Regulatory Analysis for the Proposed Rule: Reporting Nuclear Medicine Injection Extravasations as Medical Events

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U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Rulemaking, Environmental, and Financial Support

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ABSTRACT

This regulatory analysis evaluates the costs and benefits of a proposed rule to amend the NRC's regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 35, "Medical Use of Byproduct Material." The proposed rule would require reporting of certain nuclear medicine injection extravasations as medical events and require medical licensees to develop, implement, and maintain written procedures for evaluating and reporting extravasations. This rulemaking would affect medical licensees who administer intravascular radiopharmaceuticals for diagnostic or therapeutic purposes. In addition, the proposed rule would provide a regulatory guide that licensees could use to meet the requirements of the proposed rule. This regulatory analysis evaluates the costs and benefits of the proposed rule and implementing guidance relative to the baseline case, the "no action" alternative, and a third alternative of reporting extravasations at 50 rem.

EXECUTIVE SUMMARY

The U.S. Nuclear Regulatory Commission (NRC) is proposing to amend its regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 35, "Medical Use of Byproduct Material." The regulations in 10 CFR Part 35 contain the NRC's requirements and provisions for the medical use of byproduct material and for issuance of specific licenses authorizing the medical use of this material. The proposed rule addresses the issues raised in a petition for rulemaking (PRM) that asked the NRC to amend 10 CFR Part 35 to require medical event reporting of extravasations that lead to an irradiation resulting in a localized dose equivalent exceeding 50 rem (0.5 sievert), which the NRC docketed as PRM-35-22. The proposed rule would define an extravasation as the unintentional presence of a radiopharmaceutical in the tissue surrounding the blood vessel following an injection. The NRC staff submitted SECY-22-0043, "Petition for Rulemaking and Rulemaking Plan on Reporting Nuclear Medicine Injection Extravasations as Medical Events (PRM-35-22; NRC-2020-0141)," dated May 9, 2022, to the Commission requesting approval to consider PRM-35-22 in the rulemaking process. Although the staff recommended considering the PRM in the rulemaking process, the staff did not recommend adopting the proposed reporting threshold of 50 rem (0.5 sievert) in the PRM; rather the staff proposed a reporting threshold based on the potential for the extravasation to result in a radiation injury. In the staff requirements memorandum to SECY-22-0043, dated December 12, 2022, the Commission approved the staff's recommendation.

The proposed rule would amend 10 CFR Part 35 to require that licensees report as a medical event any administration of byproduct material in which an extravasation has occurred that results or has the potential to result in a radiation injury, as determined by a physician. The NRC is also proposing to amend 10 CFR Part 35 to require that licensees have procedures in place for evaluating and reporting extravasations and retain a copy of those procedures for the duration of the license. The NRC would also provide an associated regulatory guide that licensees could use to meet the requirements of the proposed rule. The purpose of the proposed rule is to remove the exclusion of extravasations from the NRC's medical event reporting regulations and allow the agency to track these events. The proposed rule would increase the NRC's ability to protect public health and safety and provide the industry and the public with greater transparency and regulatory predictability.

This regulatory analysis evaluates the costs and benefits of the proposed rule and implementing guidance relative to the baseline case, the "no action" alternative.

The NRC staff has made the following key findings:

- Proposed Rule Analysis. The proposed rule recommended (Alternative 2) by the staff or the proposed rule requested by the PRM (Alternative 3) would result in additional costs as shown in Table ES-1.

Table ES-1 Summary of Costs and Benefits

Entity	Total (2023 Dollars)		
	Undiscounted	7% NPV	3% NPV
Alternative 2			
NRC	($2,395,000)	($1,510,000)	($1,945,000)
Industry	($15,743,000)	($12,535,000)	($14,232,000)

Entity	Total (2023 Dollars)		
	Undiscounted	**7% NPV**	**3% NPV**
Agreement States	($24,265,000)	($15,312,000)	($19,712,000)
Net Benefit (Cost)	**($42,403,000)**	**($29,357,000)**	**($35,889,000)**
Alternative 3			
NRC	($355,726,000)	($211,814,000)	($282,283,000)
Industry	($2,546,998,000)	($1,594,243,000)	($2,064,361,000)
Agreement States	($3,484,091,000)	($2,084,556,000)	($2,770,889,000)
Net Benefit (Cost)	**($6,386,815,000)**	**($3,890,613,000)**	**($5,117,533,000)**

[a] NPV: net present value

- Nonquantified Benefits. The NRC concludes that the proposed rule, if issued, would improve regulatory effectiveness and knowledge by collecting data on the occurrence of reportable extravasations and would be expected to increase public confidence in the NRC's medical event reporting by including certain extravasations in the reporting requirements.

