



December 2023

LOW-DOSE RADIATION

Agency Leadership and Collaboration Are Needed to Set the Direction of Future Research

Accessible Version

Why GAO Did This Study

Ionizing radiation comes from both natural sources and medical, commercial, and industrial activities. Prior research has not clearly identified how low doses of such radiation affect the health of millions of people exposed in various settings. The 2022 National Academies report found that a coordinated, multidisciplinary low-dose radiation research program could enable a better assessment of current risk estimates.

Congress included a provision in statute for GAO to review the activities of DOE's low-dose radiation research program. This report addresses the extent to which (1) DOE and selected agencies have efforts that can help address the findings and recommendations of the National Academies report and (2) DOE has developed a plan for addressing the findings and implementing the recommendations of the report.

GAO analyzed documents from DOE and three other agencies that fund or conduct low-dose radiation research and interviewed agency officials involved in low-dose radiation research, as well as officials from OSTP. GAO compared DOE's efforts to leading practices on interagency collaboration.

What GAO Recommends

GAO is making two recommendations for DOE's Office of Science to lead a collaborative effort for an interagency low-dose radiation research program and to work with Congress if the office finds that it should share or hand over leadership to another agency. DOE concurred with both recommendations.

View [GAO-24-106317](#). For more information, contact Candice N. Wright, 202-512-6888, WrightC@gao.gov.

LOW-DOSE RADIATION

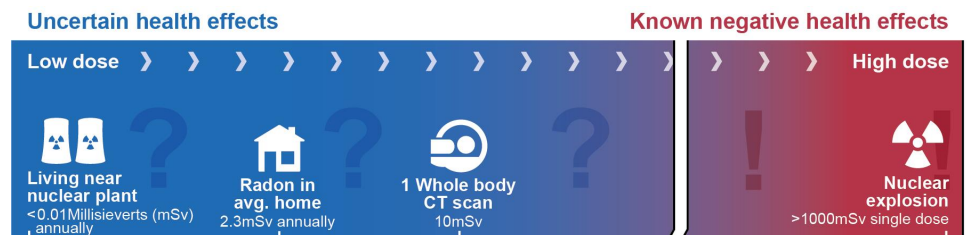
Agency Leadership and Collaboration Are Needed to Set the Direction of Future Research

What GAO Found

In 2018, Congress directed the Department of Energy (DOE) to carry out a research program on low-dose radiation and in 2020, directed DOE to enter into an agreement with the National Academies of Sciences, Engineering, and Medicine (National Academies) to develop a research agenda for that program. The National Academies issued a report in June 2022 with recommendations and priorities for a research program to better assess health effects of low-dose radiation (see figure).

DOE and three selected agencies involved in low-dose radiation research have some ongoing and planned efforts that can help address the findings and recommendations of the June 2022 report. DOE's Office of Environment, Health, Safety, and Security has long supported research on the health of people exposed to low-dose radiation. In addition, DOE's Office of Science resumed some low-dose radiation research activities in 2020 after ending its previous research program in 2016. The new research is focused on using artificial intelligence (AI) to better understand low-dose radiation biology. DOE invested \$22.3 million in this research in fiscal years 2020 through 2023. One of the funded projects uses AI to build a framework for estimating cancer risk based on long-term exposure to radiation. Other selected agencies continue to support and conduct research that generally aligns with agency specific missions, such as understanding cancer risk in people exposed to radiation and promoting occupational safety and health.

Figure: Human Health Effects of Low-Dose Exposure to Ionizing Radiation



Sources: Environmental Protection Agency (data); GAO (icons). | GAO-24-106317

Note: Low-dose radiation is a dose of less than 100 millisieverts (mSv). For details see fig. 1 in GAO-24-106317.

DOE's Office of Science—the sponsor of the National Academies report—has taken some steps in response to the report. According to DOE, its efforts—including plans to apply AI—are relevant to three of the 11 research priorities from the National Academies report. Currently, DOE does not have plans to expand its research to address the other priorities. However, DOE is seeking input from its advisory committee by spring 2024 on the potential scope of a program. Nevertheless, Office of Science officials told GAO that a low-dose radiation research program is not a priority because, among other reasons, the research might not reduce knowledge gaps enough to lead to changes in radiation protection regulations.

In 2020, Congress directed DOE to engage with other federal agencies as part of its low-dose radiation research program. Additionally, the National Academies called for coordination across federal agencies that carry out low-dose radiation research. However, DOE's Office of Science has not led a coordinated response to the National Academies report or worked with the Office of Science and Technology Policy (OSTP) or another agency to do so. By taking a leadership role for an interagency low-dose radiation research program or taking steps to initiate efforts with another agency, DOE could help to resolve uncertainty with low-dose radiation research in the United States.

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	Abbreviations	
	AFRRI	Armed Forces Radiobiology Research Institute

BERAC	Biological and Environmental Research Advisory Committee
CDC	Centers for Disease Control and Prevention
CT	computed tomography
DOD	Department of Defense
DOE	Department of Energy
DTRA	Defense Threat Reduction Agency
HHS	Department of Health and Human Services
NASA	National Aeronautics and Space Administration
National Academies	National Academies of Sciences, Engineering, and Medicine
NCI	National Cancer Institute
NCRP	National Council on Radiation Protection and Measurements
NIAID	National Institute of Allergy and Infectious Diseases
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety and Health
NSTC	National Science and Technology Council
OSTP	Office of Science and Technology Policy

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December 7, 2023

The Honorable Joe Manchin
Chairman
The Honorable John Barrasso
Ranking Member
Committee on Energy and Natural Resources
United States Senate
The Honorable Frank Lucas
Chairman
The Honorable Zoe Lofgren
Ranking Member
Committee on Science, Space, and Technology
House of Representatives

Ionizing radiation—which comes from both natural sources and medical, commercial, and industrial activities—has a number of beneficial uses but can also be harmful.¹ Long-term follow-up of exposed human populations, such as survivors of the 1945 atomic bomb attacks in Japan, as well as biological studies of laboratory animals, have shown that radiation at high doses causes cancer and other health effects. In contrast, low-dose radiation exposure is part of everyday life, and its health effects are harder to detect and identify. It can be more difficult to determine a causal relationship between a health outcome such as cancer or cardiovascular disease and exposure to low-dose radiation—for example, because such health outcomes have also been linked to other hazards and risk factors, such as smoking, diet, and genetic susceptibility.

