PROFILES IN RESPONSIBILITY
Alice Stewart

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Alice Stewart's quiet battle against bureaucratic threats to scientific freedom and human health could be described as a "David and Goliath" story, but her weapon is not a single shot, nor has the great giant fallen for good. Hers is a story of determined persistence lasting decades. Instead of David, the young boy, the hero is Alice, now an 83-year-old woman, and the drama isn't over. Dr. Stewart may still have many important scenes yet to play.

Alice Stewart's expression of social responsibility is not primarily political, but scientific. Throughout her long career, her work has been steadfastly rigorous and her attempts at persuasion and policy change have been channeled through scientific publications and professional meetings. Despite her scholarly efforts, for years her work has been hindered or stopped by its opponents. While she herself has not waged political warfare over these events, many other people and groups have done so on her behalf. The body of her work has contributed to the ability of many organizations to draw attention to the risk of radiation exposure around nuclear power plants and nuclear weapons production facilities and establish safer standards for the medical uses of diagnostic radiation technologies.

Stewart's early research work in the area of radiation epidemiology, the *Oxford Survey of Childhood Cancers*, developed from her curiosity about childhood leukemia and her innate suspicion of new and untested technologies. She succeeded in showing for the first time that the then common practice of exposing pregnant mothers to X-rays was directly correlated with the subsequent incidence of childhood leukemia. Publishing these findings in 1958 [1] was as if one had suggested in 1980 that jogging or aerobics caused cancer. The fifties were the years when we were promised that nuclear weapons would bring world peace and that peaceful atomic power would be plentiful and inexpensive. The friendly face of the atom was everywhere. Large investments were also beginning to be made, both psychologically and financially, in uses of diagnostic and therapeutic radiation within the medical community. The suggestion that a small diagnostic fetal exposure to X-rays could lead to childhood cancer was a shocking one that initially many people did not want to believe. Now this concept is universally accepted and precautions based on it are routine. This was the first of many times that Alice Stewart was to be the bearer of news that people did not want to hear, but which had enormous implications for health and survival.

Alice Stewart believes that a physician's responsibility extends beyond her individual patients to the global community. She began her career as a physician in general practice, but in 1941 she joined the faculty of Oxford University, responding to the wartime needs of the British Government. Under government contract, she studied the health effects of British munitions production on workers and discovered a number of patterns, including a suppression of hematopoetic function correlated

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Dr. Alice M. Stewart. Photograph courtesy of Dianne Quigley.

with TNT exposure. This discovery led to better worker protection. As a result of that research, she was the first woman elected to the Royal College of Physicians in 1947 and became widely regarded as one of Britain's best and most creative epidemiologists.

Stewart's discovery that the exposure of the fetus to low-dose X-rays resulted in increased numbers of childhood leukemia supported the "linear hypothesis," a new understanding that cancer risk is proportional to X-ray dose and that there is no threshold below which radiation exposure is harmless. In spite of increasing scientific data consistent with this theory accumulating over the intervening decades, guidelines for radiation exposure levels for workers set by the International Committee on Radiation Protection (ICRP) have essentially ignored this concept and adhered to a threshold standard of 5 rads per year. This standard was maintained until recently even though the ICRP acknowledged as long ago as 1962 that no safe level of exposure exists [2].

The 5 rad recommendation was the result of a cost-benefit analysis. In effect, a risk of 1:5,000 of contracting fetal cancer was declared acceptable. That gave latitude for the expansion of atomic energy programs. Karl Morgan, Director of Health Physics at Oak Ridge National Laboratory for 29 years and once Chairman of the ICRP, credited Stewart's work when, in 1978, he asserted that the radiation risk had been underestimated by a factor of 10. Morgan went on to support Stewart's research efforts, and suffered many of the same criticisms from government agencies, problems in access to data, and barriers to publication that she did. Stewart has continued, through the *Oxford Survey of Childhood Cancers*, to compile data on childhood leukemia and to study its connection to environmental factors, registering 23,000 childhood cancer deaths in the United Kingdom in the largest such database on these diseases in the world.