- Uncertainty Analysis. The regulatory analysis contains a Monte Carlo simulation analysis that shows the mean net benefit for this proposed rule as ($29,700,000) with 90 percent confidence that the net benefit is between ($43,100,000) and ($20,100,000) using a 7 percent discount rate. The rate of extravasations for therapeutic intravascular administrations is the factor responsible for the largest variation in costs.

- Decision Rationale. Relative to the no action baseline, the NRC concludes that the proposed rule would impose quantitative costs on the NRC, licensees, and Agreement States. However, the NRC expects that the proposed rule would provide qualitative benefits that outweigh the quantitative costs and justify implementation of the proposed rule. The proposed rule would improve the agency's ability to protect public health, lead to improvements in knowledge, and increase public confidence in the NRC.

- Implementation. The NRC expects that, if approved, the effective date of the final rule would be in 2026. Full implementation by the Agreement States would be approximately 3 years later. The NRC plans to issue a final regulatory guide with the final rule.

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ABBREVIATIONS

BLS	U.S. Department of Labor, Bureau of Labor Statistics
CFR	*Code of Federal Regulations*
CPI-U	consumer price index for all urban consumers
FR	*Federal Register*
MD	management directive
NMED	Nuclear Material Events Database
NPV	net present value
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC technical publication
OEWS	Occupational Employment and Wage Estimates
PERT	program evaluation and review technique
PRM	petition for rulemaking
SECY	the written issue paper that is the primary decision-making tool of the collegial Commission
SOC	Standard Occupational Classification
SRM	staff requirements memorandum
U.S.C.	United States Code
WBL	Web-Based Licensing

1 INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC) is proposing to amend its regulations under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 35, "Medical Use of Byproduct Material." This document presents the regulatory analysis for the proposed rule.

2 BACKGROUND, STATEMENT OF THE PROBLEM, AND OBJECTIVE

2.1 Background

Extravasation is the unintentional presence of a radiopharmaceutical in the tissue surrounding the blood vessel following an injection.

The NRC's medical event reporting requirements appear in 10 CFR 35.3045, "Report and notification of a medical event."[1] Under the NRC's medical event reporting requirements, medical event reporting is mandatory and requires licensees to notify the NRC Operations Center by the next calendar day and submit a written report within 15 days. The licensee must also notify the referring physician and the individual who is the subject of the medical event no later than 24 hours after its discovery (unless, based on medical judgment, informing the individual would be harmful). If the referring physician or the affected individual cannot be reached within 24 hours, the licensee shall notify the individual as soon as possible.

The Nuclear Material Events Database (NMED) includes all reported medical events. The NMED contains records of events involving nuclear material licensed under NRC regulations or compatible Agreement State regulations and reported to the NRC by licensees, Agreement States, and nonlicensees. The NRC publishes event notification reports publicly on its website, and the Advisory Committee on the Medical Uses of Isotopes conducts annual public meetings during which the staff and the committee give presentations on the medical events from the past fiscal year. If the NRC identifies similar problems reported from multiple facilities, the agency may issue generic communications to help prevent additional incidents from occurring.

The administration of certain radiopharmaceuticals is also subject to 10 CFR 35.40, "Written directives," and 10 CFR 35.41, "Procedures for administrations requiring a written directive." A written directive is an authorized user's written order for the administration of byproduct material or radiation from byproduct material to a specific patient or human research subject. Written directives must contain the information specified in 10 CFR 35.40, and 10 CFR 35.41 requires, in part, that licensees develop, implement, and maintain written procedures to provide high confidence that each administration is in accordance with the written directive.

