of Britain with different levels of terrestrial radiation. There's very little variation in Britain, but there is enough with this sensitive population and we've come out with this story that not only is the prenatal x-ray causing childhood cancers, but the inevitable fetal exposure to natural background radiation is causing the cancer. And to give you its relative importance, the figure that was given was that about 8% of the children's cancers in this long period that we've been studying, were directly ascribable to the prenatal x-rays. But the figure from background radiation -- and I must just tell you that it's been discovered through the x-rays that it's much more dangerous to take an x-ray shortly after conception that shortly before birth. The really sensitive period in life is shortly after you're conceived. And you can't escape background radiation at this time, so you're going to be the most vulnerable member of society. Well bearing that in mind, perhaps you won't be so shocked at the figure that at least 70% of children's cancers are caused by background radiation, in utero exposure to background radiation, probably most of it in the first half of pregnancy.

So, I began the whole story -- it is a malign influence. Fortunately there are very, very low levels of radiation and normally you wouldn't encounter very much. After all, we've all got to die and there are some risks and so on, but I think the moral is, be very careful; this is a very dangerous substance. And we're playing with it today like a child with matches.

Can you tell us about the Childhood Cancer Research Institute?

One of the reasons why I'm here today is that there has been an attempt in the United States to encourage the type of research that has led to this story that I've tried to tell you today. It's been my love, my professional interest is to get at the root cause of childhood cancers. This is what has impelled me over the years. It turns out that it's probably going to be the most important single cause of childhood cancers is going to be radiation. I didn't know that when I started and the information has been fed to me. Well if this is so, then we've got to find out how you can minimize this risk. Is there any other way in which you can protect children from this bad source? It turns out that there are all sorts of ways. Almost certainly the immune system is involved from the word go and there's going to be a long story there.

So, a lot of people hearing about my work and also finding out really that it was suffering as a result of the prejudice, the desire for everybody liking to say that radiation is safe, have joined together to form the Childhood Cancer Research Institute to try and encourage more research of the type that I'd been doing in this country.

When you were explaining the standards for radiation emissions are based on the studies of the A bomb victims, is that correct to say then that the standards for low level emissions are based on estimates of the health damage of high doses? And if that's true, does that mean we need different standards and are the current standards inadequate?

Yes, what you said is correct. At present moment, the basis of all studies, the methods is linear extrapolation of high dose effects. It says that you can observe high doses -- animal experiments require high doses. The A bomb survivor study provided you with high doses. You can also get them from radiotherapy treatment of non-malignant conditions. And there have been these studies. And it says, observe what is going on at the high dose and assume that there's a linearity. Just assume that the risk is directly proportional to the dose and

there's been no interference, no stoppage on the way at all. And that is the basis of our risk estimates.

When I gave you the figure that that the Oxford Survey and the MSK (Mancuso, Stewart and Kneil--spelling?) analysis of Hanford, I gave you the figure that they've come out with risk estimates that are ten to twenty time higher than the ones that had been based on the slope of the curve from the high dose to the low. So there must be something wrong with that slope. It should be much steeper, is what we're saying. And that was what I was trying to explain to you. if you allow for the selection and the bone marrow damage, that curve will come up much steeper. And then you will realize that what is really happening at low doses is considerably worse than what people had thought from the official method of risk estimation.

What does that imply regarding requirements that need to be met say at plants if they are to continue producing nuclear weapons.

The first thing that I think should occur to everybody is that it should be a compensatable disease. If you're working in the nuclear industry, it should be recognized that if you do get cancer you at least should be able to come before a tribunal to

find out whether you did in fact receive more radiation than would be say average or what's likely to cause it.

So one of the first things would be to rectify the position of the workers. At present moment it says that unless you receive more than 5 rems per annum, you will not qualify for any compensation. There are a few finer points than that in the legislation, but basically there is no compensation for the workers.

And then of course, to do everything you possibly can in the industry, to keep the radiation dose down.

And my third thing that I would put as being the most important -- to press for finding alternative sources of energy. To use our ingenuity, our human ingenuity to find something better. We can only see what is happening through cancer. But you know, always at the back of your mind about the cancer death is the defect to the next generation. That's what you ought to be really afraid of. It's the genetic damage -- the possibility of sowing bad seeds into the human gene pool. That's a way to think of it. I think there should be very much stronger pressure on people to first of all to compensate the workers who are involved now and

to think of alternative ways in the future which will stop you having this waste problem.