Because of the international recognition and controversy that this work stirred, colleagues in the United States invited Stewart to participate in a study at the Hanford Nuclear Power Plant in Washington State. In 1975, she went to Pittsburgh to join with Thomas A. Mancuso, a well-known occupational epidemiologist, who had been commissioned in the early 1960s by the Atomic Energy Commission (AEC) to study the health of workers at the Hanford Nuclear Reservation. This study was initiated in response to a growing number of worker compensation claims. Mancuso worked for 12 years collecting data on more than 35,000 workers. His early analyses found no increased cancer deaths. However, when conflicting results from another investigator suggested a higher cancer rate at Hanford than Mancuso had originally found, he called Alice Stewart and her statistician colleague George Kneale to assist him. In a reinvestigation, a year later, Mancuso, Stewart, and Kneale concluded that Mancuso's originally negative results were incorrect, and could be explained by the long latency of cancer development.

Alice Stewart understood the importance of their finding that workers exposed to radiation levels less than half the federal safety limit of 5 rads per year suffered more than the expected levels of pancreatic cancer, lung cancer, and multiple myeloma. She persuaded Mancuso to alert the AEC officials in advance of publication because she thought it would not be fair to spring this information on them. She did not expect the level of official opposition that ensued. Within months, the AEC cut off the funding of Dr. Mancuso's 13 year research grant and confis-

cated the data. Even without analysis of the remaining data, the group was able to publish an article demonstrating these early results [3], leading to a controversy that has continued to this day.

The abrupt action of the AEC prompted Congress in 1978 to initiate an investigation of a possible "cover-up" of findings unfavorable to the newly formed Department of Energy (DOE), but the DOE prevailed. Mancuso and Stewart were denied access to any government data, and all subsequent research on worker health at DOE facilities was done by a few selected DOE contractors, primarily at Oak Ridge National Laboratory and the Pacific National Laboratory in Washington State.

Since then, Stewart, now a senior research fellow at the University of Birmingham, has often come to the United States to speak to congressional committees, scientific conferences, and activist groups concerned about nuclear power, nuclear weapons production, and health risks. Her major theme has been an abiding concern for scientific freedom. She argues the need for open scientific discourse, not that the government is evil in its conduct of the nuclear industry. She argues that the data collected since 1942 on what is now a cumulative total of 600,000 American nuclear weapons employees ought to be available to researchers for independent scientific analysis. After the Hanford data were confiscated from Mancuso, subsequent research on nuclear weapons facilities health issues, performed entirely by laboratories under contract to the DOE, has consistently found no or minimal increased health risks. A few scientists who have reported increased morbidity or mortality in these workers, such as Gregg Wilkinson et al. [4], have been denied subsequent contracts. A few DOE scientists have consistently been the most vociferous critics of Stewart and her work, arguing that the data should be restricted to "legitimate" scientists because "misinformation" could have such negative public impact. Stewart is willing to debate their criticism of her methodology, but they refuse to debate in public programs and scientific meetings. She argues that these scientific controversies would be resolved more rapidly and benefit society more if investigators representing diverse points of view were able to work with the data and discuss their findings in open scientific dialogue, as in all other areas of science. Dr. Stewart speaks out against the inherent conflict of interest whereby the DOE owns and operates the nuclear weapons industry and also provides the principal source of funding to study the health effects of that industry: "The fox guarding the chickens!"

In 1985, the Three Mile Island (TMI) Public Health Fund, a research foundation created in the wake of the TMI accident, convened an international conference of scientists to decide what population groups and studies would be optimal for definitive research on the health effects of low-level radiation. Their virtually unanimous recommendation: study the hundreds of thousands of AEC/DOE nuclear weapons complex workers at all the plants and installations, not just Hanford. The TMI Scientific Advisory Board chose Stewart to head the study and, in a novel and unprecedented action, requested access, under the Freedom of Information Act, to the DOE's massive files on workers' exposure and health data. The DOE refused, reasserting its monoply on the scientific data. In 1989, TMI went to the federal courts and in 1990, the DOE capitulated and began delivering the data tapes to Stewart. The DOE's wall of secrecy had been cracked.

One reason for this capitulation was a flood of revelations of massive releases of radioactive and toxic materials into the air, groundwater, and soil at Hanford, Rocky Flats, Fernald, Savannah River, and other DOE plants, and disclosures of frightening safety problems at many of them. In response to public pressure and Congressional insistence, a series of new epidemiologic and environmental investigations was begun by agencies other than the DOE itself. Energy Secretary James Watkins, admitting past error, announced that worker health data would be released to the scientific community, and some of the DOE's health research functions were transferred to the Department of Health and Human Services. Stewart has now set to work on her analysis. Characteristically, she wants the basic data sets to be as widely studied as possible, and she is urging other epidemiologists to join the effort.