The NRC conducts reviews of medical events under the NRC Medical Event Assessment Program, the objective of which is to conduct a timely, thorough, systematic, and formal assessment of medical events. The scope of the review considers the adequacy of the licensee's actions during the event and the licensee's demonstration of compliance with the notification requirements of 10 CFR Parts 19, 20, and 35, as applicable. The procedures for the NRC medical event assessment program are contained in NRC Management Directive

[1] In addition to 10 CFR 35.3045, medical licensees are required to report events in accordance with 10 CFR 35.3047, "Report and notification of a dose to an embryo/fetus or a nursing child"; 10 CFR 35.3067, "Report of a leaking source"; 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations"; 10 CFR Part 20, "Standards for Protection Against Radiation," Subpart M, "Reports"; 10 CFR Part 21, "Reporting of Defects and Noncompliance"; and 10 CFR 30.50, "Reporting requirements."

(MD) 8.10, “NRC Assessment Program for a Medical Event or an Incident Occurring at a Medical Facility,” dated March 24, 2022 (NRC, 2022a).

The NRC amended the regulations in 10 CFR Part 35 in 1980 (45 FR 31701; May 14, 1980) (NRC, 1980) to require the reporting of medical misadministrations but did not include extravasations, reasoning that they are a frequent occurrence in otherwise normal intravenous or intraarterial injections and are virtually impossible to avoid. The NRC updated its reporting requirements in 1991 (56 FR 34104; July 25, 1991), in 2002 (67 FR 20250; April 24, 2002), and again in 2018 (83 FR 33046; July 16, 2018). In 2002, the NRC replaced the term and criteria for “misadministration” with “medical event” and made several changes to 10 CFR 35.3045.

In 2020, a petitioner submitted a petition for rulemaking (PRM) (Lucerno, 2020) requesting an NRC amendment to 10 CFR Part 35 to require medical event reporting of radiopharmaceutical extravasations that lead to an irradiation resulting in a localized dose equivalent exceeding 50 rem (0.5 sievert), which the NRC docketed as PRM-35-22. In 2022, the staff submitted SECY-22-0043, “Petition for Rulemaking and Rulemaking Plan on Reporting Nuclear Medicine Injection Extravasations as Medical Events (PRM-35 22; NRC-2020-0141),” to the Commission, requesting approval to consider the issues raised in PRM-35-22 in the rulemaking process, and provided a rulemaking plan (NRC, 2022b). Although the staff recommended considering the PRM in the rulemaking process, the staff did not recommend adopting the proposed reporting threshold of 50 rem (0.5 sievert) in the PRM; rather the staff proposed a reporting threshold based on the potential for the extravasation to result in a radiation injury. In Staff Requirements Memorandum (SRM)-SECY-22-0043, dated December 12, 2022 (NRC, 2022c), the Commission approved the staff’s recommendation to amend 10 CFR Part 35 to include certain nuclear medicine injection extravasations as reportable medical events. Additionally, the Commission directed the staff to explore approaches to reduce reliance on patient reporting, develop regulatory guidance for all medical events, and look for opportunities to accelerate the rulemaking schedule without shortening public comment periods.

2.2 Statement of the Problem

The NRC does not currently include extravasations under its regulations for medical event reporting. Therefore, extravasations that cause radiation injury to the public, including those that meet the public health and safety significance criteria for an abnormal occurrence, are not required to be reported to the NRC and likewise are not considered in the NRC’s evaluation of the abnormal occurrence of medical events. The NRC expects the frequency of intravascular administration of radiopharmaceuticals to increase over time due to the continuing evolution of nuclear medicine, including the use of higher energy positron-emitting diagnostic radiopharmaceuticals and therapeutic radiopharmaceuticals. The NRC, medical licensees, and the public would be unaware of the rate of occurrence of extravasations associated with that increase, leaving the agency and medical licensees less able to focus improvements on the prevention of extravasations and the public less able to make medical decisions regarding the intravascular administration of radiopharmaceuticals with the best available information.

2.3 Objective

The purpose of the proposed rule is to establish requirements for reporting extravasations as medical events, which would allow the NRC to obtain operating experience with extravasations that cause or have the potential to cause radiation injury and track and trend the events with the goal of improving radiation safety for patients receiving intravascular administration of radiopharmaceuticals. Additionally, the information gathered under the proposed rule could

provide the NRC with data necessary to take further regulatory action to protect public health and safety, if necessary. The proposed rule would increase transparency for the public and for medical licensees, who can access NMED annual reports to track the occurrence of extravasations to understand the rates of occurrence and injury and to improve operational performance.

