Article
Themed Issue: Radiation Effects and Events

Living in the Nuclear Age: A Course for Medical Students Outlining Key Aspects of Medicine and Health Effects

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Abstract:
At Baylor College of Medicine, for nearly two decades, we have provided an elective course entitled "Nuclear Ethics," in which we discuss the ways living in the nuclear age impacts medicine. The course reviews the health effects of the World War II Japanese bombings (including a discussion of the local medical library repository of a large collection of data related to the Atomic Bomb Casualty Commission), the health effects of nuclear testing including the Marshall Islands and the Nevada Test site (the most heavily bombed place on earth), the risks attendant with employment in the nuclear industry, the current controversies attendant with nuclear power and the data associated with accidents such as those at Three Mile Islands, Chernobyl, and Fukushima, and a final discussion of nuclear conflicts in the world today. The students who enroll are largely first-year medical students.

The Houston and Baylor College of Medicine communities benefited greatly from the presence on retirement of Dr. William Schull, the geneticist and epidemiologist who led many of the activities of the Atomic Bomb Casualty Commission. In his retirement he continued to teach students about the effects of the Japanese bombings. Through his nineties he eloquently described his love for the Japanese culture and provided in depth insights, knowledge, and experience about the effects of ionizing radiation. These discussions served as an impressive example for the medical students in the course. Much of his material are in the repository at the McGovern Historical Center of the Texas Medical Center Library.

Students participate by readings, discussion, and detailed assignments. The course is well-received and emphasizes an importance of physician involvement in nuclear issues, including the key role that the Physicians for Social Responsibility played in the test ban treaties and in the dissolution of the USSR in 1989.

Keywords: nuclear age, epidemiology, Japanese bombings, nuclear accidents

Introduction

The nuclear age began on July 16, 1945, with the explosion of the first atomic bomb at Alamogordo, New Mexico, and the subsequent detonation of the bombs by the United States over Hiroshima and Nagasaki on August 6 and 9, 1945, respectively. The historian Garry Wills in his seminal book *Bomb Power: The Modern Presidency and the National*

Security State, states that the advent of the nuclear age resulted in an increase in the power of the US president.[1]

The emotional energy extended to nuclear causes over ensuing decades was great. The Cold War was characterized as an era when the risks of nuclear war remained prevalent and at moments, such as the Cuban Missile Crisis of late 1962, imminent.

At the same time, the extensive armamentarium of nuclear weapons resulted in a need to test weapons and between 1945 and 1998; 2056 such tests took place. These were 528 above ground, 1528 underground, with the largest number by the US with 715, followed by the USSR/Russia and France.[2] These tests exposed many native populations to the risks attendant with such exposure.[3] The resulting findings are relatively few but are comparable in cancer outcomes to those from studies of the Japanese bombings.

The extensive advocacy of nuclear power by the nuclear industry resulted in another new issue: that of the risk of accidents to power plants, with several accidents occurring in the early years which were not widely broadcast (Chelyabinsk and Sellafield, both in 1957) and a host of widely publicized and variably studied accidents (Three Mile Island in the US in 1979, Chernobyl in the USSR in 1986, and Fukushima in Japan in 2011). The public reactions to these accidents have often determined the future viability of the nuclear power industry.

Finally, the nuclear era is accompanied by an ongoing specter of potential nuclear disasters, a field that was emphasized and written about by individuals, such as Dr. Alexander Leaf of the Department of Preventive Medicine at Harvard and Jonathan Schell, who philosophically analyzed the potentially catastrophic consequences of entering the nuclear age.[4] The reactions of different parts of the world to nuclear conflict are diverse and include the total disarmament of Latin America and the Caribbean through the Treaty of Tlatelolco to four ongoing Asian conflicts (North Korea, Iran, Israel, and India/Pakistan).[5]

The course that we developed examines the impact of each of these areas and the physician involvement in each of them. The aim of the course is to use epidemiologic data to emphasize the need for prevention in public health, and to promote student thinking and activism so that nuclear or related conflicts in the next generations are widely discussed and hopefully resolved.