Dr. Stewart, thank you very much for being with us.

Gayle Green
Alice Stewart - Health Effects
4/12/89

(duplicate at BA)

The Health Effects of Nuclear Radiation - 4/12/89

A: If everybody in America realized that they probably killed off more of their workers from creating the bombs than they'd certainly killed off any foreigners, they might look at the story very differently.

[An announcer comes on and talks about Alice Stewart]

Q: Welcome to Cambridge Forum, Dr. Stewart.

A: To understand why there is a quarrel about whether or not it is safe to use radiation, I think you have to have some idea in your head about what radioactivity is. Well, it is, of course, a natural form of energy to which we are all exposed and today you can actually measure the intensity of the radiation as accurately as, say, you could measure temperature and unfortunately, unlike temperature for which we can have, say, a fairly wide range of benign situations, it doesn't matter whether it's too cold or too hot or about medium. And only in the extreme situations of very great heat and very extreme cold can you, as it were, not live. Unfortunately, radioactivity is a harmful force, a malign force even at its very low dose levels. The principle is this, that the energy, if it meets with a living cell, is liable to split the smooth mechanism of the cell--the molecular mechanism of the cell--into its component parts and then they struggle to get back again and then trouble arises.

Now, any of you can afford to lose a cell, any living structure, like anything from a tree to a man, so that doesn't matter very much; but unfortunately in causing this damage you can produce a mutation. The cell will go on living but it will now require different characteristics as a result of having disturbed the nucleus of the cell. And this is the trouble with radiation and it only needs one such cell to be created and to survive to form either a totally abnormal human

being--which happens to be a germ cell--or in the case of a body cell, to be the starting point of a cancer. Now, of course, one mustn't imagine this happening very often. It's a very rare event and in most cases the event that you're afraid of, namely, that an abnormal cell will continue to survive and cause the cancer, is a very rare event. But the fact that it can occur just from a single cell puts the whole danger of radiation into a different category from, say, getting far too hot or too cold. And it is this question, Whether in practice the cancer risk comes right down to the single cell or not, that is, I think, the argument for today.

Now, there are various ways in which you can try and . . . discover whether it's dangerous, all of which have got to face the following difficulties: The types of cancer caused by radiation are indistinguishable from naturally occurring cancers and to give you a single figure, 20 percent of people in a given population can expect to die from cancer. So, you're going to have a situation in which you've got the natural disease--you've got to distinguish the extra cases from the naturally occurring ones. The next trouble is that if you, the interval between receiving the radiation and getting the cancer--

This tape is a duplicate of G-B.A. Alice.

B.A. Alice

(This begins in the middle of Side A, about halfway through!)

A: . . . getting far too hot or too cold. And it is this question, whether in practice the cancer risk comes right down to the single cell or not, that is, I think, the argument for today. Now, there are various ways in which you can try and . . . discover whether it's dangerous, all of which have got to face the following difficulties: The types of cancer caused by radiation are indistinguishable from naturally occurring cancers. And to give you a single figure 20 percent in a given population can expect to die from cancer. So you're going to have a situation in which you've got the natural disease, you've got to distinguish the extra cases from the naturally occurring ones.

The next trouble is that if you . . . the interval between receiving the radiation and getting the cancer, instead of, for instance, if your child is exposed to getting the measles and you ought to know whether the child's going to fall ill, it'll all happen within seventeen days or not at all. You've either had the trouble and you're going to have the illness or you've escaped. Now, the equivalent time for knowing whether anything has gone wrong about the radiation ranges from less than to more than fifty years. So you see, you're in trouble about knowing whether there is going to be a subsequent event. And then the third difficulty is that we're all living with the natural background radiation so how are you going to distinguish between what might have come from that and anything you've added. Well, you can see that there would be, in theory, at least two ways in which you might tackle the problem, now that we're in the stage of being able actually to make extra radiation. One is to find a high dose situation and study it. Now, in natural life you're never going to come across a lot of radiation; it's always going to be at the low levels. But, of course, we've been able to make bombs and we've actually dropped a bomb on Hiroshima and Nagasaki and we've had a survival population there known to have been exposed to a large dose and has been followed over time, to see what was the late effect from the cancer.

