OBITUARY

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With the death, at the age of 92, of Richard Doll, medical science has lost one of its greats. He will always be best remembered for establishing the causal link between lung cancer and cigarette smoking, but his contribution to other areas of epidemiology, including radiation, was substantial and he would have made his mark on scientific progress in the absence of his research on tobacco-related illness. I had the privilege of knowing and working with Richard Doll over the past two decades, but it is remarkable to think that during this period (with the exception of his briefly returning, at 75 years of age, to direct the Cancer Epidemiology and Clinical Trials Unit of the then Imperial Cancer Research Fund) he was retired from any formal position! Indeed, his life was full of work right up to its last few weeks—he chaired a two-day seminar on childhood leukaemia in London that I attended in April, where he told me that he was later to give lectures in Canada before flying straight back to Sweden to receive an honorary doctorate from the Karolinska Institute (at which ceremony an honorary doctorate was also awarded to Nelson Mandela). This is just how he would have wanted his death to be.

Richard (as he always urged me to call him, rather than Sir Richard, but I never could) studied medicine at St Thomas’s Hospital Medical School, London, and graduated in 1937. He served with the Royal Army Medical Corps in France and the Middle East during the Second World War, and experienced the difficult retreat to Dunkirk as a battalion medical officer (his diary of the retreat was published half a century later in 1990 in a series of fascinating articles in the British Medical Journal). I suspect that it was his living through the economic depression of the 1930s—he walked some of the way with, and provided medical support to, the Jarrow hunger marchers in 1936—and the war years that led to his strong views on social justice and a left-wing political stance. In 1944 he contracted tuberculosis in (fortunately only) one kidney, which was removed. After the war he joined the Central Middlesex Hospital with an attachment to the Statistical Research Unit of the Medical Research Council (run by the man who was to become Richard Doll’s great mentor, the renowned medical statistician and epidemiologist Austin Bradford Hill), which he joined in 1948. Here it was that Richard Doll’s reputation was forged.

Let us briefly examine his appreciable contribution to radiation research. In 1957, the first report of a follow-up study of British ankylosing spondylitis patients treated with x-rays was published by Richard Doll in collaboration with Michael Court Brown. This study has become one of the classic investigations of the long-term effects of the medical uses of ionising radiation, and fittingly, Richard Doll also co-authored the papers presenting the most recent results from this study, which were published in the mid-1990s. Another medically irradiated group that he studied was Scottish women who received radiotherapy for metropathia haemorrhagica, the first papers (co-authored with Peter Smith) being published in 1967–68 and the most recent in 1994. These medical irradiation studies confirmed the raised risk of leukaemia and other cancers following high doses of radiation received at high dose-rate in the course of therapy.
More controversial were the findings of the study of Court Brown, Doll and Hill published in the *British Medical Journal* in 1960. They had investigated leukaemia mortality among a large cohort of children who had received low doses of radiation during antenatal x-ray examinations at hospitals in London and Edinburgh. In 1956, a case-control study of childhood cancer mortality by Alice Stewart and her colleagues had found an association between childhood leukaemia and other cancers and obstetric diagnostic radiography, and the study of Court Brown *et al.*, using the more reliable cohort approach, should have confirmed this statistical association if it represented a genuine radiation-related raised risk. It did not, which was partly responsible for the long-standing animosity directed towards Doll by Stewart. To his considerable credit, Richard Doll, when a member of the group that produced the UNSCEAR 1994 Report, ‘concluded that there was a strong possibility that ascertainment was incomplete in his [Doll’s] investigation’—in other words, the results of the Court Brown *et al* study could not be considered reliable. The importance of this is that the Court Brown *et al* study is the only cohort study of antenatal x-ray exposure with sufficient power to have a reasonable chance of producing results that might statistically contradict the case-control study findings of Stewart *et al*., and without this study the negative evidence of such cohort studies is unimpressive. Richard Doll did not have to cast doubt on the Court Brown *et al* study so long after its publication, but it is a measure of the man that he did.