Pedagogical Framework, Principles, Competencies, and Standards

The course is offered to first-year medical students. Their backgrounds are diverse regarding past exposure to course material and university major fields of study. The course is an elective and has been offered for eighteen years and began as an offshoot of my participation on the national board of Physicians for Social Responsibility.

The course began with four students and four sessions and eventually expanded to typically between eight to ten sessions per semester. It is offered for ten weeks with about ten students per year, though enrollments have ranged from two to twenty-eight students. This course is a seminar taught by myself and invited speakers and typically takes place in a U-shared classroom to enable class participation. During the COVID-19 pandemic, Zoom techniques were predominantly used. Such techniques present some difficulties in that students are often reluctant to open their camera unless spoken to directly.

The major aim of the course is to encourage medical students to become aware of nuclear-related information in the news and contemplate how such information can impact their students and their communities. Medical students often are reluctant to venture beyond their planned areas of specialization, and a variety of elective courses provide them with the option to do such explorations without fear that their grade point average will be impacted (the course is offered as pass-fail). Attendance is monitored by an administrative assistant, and students are allowed only one absence. While absences are rare, they are excused with written essays, which document the knowledge of the material covered during the missed session.

Students are given assignments based on readings of secondary articles or investigating certain related aspects to the course. For example, for the session on nuclear waste, students are assigned to assess an up-to-date review of how countries with nuclear power handle their waste, such as the vitrification processes promoted in France.

At the end of the course students complete a one-page handout describing their reactions to and thoughts about the course. The results are submitted anonymously, typically through the administrative assistant, and compiled by me as the course director. Upon completion of the course, students are awarded one-half unit of credit toward their graduation requirements. Quantization is based on hours of participation and, in prior years, also hours of reading course material.

Course Material

1. The Japanese Bombings

The Japanese bombings represented the first and sole use of nuclear weapons in wartime, and the US remains the sole belligerent to have used them. The bombings occurred within an interval of three days. The second city initially chosen was a surrogate for Kokura, yet since Kokura was covered with clouds, Nagasaki was chosen as an alternative. The current generation is challenging the heroic status of President Harry S. Truman in a revisionist fashion, in part because it is thought that the ending of the war was about to occur. The potential of Russian involvement and the exact role of generals versus the president in deciding on the second bombing is not well-established.

The students discuss these issues and the health effects of the bombings. The concepts of a latency and degree of exposure are taught. The health manifestations occur in dividing tissue preferentially but appear to be limited to the first and not second generations of those exposed, although extensive in utero damage to fetuses exposed to the bombings are documented.[6] The unique types of leukemia that developed among survivors—both common forms of acute leukemia (lymphocytic and myelocytic) and chronic myelocytic—are discussed as well as the unique nature of chronic lymphocytic leukemia and its absence from subsequent databases.[7] The spectrum of defined risk factors for diseases and those with only a moderate risk or no risk of developing in the sequelae of the bombings are also discussed.[8] The key concepts are those of latency, dose-response, and tissue sensitivity.

A local repository of the Atomic Bomb Casualty Commission database is the topic for a presentation by the head of the McGovern Historical Center who is an archivist and custodian of the database.[9] Such material is available for investigative purposes for members of the local medical community and outside institutions on request.[10]

2. The Nevada Test Site Data

Testing of nuclear weapons tended to be carried out in the barren, backwater areas of a nation, often preferentially its territories. Hence the US used the South Pacific where it controlled several islands, in particular the Marshall Islands, and Nevada, the most arid and a low densely populated state. For relatively similar reasons, the USSR used barren Kazakhstan but also the far northern Arctic islands; the United Kingdom used the Australian outback; France used the South Pacific and Algeria; and China used its Western deserts.