Now, this is an excellent way of discovering about late effects of radiation, provided what happens from radiation at a high dose is the same as what happens at the low dose. Now, I've explained at the very beginning that you can kill cells and you can also mutate them. Cancer will be mutation cell death and I said when it's just one cell it doesn't matter. But if it's a whole string of cells you're go and destroy the tissue, then you will have a different story on your hand and you will, in fact, you can kill people with radiation. And some of the survivors from Hiroshima, you have to ask yourself whether, in fact, they only had, the late survivors, whether all the deaths that occurred earlier, whether there were any delayed deaths from non-cancers. Well, the judgment has been that there was only the late effect of radiation and that therefore you could take the risk estimate that came from the A-bomb survivors, translate them back and be able to say, Now, supposing you want to have nuclear power or you want to abuse some more weapons, you will be able, at least, to tell the workers whom they're going to keep at the low dose, whether they're going to have, how much extra cancer they're going to get. And the answer from that type of exposure is rather optimistic. It says, Yes, there may be a little trouble but it's going to be very small. Now that was the situation till, in fact, the records of the men who were working in one of your nuclear weapons productions plant in Hanford in the State of Washington, were actually came to be examined.

What had happened was that the Hanford started work in 1944 and had been going forward, and we were now at, say, 1964, when somebody thought that it would be a good idea to collect together the records of the workers and also ascertain whether, how many workers had died. Now, you in the United States are rather in a, what we epidemiologists call a 'good position'. You have a Social Security number which will enable a working population to identify deaths that have occurred long after the man has left the industry and by using that technique of tracing deaths and linking them with the actual radiation received while at work, a project was started in this country in 1964. It said go back, backlog all the radiation doses of the workers at Hanford, find out who has died and who hasn't, put two-and-two together and tell us whether there has been any danger from the small doses of radiation that these workers were getting. Well, how small were they? There were some very strict regulations

that said that no man was to receive more than 5 rems per annum. Sounds like a nice small amount of dose, certainly you wouldn't, you could have a 5 rem dose to go an have an x-ray examination. It would have to be a fairly long one like a barium meal but it would be possible, so it would be a fairly low dose if spread over a year. And sure enough, at Hanford the regulations have been very good and this dose had never been exceeded. So it was confidently expected that there would be no trouble because that was what had been forecast from the follow-up of the A-bomb.

But when they came to look at the records, they said, Here we are, none of these men have had more dose than they've allowed but they've actually had something like between 10 and 20 times as many, as much cancer as would have been expected on the basis of the A-bomb study. So then the fat was in the fire and you now have only one other test case. Was a mistake made on either side? Was a mistake made through the A-bomb survivors or was the mistake made through the workers? And there's one sort of umpire in this situation--and this is where we came in with a very unlikely sort of umpire and it was, in England, we more or less by accident discovered that a single x-ray taken shortly before birth was sufficient to increase the risk of an early cancer death. Now, how did that happen? It was way back in the '50s when the leukemia death rate in the world was increasing at an abnormally fast rate. We can look back now and know that nothing very bad was happening. All that was happening was that people were being able to live longer as a result of antibiotics and therefore a whole group of people who'd been liable to die from infections had died without your realizing sometimes the reason why they had died. And one of the reasons was leukemia. But nobody knew that at the time and one of the things that was clear was that young children were experiencing this increase more than anybody else. And so it was thought to be a good idea to go to the mothers of the children who died of leukemia and see whether they had a collective memory about what had happened to their children that might help to solve the whole problem of the world-wide increase in leukemia. And this is the so-called Oxford Survey of Childhood Cancers that did begin by just taking approximately 500 leukemia deaths of children, matching them up with 500 other forms of cancer and 1,000 live children and having one outstanding finding which was that both groups of dead

children--those who died from leukemia and those who died from solid tumors--had, in fact, been x-rayed more often than the live children. Now, that was way back in the mid-'50s, which is earlier than this time I've told you about, 1964 for the workers study here.

Nobody believed us and so we went on and we manage to include in this study in Britain, all children who died from 1953 onward, and we were steadily working away with this material until actually you can come to the present day and say that it's been proven beyond doubt that a very small dose of radiation, in this context, does have the bad effect that I described. That a single x-ray, a very small dose, is sufficient to increase the risk of cancer death in the case of children in sometime in the next fifteen years. So, this is where I stand today to say to you, to try and answer questions from you as to why there has been a quarrel, who is wrong on the studies, either of the A-bomb survivors or the workers and where do we think the truth lies. Thank you very much.

Q: Well, Dr. Alice Stewart, your research on fetal x-rays has more or less led to their discontinuation now, has it not?