Historically, the Department of Energy (DOE) has been the primary agency stewarding a low-dose radiation research program. In particular, DOE's Office of Science supported a research program on low-dose radiation from 1998 to 2016, when it ended the program to focus on bioenergy and environmental science priorities. DOE continued to fund some epidemiological research into low-dose radiation after the Office of Science ended its low-dose radiation research program, which supported laboratory-based research as well as epidemiological research. The National Institutes of Health (NIH) within the Department of Health and Human Services (HHS) and other federal agencies have also supported research to better characterize the health effects of exposure to low-dose radiation. In 2017, we reported that DOE, NIH and five other agencies

¹Ionizing radiation includes X-rays, gamma rays, and various types of atomic particles. This report uses the term "radiation" to refer to ionizing radiation.

had provided about \$210 million in funding for research on low-dose radiation's health effects in fiscal years 2012 to 2016.²

Since the end of the DOE Office of Science's low-dose radiation research program in 2016, Congress has shown an interest in restarting this research. Passed in January 2017, the American Innovation and Competitiveness Act required the National Science and Technology Council (NSTC) to formulate overarching scientific goals for the future of low-dose radiation research in the United States.³ In 2018, the Department of Energy Research and Innovation Act directed the DOE to carry out a research program on low-dose radiation.⁴ Amendments to this act in 2020 expanded on the requirements and components of the program.⁵ In particular, the amendments called for a program that would (1) enhance the scientific understanding of and reduce uncertainties associated with the effects of exposure to low-dose radiation and (2) inform improved risk assessment and risk management methods with respect to such radiation. In addition, the amendments directed DOE to engage with other federal agencies as part of the research program and to enter into an agreement with the National Academies of Sciences, Engineering, and Medicine (National Academies) to develop a long-term strategic and prioritized research agenda for the program.

In June 2022, through an agreement with DOE's Office of Science, the National Academies issued its report on developing a strategy for low-dose radiation research in the United States.⁶ In this report, the National Academies found that a coordinated, multidisciplinary low-dose radiation research program could enable a better assessment of whether current risk estimates for cancer at low doses are accurate, underestimated, or overestimated. If risk is underestimated, current protections (e.g.,

²GAO, *Low-Dose Radiation: Interagency Collaboration on Planning Research Could Improve Information on Health Effects*, [GAO-17-546](#) (Washington, D.C.: Sept. 2017).

³Pub. L. No. 114-329, § 106 (b), 130 Stat. 2969, 2986 (2017). NSTC is a cabinet-level council of advisers to the President established to coordinate the policy-making process for science and technology, among other things.

⁴Pub. L. No. 115-246, § 306, 132 Stat. 3130, 3148 (2018).

⁵Consolidated Appropriations Act, 2021, Pub. L. No. 116-260, § 11001, 134 Stat. 1182, 2610-12 (2020). As amended, the act defined low-dose radiation as a dose of less than 100 millisieverts and low dose-rate radiation as a dose rate of less than 5 millisieverts per hour. This report uses the term "low-dose radiation" to refer to both definitions. Millisieverts are a measure of the effectiveness of radiation to induce biological damage.

⁶National Academies of Sciences, Engineering, and Medicine, *Leveraging Advances in Modern Science to Revitalize Low-Dose Radiation Research in the United States* (Washington, D.C.: National Academies Press, 2022).

exposure limits for nuclear workers) do not sufficiently protect workers and the public. If risk is overestimated, unnecessary costs are being expended to reduce radiation exposure. The report also noted that a coordinated program could provide improved risk estimates for other adverse health outcomes, such as cardiovascular disease, neurological disorders, immune dysfunction, cataracts, and heritable genetic effects. The report called for an increase in funding over a sustained period of several decades and estimated that \$100 million annually would be needed during the first 10 to 15 years of the program.

The 2020 amendments to the Department of Energy Research and Innovation Act included a provision for GAO to report on the activities of DOE's low-dose radiation research program, the effectiveness of the coordination and management of the program, and the implementation of the research plan developed by the National Academies. This report examines the extent to which (1) DOE and selected agencies have existing efforts that can help address the findings and recommendations of the National Academies report and (2) DOE has addressed the findings and recommendations from the National Academies report.

To address these objectives, we analyzed agency program and budget documentation and conducted interviews with the four agencies we identified that fund or conduct terrestrial low-dose radiation research. These agencies included DOE, NIH and the Centers for Disease Control and Prevention (CDC) within HHS, and the Department of Defense (DOD). We assessed the reliability of agencies' funding amounts by reviewing corroborating documentation and determined that the data were sufficiently reliable for reporting on the scope of agencies' efforts. In addition, we spoke with officials from the White House Office of Science and Technology Policy (OSTP), which leads interagency science and technology policy coordination efforts and participated in developing the NSTC's 2022 report on radiation biology. We also interviewed a non-generalizable selection of nine subject matter experts about their views. Finally, we compared DOE's approach against leading practices on interagency collaboration that we identified in prior work.⁷ See appendix I for more information on the objectives, scope, and methodology.

We conducted this performance audit from October 2022 to December 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to

⁷GAO, *Government Performance Management: Leading Practices to Enhance Interagency Collaboration and Address Crosscutting Challenges*, [GAO-23-105520](#) (Washington, D.C.: May. 24, 2023).

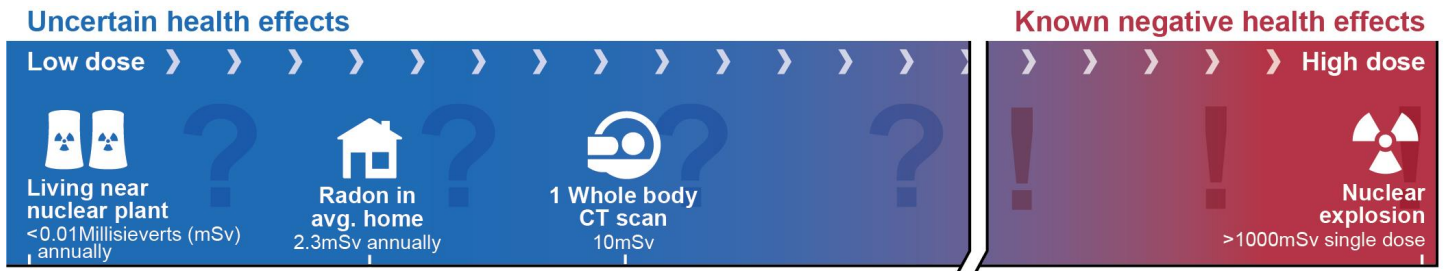
obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

As described in the June 2022 National Academies report on developing a strategy for low-dose radiation research, low-dose exposure is a high priority for radiation safety. In particular, the report cited a number of ways in which the U.S. population is exposed or could be exposed to low-dose radiation and for which a better understanding of health effects is needed. These include medical applications, occupational exposures, nuclear power routine operations and accidental releases, nuclear or radiological incidents, past nuclear weapons production and testing, and nuclear waste management. Occupations cited in the report included physicians and dentists, radiology and nuclear medicine technologists, workers employed in the nuclear power and fuel cycle industries, industrial radiographers, and aircrews.