The risks of nuclear catastrophe and the nearly miraculous exemption from such occurring are cited with reference to a key book, *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety* by Eric Schlosser.[11]

The extensive testing mentioned above document the concerns and psychologic tenor of the post-WWII period. The US carried out nearly 35% of all tests. At the same time, the US is almost unique in having studied the consequences of nuclear tests, with studies of the Nevada Test Site having been conducted downwind in Utah. A key paper, published in *JAMA* by Walter Stevens and others, shows the similarity in the types of tumors that developed to those after the Japanese bombings.[12] The concepts of a possible threshold effect with lower dose irradiation are debated. Studies of the Marshall Island populations and other exposed populations are minimal, although some work has been done in Kazakhstan as a consequence of the Russian tests conducted there.[13]

Students in this session are taught concepts related to case-control methodology (the Utah controls are a good discussion point for this), and threshold effects. Additionally, students are encouraged to discuss policy issues related to reparations and resettlement of those exposed such as, the Marshall Island residents.

3. The Risks of the Nuclear Industry and Medical Exposures

In an introduction to the course, a graphic from the National Atomic Museum in Albuquerque, New Mexico, is referenced in which the relative safety of the nuclear industry is touted. These graphics show that the highest medical risk to a man is associated with remaining single. Nonetheless, several studies document risks of radiation exposure beyond the well-recognized carcinogenic risks of early radiologists before safety measures were undertaken. These include the risks of airline attendants who work at far northerly latitudes (Iceland Air, Scandinavian Airlines) and the multicenter study of nuclear power workers showing a higher than expected risk of multiple myeloma, although the study is limited to one facility.[14] The unexpected risk attendant with computerized tomography (CT) scans among children as well as the excess lifetime risk of cancer are used as a teaching point to emphasize the evolving knowledge on nuclear risks and the similarity of outcomes to exposure to nuclear radiation and other cancer-causing substances in the environment.[15]

4. Debating Nuclear Power

In the wake of concerns regarding nuclear waste and accidents in the nuclear industry, it is appropriate that medical professionals address the issues on the pros and cons of nuclear power. While some nations such as Germany have elected to go completely non-nuclear, others such as France are becoming increasing nuclear. The industry policy is well illustrated in an article by Richard Rhodes and Denis Beller.[16] Rhodes, a seminal leader in the field, wrote *The Making of the Atomic Bomb*, and Beller is a technical writer from Los Alamos.[17] An alternative perspective is provided in the Jesuit

journal *America*, where Kristin Shrader-Frechette, a biological sciences and philosophy professor emerita of the University of Notre Dame, delineates a series of reasons as to why the nuclear industry imperils our cosmos, from its expense, risk of accidents, and the insolvable problem of handling wastes.[18] Additionally, Shrader-Frechette expands on environmental justice issues associated with nuclear waste. The students are often assigned a group of countries and asked to describe the solutions used for nuclear waste: for example, vitrification in France and an underground burial in Russia. The sad and foolishly expensive history of the Nevada waste site is also described.

Important recent developments that students outlined in the most recent debates are: 1) the development of fusion reactions, particularly one in France; and 2) a comparison published on Our World in Data website that looks at the morbidity and mortality of various sources of energy, outlining the catastrophic potential for continued cardiorespiratory illness with the current reliance on fossil fuels.[19] Eighty percent of the 2022 class favored a perusal of nuclear energy as a part of government policy.

5. Nuclear Accidents and Their Prevention

The major limitations attendant with the use of nuclear energy are the potential for catastrophic accidents and the disposal of nuclear wastes.

The serious accidents to date are discussed in class: Sellafield and Chelyabinsk in 1957; Three Mile Island in 1986 and its relatively low level of radiation emission but its profound effect on the American public perception of the danger of nuclear power; Chernobyl, by far the gravest accident to date, which occurred on April 26, 1986 and is documented in the lecture with a slide show based on a tour of the facility conducted by myself with the *New York Times* in 2019; and Fukushima, whose severity remains under study. The health effects of nuclear accidents are not studied to the extent one would hope, but a number of largely Scandinavian studies document the presence of increased rates of thyroid and breast cancer among the populations who live upwind from the radioactive emission, primarily in Belarus.[20] The principle of latency is evident in demonstrating how later studies show findings that are not seen in early studies, which do not necessarily address the issues of the adequate latency interval.[21]

Accidents are dependent on the design of the reactor, and this issue with the Chernobyl reactor is one of many explanations for the failure, including the implementation of a poorly designed test, inexperienced personnel, and lags in response time by management.