A: That is true. Having found that the x-rays weren't safe, I don't know that that was the reason why the doctors stopped because I must tell you that any but 1 in 2,000 ever goes wrong, it was a very small effect. But fortunately for those small babies a new method of examination has been invented called ultrasound and that has managed so that you have non-ionizing radiations now as a means of, as it were, looking inside the womb, a particular hazard of the prenatal x-ray has disappeared.

Q: Well, you've made a reference to a study that you did of the atomic bomb survivors of Hiroshima and my understanding is that you found that when you consider the total effects, the long-term effects, that as many as ten or perhaps more times, more death resulted from radiation than has been indicated previously, is that correct?

A: No, not quite. When the, I have had no direct access to the A-bomb survivor data till very recently but I worked up a theory that because there was this difference between Hanford and the Oxford Survey and the A-bomb survivor study which had been allowed to

set the standard, there must be something wrong with the interpretation of the A-bomb survivor study. And I, after thinking about this for some time, I decided that it could have happened in the following way. The impression left by the deaths, the mortality experience of these people who were collected together five years after the bombing, the mortality experience was that only cancers had shown any signs of being dose related. All the other causes of death, about 80 percent of other things, seemed to be occurring at the same level for the people whose estimated dose was zero or close to zero and the people whose estimated dose was over 300 rads. So the conclusion drawn was that there'd only been the cancer effect. But you see, there would be a way in which you could get a flat rate looking normal would be a bad effect and a good effect, canceling one another out. Well, at first sight you couldn't possibly have a good effect from a bomb. But you can if you're merely looking at it from the point of view of the deaths. If you succeed in killing off a whole lot of people out of your society and you selectively kill off the weaklings, you should be left with the other people who are stronger, they've survived, they've been strong enough to survive, then you should from now on have a below normal death rate. And not only lower than normal, it should have been dose related the wrong way. The strongest people should have been the people who were most exposed. They had the biggest risk of dying at the beginning. So I said to myself, Why did they not have that? And of course, it's very easy to produce the answer and it says, Well, perhaps there was another effect of the radiation that wasn't showing so obviously as the cancer. And knowing that one of the tissues that is most sensitive to radiation, your blood and the blood forming tissues, and what does the blood do, other than provide you with the means of breathing, it prevents you from getting infections. It is the seat of the immune system. Now, what was it that it enabled people to survive the debacle. It was by having a superior immune system. But supposing the price of their survival had been that they damaged their immune system. You would appear to come back to normal but, in fact, there would have been two effects--in other words, you now have three effects of the bombing. You'd had the selection effect, which should have left everything upside down. You had the marrow damage effect, which would cancel that out and everything would look lovely till you looked at the cancer story and

then you saw the effect everybody has recognized, namely, the cancer effect of the radiation.

Q: What are you saying about the positive value of nuclear radiation?

A: I don't, myself, think it's the appalling threat that people seem to think it is. But it was the industry that didn't like our finding which said that about 5 percent of these workers had, would die as a result of their work. They wanted the figure to be zero. Well, if it is 5 percent you'd better know about it because, first of all, you could bring a bit of pressure to bear on the situation, like you found with the prenatal x-ray. There may be an alternative to some of these x-ray uses. Don't use them too often. Be economical with them.

Q: Dr. Stewart, many people in the nuclear industry, especially after there's been a small accident at a nuclear reactor, announce that the amount of radiation released and exposed to the public is comparable to background radiation and therefore we shouldn't worry about it. Is it true we don't need to worry about background radiation?

A: Background radiation is not necessarily as harmless as it seems to be. Anything that is shared by everybody in a population will naturally seem normal. But you must realize that we know very little about the causes of cancer and in theory quite a lot of the cancers could be coming from background radiation. But you can't study this because the situation is so uniform. But, in fact, it has been studied through the Oxford Survey. What happened there is because we got this gigantic population of children who are probably the most sensitive to radiation, we've been able to compare the levels of childhood cancers in different parts of Britain, with different levels of terrestrial radiation. There's very little variation in Britain but there is enough with this sensitive population and we've come out with this story that not only is the prenatal x-ray causing childhood cancers but the inevitable fetal exposure to natural background radiation is cause in the cancer. And to give you its relative importance, the figure that was given was that about 8 percent--

[End of Side A]

A: --shortly after conception and shortly before birth. The really sensitive period in life is shortly after you're conceived and you can't escape background radiation this time so you're going to be the most vulnerable member of society. Well, bearing that in mind, perhaps you won't be so shocked at the figure, that at least 70 percent of children's cancers are caused by background radiation, in uterus exposure to background radiation, probably most of it in the first half of pregnancy. So it isn't, I began the whole story, it is a malign influence. Fortunately, there's very very low levels of radiation and normally you wouldn't encounter very much and, after all, we've all got to die and there's some risks and so on. But I think the moral is, do be very careful, this is a very dangerous substance and we're playing with it today like a child with matches.