The National Academies report noted that in the absence of clear evidence of risks at low doses of radiation, radiation protection is based on certain assumptions about the possible risks. In particular, the current system estimates cancer risks from low-dose radiation based on extrapolations of health effects observed in populations, such as survivors of the 1945 atomic bomb attacks in Japan, who were exposed to higher doses and different types of radiation. As such, there is greater uncertainty in the actual risk of cancer or other health effects, such as cardiovascular disease or neurological disorders, as a result of low-dose radiation exposure. Such uncertainties can complicate government decision-making—for example, about nuclear waste cleanup and handling of radiological material. Figure 1 illustrates the uncertain effects on health from common sources of radiation exposure below 100 mSv considered by the National Academies to be low dose, as opposed to the known effects of higher levels of exposure.

Figure 1: Human Health Effects of Low-Dose Exposure to Ionizing Radiation



Sources: Environmental Protection Agency (data); GAO (icons). | GAO-24-106317

Note: Low-dose radiation is defined as a dose of less than 100 millisieverts and a dose-rate of less than 5 millisieverts per hour. Millisieverts are a measure of the effectiveness of radiation to induce biological damage. This figure is a simplified illustration of example exposures and does not reflect variability in uncertainty over health outcomes for specific exposures.

The National Academies report also found that, among other things:

- A coordinated multidisciplinary low-dose radiation research program can improve understanding of adverse human health effects from low-dose exposure to radiation and enable better assessment of whether current risk estimates are accurate, underestimated, or overestimated.
- Significant investments over a sustained period spanning several decades—estimated at \$100 million annually during the first 10 to 15 years—are necessary to develop and maintain a multidisciplinary program.
- The DOE Office of Science’s shift in focus away from radiation health effects research in 2016 resulted in a lack of leadership and scientific activity in this area.

The report also included two recommendations based on its findings (see table 1). The first recommendation called for agencies responsible for the management of a multidisciplinary low-dose radiation program to fund low-dose radiation research on high-priority topics in three areas—epidemiological research, biology-based research, and research infrastructure. The second recommendation identified program components that agencies responsible for management of a multidisciplinary low-dose radiation research program should incorporate, such as a commitment to developing and maintaining a long-term multidisciplinary program and coordination across federal agencies.

Table 1: Recommendations from the National Academies Report on Low-Dose Radiation Research

Recommendation category	Recommendation details
Research priorities	<p>This recommendation called for agencies responsible for the management of a multidisciplinary low-dose radiation program to fund research on high-priority topics in three areas.</p> <p>Epidemiological research goals: (1) develop and deploy analytical tools, (2) improve estimation of risks for cancer and non-cancer health outcomes, and (3) determine factors that modify adverse health effects.</p> <p>Biological research goals: (1) develop model systems for study of health effects, (2) develop biomarkers for adverse health outcomes, (3) define dose-response relationships, and (4) identify factors that modify or confound estimation of risks for adverse health outcomes.</p> <p>Research infrastructure goals: (1) tools for detection and characterization of aberrant cell and tissue states, (2) harmonized databases to support biological and epidemiological studies, (3) dosimetry for low-dose and low-dose-rate exposures, and (4) facilities for low-dose and low-dose-rate exposures.</p>
Program components	<p>This recommendation identified program components that agencies responsible for management of a multidisciplinary low-dose radiation research program should incorporate, including:</p> <ol style="list-style-type: none"> 1. Commitment to developing and maintaining a long-term multidisciplinary program 2. Independent scientific advice and program evaluation by a trusted entity 3. Transparent management of the research process 4. Prioritized strategic research agenda developed with stakeholder input 5. Research sponsorship mechanisms that support competitive projects and employ transparent peer review 6. Training and research support for scientists of all career levels and relevant disciplines that promote equity, diversity, and inclusion 7. Commitment to engagement and communication with stakeholder communities 8. Coordination across federal agencies and other national and international organizations

Source: GAO analysis of the June 2022 report from the National Academies of Science, Engineering, and Medicine (National Academies) on developing a long-term strategic and prioritized research agenda for a low-dose radiation research program. | GAO-24-106317

Two other reports since the end of DOE’s low-dose radiation research program in 2016 have recommended a path forward for low-dose radiation research in the United States. In September 2017, we reported on selected federal agencies’ radiation protection requirements and guidance and on federal agencies’ research on low-dose radiation’s health effects.⁸ We found that agencies had collaborated on individual projects about radiation’s health effects but had not established a collaborative mechanism to set research priorities. In addition, we found that DOE could play an important role in helping federal agencies establish a coordinating mechanism because of its experience as a leader in this area of research. We recommended that DOE lead the

⁸GAO-17-546.

development of such a mechanism. DOE addressed the recommendation through its sponsorship of the National Academies study, which included addressing coordination between federal agencies and with international efforts.

In 2022, in response to requirements within the American Innovation and Competitiveness Act, the NSTC released a report to advise on policies and initiatives in radiation biology, identify opportunities to stimulate international collaboration, ensure coordination between federal agencies, identify ongoing scientific challenges, and formulate scientific goals for the future of low-dose radiation research.⁹ The agencies in our review—DOE, DOD, NIH, and CDC—and other agencies with a role in radiation protection participated in developing the report. The NSTC report stated that low-dose radiation research could decrease uncertainties in health risks and have significant implications for radiation protection worldwide. In addition, the report recommended the establishment of a new interagency collaboration mechanism to advance low-dose radiation research.

DOE Has Resumed Low-Dose Radiation Research and Other Agencies Have Continued Research Activities

DOE and the three selected federal agencies have existing efforts that can help address the findings and recommendations of the National Academies report on developing a strategy for low-dose radiation research in the United States. In particular, DOE's Office of Science resumed some low-dose radiation research activities in 2020. Other agencies and DOE's Office of Environment, Health, Safety and Security continued their ongoing efforts to conduct and support other low-dose radiation research efforts.

Existing DOE Efforts

DOE has two existing sets of activities that can help address the findings and recommendations of the National Academies report: (1) a recently started project in the Office of Science using DOE's high-performance computing capabilities and (2) long-standing support for epidemiological

⁹National Science and Technology Council, *Radiation Biology: A Response to the American Innovation and Competitiveness Act*, Jan. 2022.

research in the Office of Environment, Health, Safety and Security. The DOE Office of Science initiated its project in response to language that Congress included in explanatory statements to appropriations acts. The acts directed \$5 million for low-dose radiation research in fiscal year 2020, no less than \$5 million in fiscal year 2021, \$8 million in fiscal year 2022, and up to \$20 million in fiscal year 2023.

