National Academies' Study on Radioactive Sources And Alternative Technologies
National Academies

Produced at the request of Sandia National Laboratories, this study report (see https://www.nap.edu/catalog/26121) assesses the status of applications of radioactive sources and alternative (nonradioisotopic) technologies in the United States and internationally. The assessment will be used to inform existing and future activities under the National Nuclear Security Administration (NSSA) Office of Radiological Security program to reduce the current use of high-risk radiological materials and promote alternative technologies.

Radioactive materials are used commercially in a wide range of applications, such as treating blood before transfusion, sterilizing medical devices, treating cancer, exploring geological formations, and finding oil and gas deposits. The responsibility of securing these materials falls to the universities, hospitals, and commercial facilities that use them. If these materials are mishandled, or if they are used maliciously as part of a dirty bomb, they have the potential to cause billions of dollars of damage in economic impact, cleanup, and loss of access to affected areas – even if only small amounts of the material are involved.

CATEGORIZING RADIOACTIVE SOURCES BY RISK

The International Atomic Energy Agency (IAEA) uses a five category system to rank radioactive sources primarily in terms of their potential to cause immediate harm to people handling or otherwise coming in contact with them if these sources are not safely managed or securely protected. Category 1 and Category 2 sources are considered high risk with potential to immediately harm human health, and Category 3 sources are considered medium risk. The IAEA system does not consider two important factors: (a) health effects, such as future cancer development, that could be induced by being in proximity to the radioactive sources if not managed safely and securely; and (b) socioeconomic consequences of radiological incidents that involve these radioactive sources.

While radioactive sources continue to be used broadly, both nationally and internationally, no new applications of high-risk and moderate-risk radioactive sources have emerged during the past 10 to 15 years. However, data tracked in the United States indicate that the number of Category 1 and Category 2 sources has increased over the past 12 years by about 30 percent. One application of Category 1 sources, the use of radioisotope thermoelectric generators for land-based power, has been phased out.

The U.S. government and the international community have taken actions to strengthen the security and accountability of radioactive sources primarily for high-risk sources. Security and accountability for Category 3 sources have been a lower priority, making them more vulnerable to unauthorized transactions and theft. In addition, recent modeling analyses of radiological events and real-life events conclude that even small radiation releases and exposures below the levels that can cause immediate harm may have serious and long-term socioeconomic consequences. For example at the University of Washington, an accidental release of a very small amount of cesium-137 (a less than Category 3 amount) forced the relocation of 200 workers, interrupted 80 research projects, and will cost in excess of $100 million for full recovery, remediation, and reconstruction.

The study report recommends that the International Atomic Energy Agency, the U.S. Nuclear Regulatory Commission, and other organizations should consider reframing their source categorization schemes to account for both (a) probabilistic health impacts such as development of cancer later in life and (b) economic and social impacts. In parallel, the U.S. Nuclear Regulatory Commission should phase in tracking of Category 3 sources to help increase accountability for owning these sources and regulating their use.

PROGRESS IN DEVELOPING AND ADOPTING ALTERNATIVE TECHNOLOGIES

Progress with developing and adopting alternative technologies has been uneven across different applications and radionuclides (see Table S.1). The most notable progress is the worldwide adoption of x-ray technologies to replace the use of cesium-137 for blood and research irradiation. In the United States, that progress was facilitated in large part by financial incentives provided by the government. Also, in high- and many middle-income countries linear accelerators have almost entirely replaced cobalt-60 teletherapy.

For most applications, however, there are no broadly accepted replacement technologies. A progressive transition to alternative technologies is taking place in sterilization applications, with the use of electron-beam (e-beam) technologies in medical device sterilization increasing during the past 10 to 15 years both domestically and internationally. For some applications, for example well logging, no suitable replacement technology has been developed.

Several large companies are investing in research and development related to alternative technologies, but taking an idea to a commercial product can take years and requires substantial investments. Several smaller companies have alternative technology development projects under way with financial support from small business programs administered by NNSA.

To facilitate adoption of alternative technologies, the study report recommends:

- NNSA should prioritize funding for research and development projects that aim to develop alternatives where there are currently no acceptable nonradioisotopic technologies.
- NNSA should engage with federal partners such as the U.S. Department of Health and Human Services, the National Science Foundation (NSF), and the Food and Drug Administration to support equivalency studies for researchers who are considering replacing their cesium or cobalt research irradiators with alternative technologies.
- NNSA should engage with other offices within the U.S. Department of Energy, NSF, and professional societies to support equivalency studies for oil and gas well logging and industrial radiography service providers that are considering replacing their radioactive sources and adopting an alternative technology.
- The National Institute of Standards and Technology should engage immediately with the research community as well as federal, industry, and international partners to initiate research on alternatives to cesium chloride for calibration applications, to prepare for the possible future elimination of its use.

The report also contains a detailed table outlining findings about available alternatives, replacement challenges, adoption trends, and promising areas of research and development for each radioactive source.

REPLACEMENT IN LOW- AND MIDDLE-INCOME COUNTRIES

Consideration and adoption of alternative technologies for medical applications such as cancer therapy in low- and middle-income countries should take into account stark disparities in access to healthcare and resources. For example, adoption of alternative technologies for cancer therapy in some low- and middle-income countries has had unintended negative impacts on patient care because of lack of trained workforce, required resources, and infrastructure to make these alternatives viable options. In situations in which local resources and infrastructure cannot support alternatives, efforts should instead focus on enhancing security and assisting with infrastructure building.

PROMOTING THE USE OF ALTERNATIVE TECHNOLOGIES

Many national and international government and nongovernmental organizations have contributed to the increasing visibility of alternative technologies as a way to reduce security risks from radioactive sources. However, no organization is currently equipped to promote the broad range of alternative technologies and address adoption issues in a global context. An organization or network of organizations could unite technical, regulatory, financial, policy, and country-specific resource information to influence decisions about adopting alternative technologies and facilitate the transition to alternative technologies for medical, research, and commercial applications, where appropriate.