Q: Dr. Stewart, can you tell us about the Childhood Cancer Research Institute?

A: One of the reasons why I'm here today is that there is being an attempt in the United States to encourage the type of research that has led to this story that I've tried to tell you today. It's been my love or that, my professional interest is to get at the root cause of childhood cancers. This is what has impelled me over the years. It turns out that it's probably going to be the most important single cause of childhood cancers is going to be radiation. I didn't know that when I started and it's, the information has been fed to me. Well, if this is so then we've got to find out how you can minimize this risk. Is there any other way in which you can protect children from this bad source? It turns out that there are all sorts of ways. Almost certainly the immune system is involved from the word go and there's going to be a long story there. So, a lot of people hearing about my work and also finding out really that it was suffering as a result of the prejudice, the desire for everybody liking to say that radiation is safe, have joined together to form the Childhood Cancer Research Institute to try and encourage more research of the type that I've been doing in this country.

Q: Dr. Stewart, when you were explaining the standards--if I understood you correctly--the standards for radiation emissions are based on the studies of the A-bomb victims. Is it correct to say then that standards for low-level emissions are based on estimates of the

health damage of high doses and if that's true, does that mean we need different standards and are the current standards inadequate?

A: Yes, what you said is correct. At the present moment, the basis of all studies, the method is linear extrapolation of high dose effects. It says that you can observe high doses--animal experiments require high doses, the A-bomb study provided you with high doses. You can also get them from radiotherapy treatment of non-malignant conditions. And there've been these studies and it says, Observe what is going on at the high dose and assume that there's a linearity. Just assume the risk is directly proportional to the dose and there's been no interference, no stoppage on the way at all. And that is the basis of our risk testing. Now, this is the, when I gave you the figure, that the Oxford Survey and the MSK--that's Mancuso, Stewart and Kneale analysis of Hanford--I gave you the figure that they've come out with risk estimates that are ten to twenty times higher than the ones that have been based on the slope of the curve from the high dose to the low. So there must be something wrong with that slope; it should be much steeper is what we're saying. And that was what I was trying to explain to you, if you allow for the selection and the bone marrow damage, that curve will come up much steeper. And then you would realize that what is really happening at low doses is considerably worse than what people have thought from the official method of risk estimation.

Q: What does that imply regarding requirements that need to be met, say, at plants if they are to continue producing nuclear weapons.

A: The first thing that I think should appear to everybody is that it should be a compensatable disease. If you're working in the nuclear industry, it should be recognized that if you do get cancer, you at least should be, come before a tribunal to find out whether you did in fact receive more radiation than would be, than say average or what's likely to cause it. So one of the first things would be to rectify the position of the workers. At the present moment it's said, unless you receive more than five rems per annum you will not qualify for any compensation. I mean, there are a few finer points than that in the legislation but basically there is no compensation for the workers. And then, of course, to do everything you possibly can in the industry to keep the radiation dose down and--and I think, my

third thing, I would put as being the most important--to press for finding alternative sources of energy, to use our ingenuity, our human ingenuity, to find something better. We can only see what is happening through cancer but you know, always at the back of your mind about the cancer death is the defect to the next generation. That's what you ought to be really afraid of is the genetic damage, the possibility of sowing bad seeds into the human gene pool, that's the way to think of it. I think there should be very much stronger pressure on people, first of all, to compensate the workers who are involved and to think of alternative ways in the future which will stop you having this waste problem.

Q: Dr. Stewart, thank you very much for being with us.

Applause.

The English Forum has presented Dr. Alice Stewart of Birmingham University. . . . Cambridge Forum is a program of the Social Responsibility Committee of the First Parish in Cambridge. The director is Rev. Hubert Vetter, the producer is Pat MacMurray. Cambridge Forum is presented in associated with WGBH radio, Boston, engineering by the Harvard University of Media Services.

Music. Artie Shaw playing Noel Coward. Music to the end of side B

[END OF INTERVIEW].