The purpose of the high-performance computing project is to evaluate the potential of artificial intelligence (AI) to advance the understanding of low-dose radiation biology. For example, the project's objectives include using AI-based approaches to examine the molecular basis for low-dose radiation response and creating a computational framework that could help estimate the effects of radiation exposure. According to Office of Science officials, the project builds on DOE's collaboration with the National Cancer Institute (NCI) to include research on low-dose radiation. In particular, DOE and NCI signed a memorandum of understanding in 2016, which they renewed in 2021, to collaborate on the development of advanced computing solutions for cancer and related research activities. According to the memorandum of understanding, the collaboration brings together DOE's lead role in high-performance computing research, development, and deployment and NCI's mission to lead, conduct, and support cancer research.¹⁰

According to the Office of Science, the high-performance computing project is a separately funded activity that does not involve NCI but draws from the two agencies' existing collaborative project using advanced computational techniques for cancer research. NCI officials stated that the tools and data resources developed through its collaboration with DOE are potentially relevant for future low-dose radiation research and that NCI and DOE have discussed opportunities for DOE's high-performance computing capabilities to enable such research.

Office of Science officials said that the focus of its high-performance computing project is on addressing knowledge gaps regarding cancer and not on other health effects, but that it would be possible to extend the project's computational methods to other health effects. According to the National Academies report, there are also knowledge gaps regarding—but increasing evidence for—associations between low-dose radiation

¹⁰For more information on DOE's lead role in this area of research, see GAO, *High-Performance Computing: Advances Made Towards Implementing the National Strategy, but Better Reporting and a More Detailed Plan Are Needed*, [GAO-21-104500](#) (Washington, D.C.: Sept. 30, 2021).

exposure and non-cancer health outcomes such as cardiovascular disease and neurological disorders.

Three DOE national laboratories—Argonne, Brookhaven, and Oak Ridge—have collaborated on the high-performance computing project. The Office of Science provided \$22.3 million to the three laboratories for the project in fiscal years 2020 through 2023 (see table 2). Office of Science officials said that if the program grows, they could extend their support to include academic research on low-dose radiation.

Table 2: DOE Funding for the Application of High-Performance Computing to Low-Dose Radiation Research, by National Laboratory, Fiscal Years (FY) 2020 to 2023

Dollars are in millions and have not been adjusted for inflation

DOE National Laboratory	FY2020	FY2021	FY2022	FY2023	Total
Argonne	2.2	2.6	1.9	3.5	10.2
Oak Ridge	1.4	1.0	1.4 ^a	2.5	6.3
Brookhaven	1.4	1.0	1.4	2.0	5.8
Total	5.0	4.6	4.7	8.0	22.3

Source: GAO analysis of funding information provided by Department of Energy (DOE) officials. | GAO-24-106317

^aThe Department of Energy (DOE) provided an additional \$2.9M to Oak Ridge National Laboratory in FY 2022 as part of a collaborative effort that never materialized. DOE plans to repurpose this additional funding for an FY 2024 funding opportunity. GAO's final calculations for DOE funding do not include this \$2.9M.

Million Person Study

Epidemiological studies aim to examine the health effects of chronic exposure to low levels of radiation. One such study, the Million Person Study, tracks American workers and veterans throughout the 20th century, including hundreds of thousands of workers at nuclear weapon and processing facilities, nuclear power plant workers, and radiation workers.

A key aim of the study is to provide scientific evidence for sound radiation protection policy and recommendations by evaluating radiation risks among healthy American workers and veterans. For example, the study examines the lifetime risk of cancer among radium dial painters. These workers, mainly women, painted dials and instruments with radium paint in the early 1900s—sometimes using their lips to finely point the paint brushes.



Source: Wikimedia Commons/Public Domain.

DOE's Office of Environment, Health, Safety and Security can also help address the findings and recommendations of the National Academies report through its support for epidemiological studies. The office's role in these studies stems from the Atomic Energy Act of 1957, which according to DOE assigns the agency responsibility for research related to nuclear energy, including the protection of health during activities that can result in exposure to radiation. In particular, the office focuses on the protection of DOE workers and residents of neighboring communities.

The Office of Environment, Health, Safety and Security supports both domestic and international studies. For example, the office supports the Million Person Study through a grant to the National Council on Radiation Protection and Measurements (see sidebar). The study began in 2007 and includes plans to examine mortality statistics on multiple cohorts (populations) of over a million U.S. radiation workers, veterans, and other individuals. DOE is one of multiple agencies that has provided funding for

the study. According to Office of Environment, Health, Safety and Security officials, the office has provided between \$500,000 and \$1 million per year for the study from fiscal years 2017 to 2023. The office also manages the Comprehensive Epidemiologic Data Resource as a data repository for researchers derived from epidemiologic studies of DOE workers at large nuclear weapons plants. Similarly, the office supports a program that obtains human tissue samples or posthumous whole-body donations from volunteers who had documented intakes of uranium and transuranium elements from having worked at government sites during the development of nuclear weapons. The program preserves these samples and makes them available for future research.

An example of the office's support for international studies is its support for a program that focuses on the impact of radiation exposure on atomic bomb survivors in Japan. Another study focused on workers exposed to low-dose radiation in Russia; however, this study was operating in collaboration with Russian scientists and stopped due to the war in Ukraine.

Selected Agencies' Efforts

The other selected federal agencies in our review—NIH, CDC, and DOD—have supported ongoing efforts in low-dose radiation research and publication of research findings. These efforts can help address the findings and recommendations of the National Academies report but were not a response to the report. The agencies supported the research in accordance with their individual agency missions rather than as part of a broader interagency research agenda. See table 3 for a summary of selected agencies' recent low-dose radiation research activities and relevant mission requirements.