6. Nuclear Conflicts in the World Today

A final session or two, if time allows, of the course directs attention to four major potential nuclear conflicts in the world today with articles used to assess these conflicts referenced): 1) North Korea, who is not a signatory to test ban treaties yet continued oceanic-above-ground nuclear tests despite sanctions and international condemnation;[22] 2) India/Pakistan, where the development of nuclear weaponries had a self-stated different rationale, such as energy for country versus defenses against a powerful neighbor, but whose nuclear status is of particular concern with four border wars over a fifty-two-year period between 1947 and 1999;[23] 3) Iran, where the nuclear agreement, officially titled Joint Comprehensive Plan of Action—ratified during the Obama administration on July 15, 2015 and allowed for inspections—was shuttled during the Trump administration, making current attempts to re-establish it difficult with Iranian suspicion of the American public;[24] and 4) Israel, whose suspected but never proven status is attendant with a alleged middle-of-the-night strike of a Syrian weapons plant.[25]

In the end, the course offers the Schell rationale that no nuclear weapons should exist and the Schlosser exposé that deterrence has almost mysteriously failed to be associated with any major conflict or any accident over a populated area over seventy years. The "logic of zero," a concept advocated by Ivo Daalder and Jan Lodal, is also explained and is one of the bases for a moral and academic rationale for the obliteration of all nuclear weapons.[26]

The students usually vote at the end of the course regarding the complete abolition of nuclear weapons. In the last tally, 70% advocated such abolition, but 30% felt it could only be done with great caution. However, understanding the consequences of their use at times when nuclear powers are engaged in serious border conflicts, such as currently Russia versus Ukraine, allows for constant revision of nuclear policy. In the end, the course tries to encourage medical participation in serious nuclear conflicts, a principle active among members of Physicians for Social Responsibility and a principle which has shown positive effects in the past.

Results to Date of Assessments Gathered

Attendance is consistently high, and no course grading restrictions have been based on absences, although about 20% of the students who initially enroll drop the course before a required deadline. On one occasion, the year in which 28 were enrolled, scheduling difficulties resulted in a host of students asking to switch over to another required course, and restricted credit was given. The evaluations provided by the students uniformly report that the course should be offered, but as an elective rather than

a requirement. The amount of reading material is the major complaint and is probably a function of the amount of material first-year medical students are required to learn. A final issue is that the course offers and subscribes to subject material that does not actively align with any of the students' areas of expertise. Information and figures are constantly changing, which presents a challenge for the course faculty to constantly provide updated information and reference material in the readings.

In order to increase participation in the course, the students are asked to report on the essential aspects of supplementary readings for most of the sessions. For two of the sessions, all the students participate: one session on the debate of nuclear power, and the other on a discussion of current nuclear conflicts in the world. For the session on the debate of nuclear power, student leaders are designated to organize the remainder of the students. For the session on nuclear conflict, the entire class takes on one of six major conflicts in the world today, and each student has four-to-six minutes to present the assigned material concisely. Most students employ the didactic sense of medical students, reporting on the material without access to supplementary readings, despite an admonition to do so. Rare students take the assignment further and improve the reading list with updated articles. Such independence is encouraged, but in a pass-fail setting, it is hard to promote.

Students are uniformly reluctant to open the cameras on Zoom sessions. It is too punitive in a graduate style setting to demand this be done to pass the course, and establishing a requirement that this be done has been currently unsuccessful. This is one obstacle of online learning that the faculty have been unable to overcome.