This regulatory analysis evaluates the NRC's proposed rulemaking alternatives: a "no action" alternative, for which the NRC would not conduct rulemaking and would continue to exclude extravasations from its medical event reporting requirements, and two rulemaking alternatives to amend the NRC's medical event reporting requirements. The no action alternative is the baseline to which the proposed action is compared.

3 IDENTIFICATION AND PRELIMINARY ANALYSIS OF ALTERNATIVE APPROACHES

The NRC analyzed the alternatives regarding the proposed rule as described in this section.

3.1 Alternative 1: No Action Alternative

The no action alternative is to maintain the status quo. Under the no action alternative, the NRC would not pursue a rulemaking to include extravasations under its medical event reporting requirements and would rely on its current regulatory regime. This alternative would result in no new direct costs to the NRC, Agreement States, or the industry and serves as the baseline for this analysis.

This alternative would be consistent with the views of some medical community stakeholders and some Agreement States that extravasation is a generic medical issue to be addressed at the institutional level and that the NRC's addition of a regulation would not lead to an appreciable reduction in occurrence rates. Extravasations are not fully preventable, and the occurrence of one does not necessarily indicate a potential problem in a licensee's use of radioactive materials nor does an occurrence mean that the administration deviated from the written directive or authorized user's intent. This alternative would continue to rely on the NRC's existing medical use regulations to protect public health and safety and on physicians to continue to address significant extravasations.

The no-action alternative would not position the NRC to address the potential and expected increase in the use of radiopharmaceuticals,[2] including several new therapeutic radiopharmaceuticals, which could lead to an increase in occurrence of extravasations that could cause radiation injury. In addition, this alternative does not allow the NRC to track and trend their occurrence with the goal of improving radiation safety for patients and is not responsive to stakeholder concerns about excluding extravasations from medical event reporting.

3.2 Alternative 2: Rulemaking to Include Radiation Injury Extravasations

Under Alternative 2, the NRC would amend its regulations to require medical event reporting if an extravasation that results or has the potential to result in a radiation injury, as determined by

[2] According to several market research firms, the global nuclear medicine market is expected to grow at a compound annual growth rate of about 12 percent from 2024 to 2034, driven by patient demand, a strong product pipeline, and improving cost reimbursements.

a physician. The requirements for reporting would not contain a dose threshold for reporting. The rule includes the "potential to result in" a radiation injury to allow licensees to report extravasations at the time of detection, rather than waiting for an injury to manifest. Alternatively, the rule would allow for reporting of extravasations that are undetected at the time of administration by allowing for reporting of events if a patient follows up with the licensee several days or weeks later. In either case, a physician would determine the potential for a radiation injury, potentially with input from other medical staff (e.g. nurses, technologists, other physicians). The revised regulations would require licensees to develop written procedures for evaluating and reporting extravasations, as well as recordkeeping requirements for the procedures. The NRC would issue a regulatory guide with an approach that licensees could use to meet the requirements of the rule.

The Alternative 2 rulemaking is limited in scope because the proposed regulation is based on the potential for radiation injury and would not require monitoring of all intravascular administrations of radiopharmaceuticals or dosimetry to determine whether an extravasation meets the criteria of a medical event. The proposed requirements could improve patient safety by increasing oversight of NRC and National Materials Program licensees for those extravasations that result or have the potential to result in a radiation injury, as determined by a physician. The proposed requirements would allow the NRC to collect and analyze operating experience on extravasations that result or have the potential to result in a radiation injury, as determined by a physician, which would facilitate NRC evaluation of its regulatory efforts and better determine the need for further regulatory action toward assuring safety. The NRC staff considers the proposed reporting requirement to be risk-informed: it balances the radiation-safety-risk of extravasations (i.e., lower risk associated with diagnostic administrations and higher risk associated with therapeutic administrations) and the difficulty in some cases in preventing extravasations, with the regulatory burden and costs associated with monitoring for and reporting extravasations. Furthermore, the proposed reporting requirement aligns with the objectives of medical event reporting (NRC, 2002) and the NRC's Medical Use Policy Statement (NRC, 2000). The proposed rulemaking would include certain extravasations in the NRC's medical event reporting requirements, which could improve NRC opportunities for regulatory effectiveness as a result of improved data on extravasations. Further, the proposed rulemaking could improve patient outcomes after radiopharmaceutical injection by leading to an increased licensee focus on quality improvement programs for intravascular administration of radiopharmaceuticals and by making information collected by the NRC under the proposed regulation available for licensee and public use.