Table 3: Descriptions of Other Federal Agencies’ Missions and Low-Dose Radiation Research Activities Since 2017

Agency	Agency mission for low-dose radiation research	Research activities and funding
National Institutes of Health (NIH)	Intramural (internal) research program of the National Cancer Institute’s (NCI) Radiation Epidemiology Branch	Understand cancer risk in populations exposed to medical, occupational, or environmental radiation
	NCI investigator-initiated extramural (external) research	The program conducts epidemiological studies of populations exposed to radiation that include low-dose exposures. Examples include investigation of thyroid cancer and transgenerational effects from the Chernobyl nuclear power plant incident, cancer incidence among U.S. radiologic technologists, and cancer risks associated with computed tomography (CT) scans in childhood; and development of tools for estimating organ doses from medical exposures (no funding estimate available)
	NCI Radiation Oncology Branch	Two epidemiological studies on medically exposed patients and an international cohort of workers (about \$5 million in funding through fiscal year 2023)
	National Institute of Allergy and Infectious Diseases (NIAID) Radiation and Nuclear Countermeasures Program	Plan and conduct research on the biologic and therapeutic effects of radiation
Centers for Disease Control and Prevention (CDC)	National Center for Environmental Health	No recent studies on low-dose radiation
	National Institute for Occupational Safety and Health (NIOSH)	Through a collaborative agreement with NCI, supported research on the health impacts of high-dose radiation exposure with findings relevant to low-dose radiation
Centers for Disease Control and Prevention (CDC)	National Center for Environmental Health	Provide technical assistance and training to help preparedness professionals and communities be ready for a radiation emergency
	National Institute for Occupational Safety and Health (NIOSH)	Develop and transfer into practice new knowledge in the field of occupational safety and health
		Supported five epidemiological studies (three internal and two external) related to occupational exposure to low-dose radiation (about \$3.8 million in funding since fiscal year 2017)

Letter

Agency	Agency mission for low-dose radiation research	Research activities and funding
Department of Defense (DOD)	Armed Forces Radiobiology Research Institute (AFRRI) Protect the health and performance of U.S. military personnel operating in radiologically contaminated environments	Supported two studies on the effects of low and chronic gamma radiation on humans, including a study mimicking a realistic military radiation exposure to measure the impact on soldiers' organs (\$0.5 million in funding for fiscal years 2020 to 2023)
Defense Threat Reduction Agency (DTRA)	Low-dose radiation research is currently not part of DTRA's mission	Provided support for inclusion of atomic veterans in epidemiological studies conducted by other organizations, such as the Million Person Study (no funding estimate for support activities)

Source: GAO analysis of research program and budget information from NIH, CDC, NIOSH, and AFRRI. | GAO-24-106317

NCI officials stated that many of the knowledge gaps outlined in the National Academies report were known prior to the report and that NCI had been working for many years to address them. For example, NCI cited the agency's leadership of an international, interdisciplinary effort to summarize epidemiologic evidence for radiation-related cancer risks, which resulted in publication of a series of papers in 2020. The papers found that studies published since 2006 showed excess cancer risks from low-dose radiation and that the magnitude of the risks was statistically compatible with the cancer risks experienced by atomic bomb survivors.

NCI also cited its development of tools for estimating the radiation doses absorbed by organs in patients undergoing diagnostic procedures as a recent advance. According to NCI, these tools were the product of years of research and development.¹¹ The National Academies report included recommendations for improvements to such tools as one of the research infrastructure goals for low-dose radiation research.

NIOSH officials also described advances in low-dose radiation research and plans to continue the agency's research activities. For example, NIOSH contributed to a study published in August 2023 that found positive associations between radiation exposure and elevated rates of

¹¹Radiation Dosimetry Tools: NCIDose. National Cancer Institute. <https://dceg.cancer.gov/tools/radiation-dosimetry-tools>

mortality for lung cancer in U.S. nuclear workers, among other findings.¹² In addition, NIOSH officials said that they plan to remain involved in the International Nuclear Workers Study, a multi-year study that includes over 300,000 workers from France, the United Kingdom, and the United States. CDC stated that participants in this study all experienced a similar form of radiation exposure, which has simplified the assessment of doses and interpretation of results. According to CDC, the study has found significant associations between low-dose exposure and leukemia and solid cancers.

Officials from the Armed Forces Radiobiology Research Institute (AFRRI), which focuses on health effects of radiation on military personnel, stated that it had conducted limited research in low-dose radiation in the last 5 years. In addition, officials stated that such research was not well-funded in DOD compared to chemical and biological areas. As a result, AFRRI officials said that there is an unmet need for evaluating low-dose health effects, particularly for combat personnel conducting their operations in a post-nuclear detonation environment.

DOE Has Taken Some Steps in Response to the National Academies Report but Has Not Coordinated with Other Agencies

Steps to Address Research Priorities

DOE's Office of Science—the sponsor of the June 2022 National Academies report on low-dose radiation research—has taken some steps to respond to the report. Specifically, it has:

- Continued its earlier plans to apply artificial intelligence techniques to low-dose radiation research,
- Added low-dose research to its fiscal year 2024 budget request to Congress, and

¹²Kaitlin Kelly-Reif and others, "Ionizing radiation and solid cancer mortality among US nuclear facility workers," *International Journal of Epidemiology*, Volume 52, Issue 4, August 2023, Pages 1015–1024, <https://doi.org/10.1093/ije/dyad075>. This study included over 100,000 workers across five US nuclear facilities. The authors note important study limitations including potential confounding by unmeasured environmental and occupational co-exposures.

- Sought advisory committee input on the potential scope of a low-dose program.

However, we found that these steps do not address most of the research priorities that the National Academies report identified.

According to a January 2023 Office of Science presentation to the National Academies, DOE plans to address the National Academies report primarily through a computational project it began in fiscal year 2020. According to the Office of Science, a potential outcome of this project is to use artificial intelligence techniques to identify patterns in disparate genomics, cancer treatment, and radiation exposure data. These patterns could lead to hypotheses regarding cancer and low-dose radiation exposure, which further research could test. According to the Office of Science, this line of work will generate hypotheses relevant to three of the 11 research priorities identified in the National Academies report. Specifically, it would be relevant to these priorities to:

- Improve estimation of risks for cancer and non-cancer health outcomes from low-dose radiation exposures,
- Develop biomarkers for radiation-induced adverse health outcomes, and
- Develop tools for detection and characterization of aberrant cell and tissue states.

In its January 2023 presentation, an Office of Science official announced that it would begin including funding for low-dose radiation research in its annual budget request to Congress. Also, the official told us that DOE's Office of Science fiscal year 2024 budget request included \$10 million for this research. In April 2023, the Office of Science requested input from the Biological and Environmental Research Advisory Committee (BERAC), which advises the Office of Science on scientific and technical issues that arise in its biological and environmental research program. In particular, the Office of Science requested that BERAC provide a report by spring 2024 with input on the potential scope of a low-dose radiation research program. The request directed BERAC to consider (1) whether there are existing capabilities and expertise within the Office of Science's biological and environmental research program that could be employed in low-dose radiation research; (2) whether a program of basic research could be identified using DOE's capabilities to make specific advances toward understanding the effects of low-dose radiation exposure on human biological systems; and (3) whether the program would be non-

duplicative and complementary to efforts in other agencies, such as NIH, and whether there would be opportunities to leverage such efforts.