In 1958, the first paper in another long-running study was published (again, with Michael Court Brown), that of mortality from cancer and other causes among British radiologists. The most recent paper reporting results from this study, also co-authored by Richard Doll, was published in 2001. The study found an increased risk of cancer mortality among radiologists who started work early in the twentieth century and continued in the profession for many years—those who might be presumed to have received the highest cumulative doses. This study points to an excess risk of cancer following prolonged exposure to intermittent low doses of radiation, in addition to the established excess risk experienced by patients after receiving high dose-rate radiotherapy. In a similar vein, in 1960 Richard Doll was a member of the team that investigated whether the geographical variation of leukaemia mortality in Scotland might be related to the level of chronic exposure to background radiation. They concluded that background radiation was unlikely to be an important factor in determining the geographical pattern of leukaemia mortality, but also that social and economic factors must be properly assessed in such a study.

The picture that this paints is of a scientist heavily involved at an early stage in studies of the health effects of exposure to ionising radiation, making use of a variety of sources of information involving people irradiated under differing conditions. It should be borne in mind that the Life Span Study of the Japanese atomic bomb survivors was only established in 1950, so that the studies initiated by Richard Doll and his colleagues in the 1950s and 1960s were in the vanguard of radiation epidemiology. In later years, he was at the centre of the fray when the level of risk arising from exposure to low level radiation became a very public question. He took part in investigations into the health of those who had participated in the UK nuclear weapons testing programme, two review papers on this study that he co-authored being published in this journal just last year (Kendall *et al* 2004 *J. Radiol. Prot.* 24 199–217, Muirhead *et al* 2004 *J. Radiol. Prot.* 24 219–241), and into lung cancer following residential exposure to radon, notably the study in South-West England conducted with Sarah Darby. He also encouraged the large studies of radiation workers, especially those in the nuclear industry, and was instrumental in the establishment of the international nuclear worker study co-ordinated by the International Agency for Research on Cancer (IARC). Following the discovery in 1984 of the childhood leukaemia cluster at Seascale near Sellafield, and of reports of excesses of childhood leukaemia near certain other nuclear installations, Richard Doll was a
member of the group that during the 1980s examined the geographical distribution of childhood leukaemia in relation to nuclear establishments, and with Sarah Darby he investigated the impact of atmospheric nuclear weapons testing fallout during the late-1950s and early-1960s upon the subsequent risk of childhood leukaemia. This latter investigation was especially pertinent since the spectrum of radionuclides in fallout is very similar to that in discharges from nuclear installations. His work (along with that of others) did not suggest that the risk of radiation-induced childhood leukaemia had been seriously underestimated, but it did take him back to studies on childhood leukaemia clusters with which he had been involved in the 1960s, in particular to the idea that childhood leukaemia might be a rare response to a common infection. The hypothesis that under the unusual conditions of contact that occur during pronounced (especially urban–rural) population mixing excess cases of childhood leukaemia will result from this rare response in the susceptible population due to localised epidemics of the underlying infection was investigated in some depth during the late-1980s and 1990s by Leo Kinlen. Richard Doll did not believe that Leo Kinlen had been given sufficient credit for this work, with its important general implications for the aetiology of childhood leukaemia, and he said so strongly.

Richard Doll’s reputation for a powerful intellect and, especially, clear-thinking led to his serving on many review groups, including Committee 1 of the International Commission on Radiological Protection (ICRP), which reported in 1966, and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), which reported in 1994. He was also a consultant on epidemiology to the UK National Radiological Protection Board (NRPB).

The rise in interest in the risk of exposure to low level ionising radiation was accompanied by concern over the risk of cancer, in particular childhood leukaemia, arising from exposure to non-ionising radiation, especially that associated with extremely low frequency electric and magnetic fields (ELF-EMF) associated with power lines and electrical appliances. Richard Doll was a prime mover in the establishment of the UK Childhood Cancer Study (UKCCS), a nationwide prospective case-control study of childhood cancer one of the principal aims of which was to investigate the impact of ELF-EMF, and was the chairman of the management committee of the study. He also chaired the Advisory Group on Non-ionising Radiation (AGNIR) of the then NRPB from its creation in 1990 until 2003, during which time it produced a number of comprehensive reports on a variety of non-ionising radiations. The data from the UKCCS, when appropriately combined with data from comparable studies in other countries, were able to demonstrate that a raised risk of childhood leukaemia is statistically associated with exposure to high level ELF magnetic fields, although the reason for this remains unclear. The UKCCS also found no evidence that the risk of exposure to background gamma radiation or radon had been underestimated.