Alternative 2 could result in underreporting of medical events that would qualify under the proposed regulations because it would rely, in part, on the patient's action to seek follow-up care for an adverse tissue reaction due to an extravasation that was undetected at the time of administration. Furthermore, a regulation based on a physician's assessment of what constitutes a "radiation injury" focuses on the physician as the only form of evaluation to provide a subjective determination. Such an approach differs from the objective dose criteria for most current medical event reporting, which is based on scientific data gained from studies of dose-based responses in human tissue.

3.3 Alternative 3: Rulemaking to Include 50 Rem (0.5 Sievert) Threshold Extravasations

Under Alternative 3, the NRC would amend its regulations to require medical event reporting for all extravasations that exceed a localized dose equivalent threshold of 50 rem (0.5 sievert). The requirement would be a prescriptive dose-based methodology. The proposed rule would require

licensees to monitor every radiopharmaceutical intravascular administration for extravasation to ensure that tissue doses at 50 rem (0.5 sievert) are detected. The requirement would not prescribe a particular dose monitoring methodology. Once a licensee detected an extravasation, it would need to calculate the radiation dose. The proposed rule would require licensees to create written procedures and maintain recordkeeping requirements for the procedures. The NRC would issue a regulatory guide with an approach that licensees could use to meet the requirement of the rule.

The proposed requirements would increase oversight of NRC licensees and across the National Materials Program for extravasations of varying levels of radiation safety significance. Reporting at the 50 rem (0.5 sievert) limit would capture extravasations that could result in radiation injury, reducing the risk to patients. The proposed requirements would allow the NRC to collect and analyze operating experience on extravasations that could be used as the basis for further regulatory activities. The rule would improve patient outcomes by increasing licensee focus on quality improvement programs for intravascular administration of radiopharmaceuticals and by making information collected by the NRC under the proposed regulation available for licensee and public use. Additionally, reporting extravasations at 50 rem (0.5 sievert) would be consistent with the existing dose threshold for reporting other types of medical events.

The NRC's medical event reporting criteria are set at conservative levels that rarely would cause patient harm, and this low-dose threshold for reporting could result in tens of thousands of extravasation events of low radiation-safety significance reported annually with no guaranteed corresponding benefit to patient safety. Requiring the reporting of such low-safety significance events would not align with the objectives of the NRC's Medical Use Policy Statement which specifies that the NRC will regulate the radiation safety of patients only when justified by the risk to patients. This alternative would impose significant regulatory and financial burden on the NRC, the National Materials Program, and licensees to monitor all radiopharmaceutical administrations and perform dosimetry for each detected or suspected extravasation without safety benefit. The resulting increase in qualifying medical events would lead to a large number of inspections of licensees, as mandated by MD 8.10, "NRC Assessment Program for a Medical Event or an Incident Occurring at a Medical Facility."

4 ESTIMATION AND EVALUATION OF COSTS AND BENEFITS

This section examines the costs and benefits expected to result from the NRC's proposed rule. All costs and benefits are monetized, when possible. The total costs and benefits are then summed to determine whether the difference between the costs and the benefits results in a positive benefit. In some cases, costs and benefits are not monetized because meaningful quantification is not possible.

4.1 Identification of Affected Attributes

This section identifies the components of the public and private sectors, commonly referred to as attributes, that are expected to be affected by the alternatives identified in section 3. The NRC staff developed an inventory of these attributes using the list in NUREG/BR-0058, draft Revision 5, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," January 2020 (NRC, 2020a). Alternatives 2 and 3 would affect the attributes described below.