However, the DOE Office of Science does not currently have plans for expanding its research to address the eight research priorities from the National Academies report that are not part of its current computational efforts. Moreover, officials told us that low-dose radiation research is not a priority for the office and provided several reasons for not making it a higher priority. For example, they told us that they look to the presidential administration's R&D priorities, as issued by OSTP and the Office of Management and Budget. According to these officials, the administration's priorities do not include low-dose radiation research.¹³ DOE Office of Science officials also questioned whether the large investment in low-dose radiation research envisioned by the National Academies report would reduce knowledge gaps enough to result in changes to radiation protection regulations. During the January 2023 presentation, an Office of Science official pointed out that DOE's previous low-dose radiation research program produced fundamental discoveries but had little impact on regulations and did little to ameliorate public fear of radiation.

The director of radiation health studies in DOE's Office of Environment, Health, Safety and Security stated that the office has not addressed any of the findings or recommendations from the National Academies report. The official agreed with the report's focus on collaboration and stated that DOE could play a role in leading a low-dose radiation research program, including an effort to coordinate with agencies outside of DOE. Further, this official said that coordination of low-dose radiation research across agencies is important to prevent overlapping efforts or gaps in important research.

Steps to Coordinate Across Agencies

Under the Department of Energy Research and Innovation Act, DOE is to carry out a low-dose radiation research program to enhance scientific knowledge and reduce uncertainties in the field. DOE is also directed to engage with other federal agencies as part of a research program on low-dose radiation. In addition, the National Academies stated in its report that for the program to succeed, it will need mechanisms for coordination across federal agencies that carry out low-dose radiation research or

¹³According to OSTP officials, agencies are not precluded from pursuing research that falls within their missions but that is not included in the administration's R&D priorities.

have relevant expertise. The report noted that its proposed research agenda extends beyond the resources of a single federal agency and thus requires coordination. Similarly, the NSTC's January 2022 report on radiation biology recommended the establishment of a new interagency coordination mechanism.

However, DOE's Office of Science has not led a coordinated response to the National Academies report or worked with another agency to do so. Office of Science officials told us that DOE can play a role in the low-dose radiation research program, but that NIH might be better suited to lead it given its focus on public health. In the Office of Science's April 2023 letter requesting that BERAC provide input on the potential scope of a low-dose radiation research program, the office did not indicate that it would take an interagency leadership role.¹⁴ The letter instead directed the committee to consider the missions of DOE and other agencies, such as NIH and National Aeronautics and Space Administration (NASA), and to provide input on how the Office of Science could complement the efforts of other agencies.

Moreover, the Office of Science has not worked with OSTP on how to respond to the National Academies report. According to OSTP, its mission includes working with federal departments and agencies and with Congress to create unified strategies and clear plans for science and technology. In addition, it leads interagency science and technology policy coordination efforts.

The National Academies report raised concerns that DOE does not meet important criteria for an effective managing agency for a low-dose program, such as a commitment to the program. It also expressed support for DOE leading a portion of the strategic research agenda, such as computational research, and NIH leading the epidemiological and biological research. Nevertheless, the report noted that DOE is the only entity that Congress has tasked with a focused low-dose radiation program. The National Academies report also stated that DOE is the most viable option for immediately reestablishing a program.

The nine subject matter experts we interviewed had differing views on which body should lead a low-dose radiation research program. However, they all agreed that interagency collaboration with a lead agency or

¹⁴Letter from the Department of Energy Office of Science to the Biological and Environment Research Advisory Committee (BERAC). April 6, 2023. https://science.osti.gov/-/media/ber/berac/pdf/202304/2023-183_BERAC_Low_Dose_Charge_Letter_AA-Berhe-Signed.pdf

consortium is necessary to ensure such a program meets its goals.¹⁵ Most experts we spoke with said that an agency besides DOE could lead low-dose radiation research efforts. For example, many said that agencies within HHS could lead a low-dose radiation research program. Many experts said that certain agencies, such as NASA and NIAID, have staff with expertise in low-dose radiation research and are therefore better able to guide such research than DOE's Office of Science.

Officials from selected agencies also provided varying views on the appropriate leadership for a low-dose radiation research program:

- Some officials from AFRRRI and DOE's Office of Science suggested that an agency other than DOE, such as HHS, could lead low-dose radiation research efforts. DOD officials pointed out that regardless of who leads the research the leading agency or groups should take into consideration low-dose radiation exposure scenarios relevant to DOD and first responders. AFRRRI officials also echoed concerns raised in the National Academies report that DOE has a perceived conflict of interest on low-dose radiation research given that it also has a role in regulating radiation protection.
- An official from DOE's Office of Environment, Health, Safety and Security said that DOE could act as the lead agency on occupational epidemiological low-dose radiation studies because it has institutional experience, existing epidemiological programs, and access to large data sets from decades of research.
- NIH officials disagreed with the suggestion that it would be better suited than DOE to lead a low-dose radiation research program. In particular, officials noted that NIH's most relevant areas of expertise and ongoing research focus on the evaluation of health risks from radiation exposures across a range of doses. The officials stated that, while NIH supports research on low-dose exposure, exclusive focus on exposures at the lowest doses is not directly aligned with NIH priorities. NIH officials also stated that its subject matter experts could offer expertise and input as DOE's Office of Science determines the scope and areas of focus for its low-dose radiation research program.

Identifying and sustaining leadership and clarifying agency roles and responsibilities are two leading practices for interagency collaboration that

¹⁵When summarizing responses from the nine subject matter experts we interviewed, we used "some" to refer to two to three subject matter experts, "many" to refer to four to six, and "most" to refer to seven to nine.

we have identified in prior work.¹⁶ By not taking a leadership role for an interagency low-dose radiation research program, DOE cannot effectively engage with other federal agencies as required under the amended Department of Energy Research and Innovation Act. In addition, by initiating efforts to share leadership with another agency as an alternative to taking a sole leadership role and clarifying agencies' roles and responsibilities, DOE would be better positioned to determine future steps to inform a research program for low-dose radiation. Doing so would help resolve uncertainty with the future of low-dose radiation research in the United States.

Conclusions

DOE, NIH, and other agencies have long-standing efforts that could be part of the multidisciplinary program envisioned by the National Academies in its June 2022 report on developing a strategy for low-dose radiation research in the United States. DOE, DOD, NIH, and CDC generally conduct research activities in accordance with their respective agency missions, rather than as part of a larger program. Recent studies supported by these agencies have helped to better understand the potential health risks from low-dose radiation exposure. Furthering an understanding of those risks, including from the variety of ways in which the U.S. population is exposed to low-dose radiation, can help inform radiation safety practices and standards.