Richard Doll had a wonderfully sharp mind and a remarkable ability to clearly précis large volumes of results in an enviably insightful manner that exposed the essential evidence of a subject. Not surprisingly, therefore, he was frequently invited to lecture and write reviews on a wide range of issues. His refreshing style of presentation was one that encouraged understanding, in contrast to some of the dense argot used by others that only encouraged slumber. It is indicative of the esteem in which Richard Doll was held that he was invited to give two lectures in 1995 on the hazards of ionising radiation to mark the centenary of the discovery of radiation by Röntgen. Other reviews were particularly influential, including that with John Evans and Sarah Darby published in *Nature* in 1994, which considered the controversial evidence for a raised risk of childhood leukaemia following preconceptional irradiation of the father, and concluded that such irradiation was not a material risk. I was fortunate to be the co-author of a paper published in 1997 that reviewed the evidence for a raised risk of childhood cancer following intrauterine exposure to low level radiation, in which
we concluded that there was strong evidence for an increased radiation-related risk.

Richard Doll was a firm believer throughout his career in the segregation of the process of drawing the best scientific conclusions based upon the available evidence from the societal implications of those conclusions, which should be left for policy-makers and regulators to decide. In his view, confusion of these two roles could lead to a distortion of scientific judgement. His strong views on what could, or could not, be inferred from the scientific evidence, regardless of the consequences, led to clashes with those who were driven by certain political objectives and looked to science to support these objectives. Thus, Richard Doll did not endear himself to those over-enthusiastic supporters of nuclear power for his conclusion that the linear no-threshold (LNT) dose-response model for radiation-induced cancer at low doses was the one best supported by the evidence, rather than a threshold or hormetic relationship; and his failure to conclude that childhood leukaemia clusters were indicative of a gross underestimation of radiation risk infuriated extreme environmentalists (see, for example, Doll 1998 *J. Radiol. Prot.*, 18, 163–74). He felt a strong duty to society, which led to a number of high profile appearances as an expert witness. One English High Court judge described Richard Doll as ‘an epidemiologist of the highest standing and experience ... an impeccable witness’. It should not be thought, however, that he was an uncritical pillar of the Establishment. He was concerned by the composition of the NRPB in its early years at the beginning of the 1970s, when he believed it was too close to the nuclear industry to give independent advice (although he also made it clear that the situation changed in the mid-1970s), and in 1955 he was prevented from publishing a note on the risk of leukaemia arising from atmospheric nuclear weapons testing, the note eventually appearing some forty years later in this journal (Doll 1996 *J. Radiol. Prot.*, 16, 3–5).

The awards and honours received by Richard Doll are too great to mention in their entirety. Perhaps it will suffice to say that he was elected to the Fellowship of the Royal Society in 1966, was knighted in 1971 and was made a Companion of Honour in 1996 (the Order is limited to the Sovereign and 65 ordinary members). In passing, perhaps I should also mention that he received an Honorary Fellowship from the Society for Radiological Protection in 1994. Among the prestigious posts he held were Director of the Medical Research Council’s Statistical Research Unit (1961–69), Regius Professor of Medicine at the University of Oxford (1969–79) and the first Warden of Green College, Oxford (1979–83), a college concentrating on postgraduate medical studies that was Richard Doll’s concept and which he continued to support strongly during his ‘retirement’.

Perhaps the most remarkable thing about a truly remarkable man was his ability to hold in his memory vast quantities of information ranging over a wide variety of subjects, which he could recall as a highly structured and erudite summary to provide state-of-the-art expert opinion covering the greater part of the field of epidemiology. Most of us mere mortals are doing well if we are considered experts in just one area of the field. He also had the reputation for always uncannily ‘riding the winner’ when there was a dispute over the interpretation of certain epidemiological findings. I suspect that this was due to his substantial experience and his wisdom in keeping his counsel until sufficient information had accrued for him to make a reliable judgement on a contentious issue—a rare ability. There is no doubt that Richard Doll had a huge impact upon epidemiology in particular and medical science in general. Those of us working in radiological protection can only be grateful that he directed some of his attention towards our discipline; it is all the richer for it.

Richard Wakeford