In the face of so much political controversy and blatant opposition, Stewart remains modest but direct in her insistence on continuing scientific inquiry

> Many times I've been asked why I didn't follow my friends into quiet retirement. If I was a coward and afraid for my job, I wouldn't say a thing. But I am retired, I have no department that anybody depends upon for work. I speak out because I think there are not a lot of other

people in such a good position. I have nothing to lose. A lot of people do. This area of research can be shut down. I've watched it happen [5].

In a recent article in the *Bulletin of Atomic Scientists* [6], Stewart enumerates three major design problems faced by low level radiation research: 1) how to measure accurately the radiation doses large numbers of people have received; 2) how to prevent comparisons between exposed and unexposed groups from being confounded by other differences; and 3) how to cope with the varying lengths of cancer latency. She has developed creative approaches to all of these issues in her work. For example, in a 1982 review of the analysis of the Hiroshima and Nagasaki data performed by the Radiation Effects Research Foundation (RERF), Stewart challenges the official position that the only late effect of radiation exposure is cancer. She and George Kneale developed a method to describe the probability that the less healthy people in Hiroshima and Nagasaki died of generalized radiation effects to the bone marrow, such as anemia and vulnerability to infection, before the government study began. The Atomic Bomb Casualty Commission, as it was called then, did not begin identifying exposed persons until 5 years after the end of World War II. This selection bias, Stewart and Kneale argue, distorted the analysis of radiation consequences.

Stewart reasoned that "with only one bomb in each city, any selection effects of the early deaths would be as strongly dose-related as any late effects of the radiation. Therefore, a balancing act between the contrasting effects of selection and damage to the immune system could leave the false impression that neither effect had occurred" [6]. Stewart and Kneale were able to study this question in 1982 when RERF released the data on deaths from 1950 to 1982. Their analysis of 24,461 noncancer deaths showed a greater tendency toward deaths from infection when adjusted for the "healthy survivor" effect. Stewart does not claim this study to be conclusive of a noncancer related late effect of radiation exposure, but calls for further studies to be done so that if her hypothesis is true, official recommendations about exposure can be adjusted. This is the part of her argument that repeatedly falls on deaf ears.

Stewart applied the concept of the healthy survivor effect to her work on the Hanford employees; the phrase "healthy worker effect" has widely influenced occupational epidemiology. According to the government contractors, Hanford workers have a lower cancer death rate than the expected rate for all U.S citizens of comparable age. To Stewart, this suggested exactly her point—that Hanford workers are considerably healthier than the average population and, indeed, that sickly persons would be likely to be excluded from employment there.

Stewart dealt with a further methodologic challenge in another innovative way. Over time, many workers at Hanford were classified in a number of different job titles, perhaps because they needed to be moved from one activity to another to avoid exposures above the maximum permitted dose, or perhaps to meet secrecy requirements. In any case, this made it very imprecise to rely on job titles as a proxy for exposure Stewart decided to correlate the level of exposure with the frequency of urine tests that were done as a bioassay for internal radiation retention, reasoning that the plants would not have selected workers for this extra testing if they were not in a higher risk situation. It is this sort of imaginative methodology that has allowed greater specificity in Stewart's work, but has also brought her under attack from DOE researchers.

Stewart thinks that much of the controversy regarding the relationship between exposure to low-level radiation and subsequent development of cancer could be resolved "by the end of the century" [6]. As testimony to her intent to take full part in the work that lies ahead, she is now embarking on a major new project in addition to the Hanford study. Through the Childhood Cancer Research Institute, which she has been instrumental in organizing, she is coordinating a collaborative study to follow up on the provocative work reported in 1990 by Martin Gardner in the *British Medical Journal* [7,8]. Gardner studied children in the communities around the nuclear plant at Sellafield in England and found a correlation between a father's exposure to radiation and the incidence of childhood cancer in his offspring. This was the first study ever to demonstrate a correlation between paternal exposure and childhood cancer, and it suggests radiation damage at the level of the gene This too, of course, is highly controversial. Alice Stewart's response is what we have come to expect She proposes to study the issue in greater detail with an open mind and an energetic and creative methodology. She has invited inter-

ested investigators who live or work near a nuclear power plant or production facility to collect case control data on the parents of children with leukemia according to a consistent and systematic protocol that she has designed. Perhaps, with just this kind of innovative and dogged epidemiology that has characterized her work for decades, Alice Stewart may indeed reach the answers we still lack well before the century is out. ❧

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