However, DOE—the agency tasked by Congress to carry out a low-dose radiation research program—has not led a coordinated response to the National Academies report. The report expressed support for DOE and another agency leading different portions of the research, but DOE has not initiated efforts to share leadership. In addition, it has not coordinated a response to the National Academies report with OSTP, which has an interagency coordination role. DOE's Office of Science, which sponsored the report, has prioritized other types of research over further research on the health effects of low-dose exposure to radiation.

The National Academies report noted that its proposed research agenda extends beyond the resources of a single federal agency and requires coordination. Further, our leading practices for interagency collaboration call for agencies to identify and sustain leadership and to clarify roles and responsibilities. By taking a leadership role for an interagency low-dose radiation research program or taking steps to initiate efforts with another

¹⁶[GAO-23-105520](#).

agency, DOE could help to resolve uncertainty with low-dose radiation research in the United States.

Recommendations for Executive Action

We are making the following two recommendations to DOE:

The Secretary of Energy should ensure that the Director of the Office of Science leads a collaborative effort with all other relevant agencies to determine how to respond to the National Academies report, including clarifying roles and responsibilities for a research program on low-dose radiation. (Recommendation 1)

If in the process of leading a collaborative effort, the Office of Science finds that it should share or hand over leadership to another agency, the Secretary of Energy should ensure that the Director of the Office of Science or other designee work with Congress to determine how best to meet DOE's statutory requirements under the Department of Energy Research and Innovation Act. (Recommendation 2)

Agency Comments

We provided a draft of this report to DOD, DOE, HHS, and OSTP for review and comment. DOE provided written comments, which are reproduced in appendix II. In its written comments, DOE concurred with our recommendations and identified steps it plans to take to implement them. DOE and HHS also provided technical comments, which we incorporated as appropriate. DOD and OSTP did not provide any comments.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Energy, the Secretary of Defense, the Secretary of Health and Human Services, and other interested parties. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-6888 or wrightc@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Letter

A handwritten signature in black ink that reads "Candice N. Wright". The signature is written in a cursive style with a large initial 'C' and 'W'.

Candice N. Wright
Director
Science, Technology Assessment, and Analytics

Appendix I: Objectives, Scope, Methodology

Our objectives were to examine the extent to which (1) DOE and selected agencies have existing efforts that can help address the findings and recommendations of the National Academies report and (2) DOE has developed a plan for addressing the findings and implementing the recommendations from the National Academies report.¹

The scope of our review included the following agencies that engaged in terrestrial research on the health effects of low-dose ionizing radiation exposure:

- Department of Energy (DOE), including the Office of Science and Office of Environment Health, Safety and Security;
- Department of Defense (DOD), including the Armed Forces Radiobiology Research Institute (AFRRI) and the Defense Threat Reduction Agency (DTRA);
- Department of Health and Human Services' (HHS) National Institutes of Health (NIH), including the National Cancer Institute (NCI) and the National Institute of Allergy and Infectious Diseases (NIAID); and
- HHS' Centers for Disease Control and Prevention (CDC), including the National Institute for Occupational Safety and Health (NIOSH).

We selected agencies that we identified in our 2017 report on low-dose radiation as having funded or conducted low-dose radiation research.² We confirmed our agency selections by reviewing a January 2022 National Science and Technology Council (NSTC) report on radiation biology, which included descriptions of agency missions and their relevance to low-dose radiation.³ We did not include agencies that use research on the health effects of low-dose radiation to inform their work

¹National Academies of Sciences, Engineering, and Medicine, *Leveraging Advances in Modern Science to Revitalize Low-Dose Radiation Research in the United States* (Washington, D.C.: National Academies Press, 2022).

²GAO, *Low-Dose Radiation: Interagency Collaboration on Planning Research Could Improve Information on Health Effects*, [GAO-17-546](#) (Washington, D.C.: Sept. 26, 2017).

³National Science and Technology Council, *Radiation Biology: A Response to the American Innovation and Competitiveness Act* (Jan. 2022).

but that do not fund or participate in the research. Additionally, we excluded the National Aeronautics and Space Administration because its low-dose radiation research efforts are focused on non-terrestrial radiation.

To examine the extent to which DOE and selected agencies have existing efforts that can help address the findings and recommendations of the National Academies report, we reviewed documentation about low-dose radiation research programs, funding, and results provided to us by DOE, DOD, NIH, and CDC. These documents included DOE and selected agencies' program and research activity descriptions, funding amounts and progress updates for research activities, and descriptions of interagency collaboration. In particular, we requested documentation on agencies efforts in fiscal years 2017 to 2022. To assess the reliability of funding amounts, we asked the agencies to provide documentation to corroborate any funding amount that was discussed during interviews with officials. We also reviewed appropriation legislation from fiscal years 2017 to 2023 related to DOE's low-dose radiation research efforts. We determined that the data were sufficiently reliable for reporting on the scope of agencies' research on the health effects of low-dose radiation.

We also interviewed officials with a role in managing or conducting low-dose radiation research at each of the agencies and obtained detailed follow-up information from agencies as needed. In our interviews, we asked officials about their agencies' roles in developing low-dose radiation research goals, research activities and related funding amounts over the past 5 years, and key research outcomes and advances.

To examine the extent to which DOE has developed a plan for addressing the findings and implementing the recommendations to DOE from the National Academies report, we interviewed DOE officials about their plans for implementing a low-dose radiation research program. We asked DOE and other agency officials about the National Academies report, including their views on the report's findings and recommendations. We also interviewed Office of Science and Technology Policy (OSTP) officials about the National Academies report given the report's findings on coordination of research and OSTP's role in leading interagency science and technology policy coordination efforts.

In addition, we asked agency officials about interagency collaboration on low-dose radiation research activities and their perspectives on what group, government agency, or body should perform this research and who should act as the primary coordinating body. We also reviewed

DOE's 2023 letter to the *Biological and Environmental Research Advisory Committee* (BERAC) and its fiscal year 2024 budget request. Finally, we compared DOE's approach against our previously identified leading practices on interagency collaboration and selected those practices which identify and sustain leadership and clarify roles and responsibilities.⁴ We focused on these leading practices because our 2017 report and the 2022 National Academies report both identified a lack of leadership for low-dose radiation research and because defining how a collaborative effort will be led is part of the leading practice for clarifying roles and responsibilities.