Discussion and Summary

The medical community is given credit for its lobbying activity in passing the 1963 Comprehensive Test Ban Treaty (CTBT) and by Mikhail Gorbachev in helping him to delineate the concepts of glasnost and perestroika, which indirectly may have led to the demise of the Soviet Union. Both activities occurred in the medical community through the organizing activities of non-governmental organizations, in particular the International Physicians for the Prevention of Nuclear War (IPPNW) and its individual affiliates, such as its American companion Physicians for Social Responsibility, which worked assiduously for the passage of the CTBT.

The need for recognizing the dangers of nuclear war is constantly reinforced by political events, be it the intermittent India/Pakistan border wars, the above ground and condemned testing by North Korea, or the current border crisis between Ukraine and Russia.

While medical students have clearly elected to choose a profession that is decidedly apolitical in most circumstances, at some point in their lives their choices and decision may determine the fate of many. Students need a better understanding of the importance of epidemiology as a science of public health. A nuclear war is often called the Final Epidemic and the tools of prevention applied to a church supper, a new Ebola or COVID-19 outbreak, or a rash of violent crimes in a city, can also be applied to nuclear war: describing the who, what, and where; analyzing the causes; and trying to establish a means of prevention. The means historically advocated include total disarmament—championed by Bernard Baruch, Schell, and momentarily President Ronald Reagan—and the more popular, deterrence whereby the containment of weapons use is a product of their presence. The work of Schlosser cited above outlines this framework. However, because the issues of the future are unknown and the risks of nuclear catastrophe remain, it is exceptionally important that the medical staff in training be attendant to these issues and learn to work out the solutions based in the specifics of their unique times.

What can a course such as this recommend for the future? First, students need to be aware of the importance of the medical community in making an impact on significant future sociopolitical issues. Physicians may be the first to recognize certain occupationally or environmentally related disorders, and their documentation of such findings are an important avenue for establishing the causes of certain disorders and preventing them in the future. Second, students need see public health as an encompassing science, recognizing the role of epidemiology to analyze associations and establish the basis for preventive medicine. Third, an awareness of the developments in society that impact man's health is a lifelong endeavor, and a course such as this helps make this philosophy apparent to early trainees in the medical community.

Notes

[1] Garry Wills, *Bomb Power: The Modern Presidency and the National Security State* (New York: Penguin, 2010).

[2] "The Nuclear Testing Tally," Arms Control Association, last modified August 2023, accessed January 21, 2022, https://www.armscontrol.org/factsheets/nucleartesttally.

[3] See Steven L. Simon and André Bouville, "Health Effects of Nuclear Weapons Testing," *Lancet* 386, no. 9992 (August 2015): 407–9.

[4] Alexander Leaf, "New Perspectives on the Medical Consequences of Nuclear War," *New England Journal of Medicine* 315, no. 14 (October 1986): 905–12; and Jonathan Schell, *The Fate of the Earth* (New York: Alfred A. Knopf, 1982).

[5] For the text of the Tlatelolco Treaty, see "Tratado para la Proscripción de las Armas Nucleares en la América Latina y el Caribe: Tratado de Tlatelolco," OPANAL, signed February 12, 1967, accessed January 21, 2022, https://www.opanal.org/texto-del-tratado-de-tlatelolco/.

[6] See William J. Schull, "The Somatic Effects of Exposure to Atomic Radiation: The Japanese Experience, 1947–1997," *Proceedings of the National Academy of Sciences of the United States of America* 95, no. 10 (May 1998): 5437–41.

[7] See Yukiko Shimizu, Schull, and Hiroo Kato, "Cancer Risk among Atomic Bomb Survivors: The RERF Life Span Study," *JAMA* 264, no. 5 (October 1990): 601–4.

[8] See Yasuhiko Yoshimoto, "Cancer Risk among Children of Atomic Bomb Survivors: A Review of RERF Epidemiologic Studies," *JAMA* 264, no. 5 (October 1990): 596–600.

[9] See "Atomic Bomb Casualty Commission," McGovern Historical Center, Texas Medical Library, https://library.tmc.edu/mcgovern/atomic-bomb-casualty-commission/.