For both objectives, we reviewed the findings and recommendations of the National Academies report and identified the ones that were most critical for our report objectives. In particular, we focused on the report's findings and recommendations on developing a coordinated multidisciplinary program and establishing leadership because of the importance of these factors to the future of low-dose radiation research in the United States. For further context, we interviewed the chair of the National Academies committee and the National Academies study director for the report.

We worked with a GAO research librarian to conduct a literature search of low-dose radiation research funded by U.S. agencies or written by agency-affiliated authors. The librarian conducted literature searches within databases such as Scopus and PubMed. We conducted a broad search of materials published within the last 10 years, including scholarly articles and government reports. From these searches, we identified and selected relevant articles to include in our review. We used the results of our literature review to inform our findings.

We also interviewed a non-generalizable selection of nine subject matter experts about their views on the state of low-dose radiation research, the efforts of DOE and other agencies in this area of research, and the appropriate agency or agencies for leading a low-dose radiation research program. We developed a list of potential experts to interview through our review of publications and literature about low-dose radiation research. We selected subject matter experts from our list to include a mix of

⁴GAO, *Government Performance Management: Leading Practices to Enhance Interagency Collaboration and Address Crosscutting Challenges*, [GAO-23-105520](#) (Washington, D.C.: May. 24, 2023).

individuals with expertise in radiation epidemiology and radiation biology research. We interviewed five biologists and four epidemiologists from a range of academic institutes and organizations, such as the National Council on Radiation Protection and Measurements (NCRP). We conducted semi-structured interviews with each expert using the same set of questions for each interview, while allowing for additional follow-up questions specific to an interviewee's responses or context. The views of these experts are not generalizable to all subject matter experts in the low-dose radiation field. When summarizing responses from the nine subject matter experts, we used "some" to refer to two to three subject matter experts, "many" to refer to four to six, and "most" to refer to seven to nine. We also attended and reviewed selected presentation materials from subject matter experts who participated in the 2023 NCRP conference.

We conducted this performance audit from October 2022 to December 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Comments from the Department of Energy



Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

November 9, 2023

Ms. Candice N. Wright
Director
Science, Technology Assessment, and Analytics
Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Ms. Wright:

The Department of Energy (DOE), Office of Science appreciates the opportunity to comment on the Government Accountability Office's (GAO) draft report titled, "*Low Dose Radiation: Agency Leadership and Collaboration are Needed to Set the Direction of Future Research (GAO-24-106317)*." The draft report contains two recommendations. DOE agrees with the recommendations with details provided in the enclosure.

DOE will lead a discussion to gain meaningful collaborative and integrative support among agencies with relevant capabilities for conducting low dose radiation research. A recent strategic plan published by the National Academies outlines an extensive research portfolio best accomplished through capabilities resident in multiple Federal agencies. If in the process of leading discussions among agencies, the Office of Science finds that it should share or hand over leadership to another agency, DOE will work with Congress on how best to meet DOE's statutory requirements under the Department of Energy Research and Innovation Act.

GAO should direct any questions to Todd Anderson in the Office of Biological and Environmental Research at 301-903-5469 or todd.anderson@science.doe.gov.

Sincerely,

A handwritten signature in blue ink that reads "Asmeret Asefaw Berhe".

Asmeret Asefaw Berhe
Director, Office of Science

Management Response
GAO Draft Report, “Low Dose Radiation: Agency Leadership and Collaboration Are Needed to Set the Direction of Future Research (GAO-24-106317)”

Recommendation 1: The Secretary of Energy should ensure that the Director, Office of Science leads a collaborative effort with all other relevant agencies to determine how to respond to the National Academies report, including clarifying roles and responsibilities for a research program on low-dose radiation.

DOE Response: Concur

The National Academies report outlines an extensive plan for low dose radiation research over a 15-year timeline with funding needs of \$100M per year. A program of that scale would require multi-agency commitment to long-term support and dedicated funding trackable through the budget process. The National Academies’ plan is structured to apply to related efforts ongoing in multiple agencies.

DOE will lead discussions with senior leaders from multiple agencies, including the Office of Science and Technology Policy as appropriate, on how to collaboratively address the plan put forth by the National Academies. However, DOE cannot compel actions by other agencies to conduct collaborative research on low dose, which would be subject to available funding for the other agencies.

Estimated Completion Date: DOE will complete interagency discussions by September 30, 2024.

Recommendation 2: If in the process of leading a collaborative effort, the Office of Science finds that it should share or hand over leadership to another agency, the Secretary of Energy should ensure that the Director of the Office of Science or other designee work with Congress to determine how best to meet DOE’s statutory requirements under the Department of Energy Research and Innovation Act.

DOE Response: Concur

DOE concurs with the recommendation. If in the process of leading discussions among agencies, the Office of Science finds that it should share or hand over leadership to another agency, DOE will coordinate with the Office of Science and Technology Policy, as appropriate, to communicate DOE’s plans to meet the statutory requirements under the Department of Energy Research and Innovation Act, consistent with available funding and planned complementary work to be performed by other agencies.

Estimated Completion Date: DOE will complete interagency discussions by September 30, 2024 and communicate to Congress its plans to implement the statutory requirements of the Department of Energy Research and Innovation Act by April 1, 2025.

Text of Appendix II: Comments from the Department of Energy

Ms. Candice N. Wright Director

Science, Technology Assessment, and Analytics Government Accountability Office

441 G Street NW Washington, DC 20548

Dear Ms. Wright:

The Department of Energy (DOE), Office of Science appreciates the opportunity to comment on the Government Accountability Office's (GAO) draft report titled, "Low Dose Radiation: Agency Leadership and Collaboration are Needed to Set the Direction of Future Research (GAO-24-106317)." The draft report contains two recommendations. DOE agrees with the recommendations with details provided in the enclosure.

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Sincerely,

Asmeret Asefaw Berhe Director, Office of Science

Management Response

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DOE Response: Concur

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Estimated Completion Date: DOE will complete interagency discussions by September 30, 2024 and communicate to Congress its plans to implement the

**Appendix II: Comments from the Department
of Energy**

statutory requirements of the Department of Energy Research and Innovation Act by
April 1, 2025.

Appendix III: GAO Contacts and Staff Acknowledgments

GAO Contact

Candice N. Wright at (202) 512-6888 or WrightC@gao.gov.

Staff Acknowledgments

In addition to the individual above, Joseph Cook (Assistant Director), Calaera Powroznik (Analyst in Charge), Matthew Curtis, Eliot Fletcher, and Megan Johnson made key contributions to this report. Also contributing to this work were Virginia Chanley, Patrick Harner, Joseph Rando, Ben Shouse, Amber Sinclair, and Sarah Veale.

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