[10] For finding aids related to the ABCC Collections, see "Atomic Bomb Casualty Commission (ABCC) Resource Guide," McGovern Historical Center, Texas Medical Library, https://libguides.library.tmc.edu/c.php?g=243656.

[11] Eric Schlosser, *Command and Control: Nuclear Weapons, the Damascus Accident, and the Illusion of Safety* (New York: Penguin, 2013).

[12] Walter Stevens et al., "Leukemia in Utah and Radioactive Fallout from the Nevada Test Site: A Case-Control Study," *JAMA* 264, no. 5 (October 1990): 585–91.

[13] See Bernd Grosche, Tamara Zhunussova, Kazbek Apsalikov, and Ausrele Kesminiene, "Studies of Health Effects from Nuclear Testing near the Semipalatinsk Nuclear Test Site, Kazakhstan," *Central Asian Journal of Global Health* 4, no. 1 (May 2015): 127.

[14] See Eero Pukkala et al., "Cancer Incidence among Nordic Airline Cabin Crew," *International Journal of Cancer* 131, no. 12 (December 2012): 2886–97; and Vilhjálmur Rafnsson, Hrafn Tulinius, Jón Gunnlaugur Jónasson, and Jón Hrafnkelsson, "Risk of Breast Cancer in Female Flight Attendants: A Population-Based Study (Iceland)," *Cancer Causes and Control* 12, no. 2 (February 2001): 95–101.

[15] See David J. Brenner and Eric J. Hall, "Computed Tomography—An Increasing Source of Radiation Exposure," *New England Journal of Medicine* 357, no. 22 (November 2007): 2277–84.

[16] Richard Rhodes and Denis Beller, "The Need for Nuclear Power: Viewpoint on the World's Challenging Energy Future," *International Atomic Energy Agency Bulletin* 42, no. 2 (June 2000): 43–50.

[17] Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Shuster, 1986).

[18] Kristin Shrader-Frechette, "Five Myths about Nuclear Energy," *America: The Jesuit Review*, June 23, 2008, https://www.americamagazine.org/issue/660/article/five-myths-about-nuclear-energy.

[19] See Clara Moskowitz, "World's Largest Fusion Reactor Begins Assembly," *Scientific American*, December 1, 2020, https://www.scientificamerican.com/article/worlds-largest-fusion-reactor-begins-assembly/; and Hannah Ritchie and Max Roser, "What Are the Cleanest and Safest Sources of Energy?," Our World in Data, accessed February 2, 2022, https://ourworldindata.org/uploads/2020/10/What-is-the-safest-form-of-energy.png

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[21] Yoshisada Shibata et al., "15 Years after Chernobyl: New Evidence of Thyroid Cancer," *Lancet* 358, no. 9297 (December 2001): 1965–6.

[22] Thomas Plant and Ben Rhobe, "China, North Korea, and the Spread of Nuclear Weapon," *Survival* 55, no. 2 (April/May 2013): 61–80.

[23] "Nuclear Power in India," World Nuclear Association, last modified June 2023, https://world-nuclear.org/information-library/country-profiles/countries-g-n/india.aspx; "Nuclear Power in Pakistan," World Nuclear Association, last modified July 2023, https://world-nuclear.org/information-library/country-profiles/countries-o-s/pakistan.aspx.

[24] George Perkovich, "Dealing with Iran's Nuclear Challenge," *Carnegie Endowment for International Peace*, March 1, 2005, https://carnegieendowment.org/2005/03/01/dealing-with-iran-s-nuclear-challenge-pub-16604.

[25] David Makovsky, "The Silent Strike," *New Yorker*, September 10, 2012, https://www.newyorker.com/magazine/2012/09/17/the-silent-strike.

[26] Ivo Daalder and Jan Lodal, "The Logic of Zero: Toward a World without Nuclear Weapons," *Foreign Affairs* 87, no. 6 (November/December 2008): 80–95.

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