4.1.1 Public Health (Accident)

This attribute measures expected changes in radiation exposures to the public due to changes in accident frequencies or accident consequences associated with the proposed action. Under the alternatives, there may be a reduction in radiation exposure to the public. As a result of the regulatory focus resulting from the alternatives, licensees may improve quality control for operations and pay increased attention to improving patient outcomes during radiopharmaceutical administration. Thus, there may be a resultant decrease in the number of accidental extravasations that may be attributable to human error.

4.1.2 Public Health (Routine)

This attribute accounts for changes in radiation exposures to the public during normal facility operations (i.e., nonaccident situations). Under the alternatives, there may be a reduction in radiation exposure to the public. Similar to above, as a result of the regulatory focus resulting from the alternatives, licensees may improve quality control for operations and pay increased attention to improving patient outcomes during radiopharmaceutical administration by incorporating more industrywide intravascular injection best practices in their day-to-day operations. Thus, there may be a resultant decrease in the number of extravasations that are not directly attributable to human error and not preventable by any direct actions.

4.1.3 Industry Implementation

This attribute accounts for the projected net economic effect on all affected licensees to place the alternative into operation. Costs would include procedural and administrative activities, equipment, labor, and materials. Additional costs above the status quo would be considered negative; cost savings would be considered positive. Under the alternatives, licensees would incur costs resulting from the new requirements in the proposed rule. Licensees would have to revise their procedures to implement the new reporting requirement and train their staff on the new procedures. Some licensees might need to procure an extravasation dose verification methodology, in which case, licensees would incur additional costs to train staff in applying the methodology. The industry would also incur costs to participate in the rulemaking process.

4.1.4 Industry Operation

This attribute measures the projected net economic effect on all affected licensees of routine and recurring activities required by the proposed action. Additional costs above the status quo are taken to be negative; cost savings are taken to be positive. Costs falling in this category, and those associated with operational considerations, generally occur over long periods of time. These costs are particularly sensitive to the discount factor used. Under the alternatives, licensees would incur costs resulting from new requirements and procedures on a per extravasation basis. This would include procedures to document and characterize a medical event. Depending on the alternative, this may also include applying a dose verification method for qualifying events. Certain extravasation dose verification methodologies may have an additional associated annual upkeep cost.

4.1.5 NRC Implementation

This attribute accounts for the projected net economic effect on the NRC to place the alternative into operation. Costs already incurred, including all activities performed by the NRC in making the regulatory decision, are viewed as “sunk” costs and are not to be included. Additional costs above the status quo are taken to be negative; cost savings are taken to be positive. To implement the alternatives, the NRC would incur a cost in relation to Alternative 1 (i.e., status

quo alternative, current regulatory baseline) to issue a rule. The NRC may also need to upgrade its NMED software and database. Lastly, the NRC would incur costs to compose a regulatory guide.

4.1.6 NRC Operation

This attribute accounts for the projected net economic effect on the NRC caused by routine and recurring activities required by the alternatives. Additional costs above the status quo are taken to be negative; cost savings are taken to be positive. As with industry operation costs, NRC operation costs generally occur over long periods of time and are sensitive to the assumed discount factor. The NRC would incur costs under the alternatives to review and process qualifying event reports. In addition, the increased number of medical event reports would lead to more NRC inspections of licensee facilities and might require the agency to increase its NMED support contracts.

4.1.7 Other Government Entities

Agreement States would need to amend their regulations to maintain compatibility with NRC requirements and would be expected to base changes to their regulations on the NRC's rulemaking. Agreement States would also incur costs to participate in the NRC rulemaking process. Similarly to the NRC, Agreement States would incur costs to review and process qualifying event reports. Lastly, Agreement States might incur costs to inspect licensee facilities related to the medical event reports.

4.1.8 Improvements in Knowledge

Under the alternatives, the NRC would begin to gather information on the rate of occurrence of extravasations and the associated level of radiation harm, which currently is not tracked. The NRC would analyze the data for patterns associated with patient outcomes. The resultant information could be available to licensees and the public through generic communications or guidance.

4.1.9 Other Considerations

The alternatives would be expected to increase public confidence in the NRC's medical event reporting because they would provide a more complete understanding of extravasations and would be responsive to stakeholder concerns.

4.1.10 Attributes with No Effects

The following attributes are not expected to contribute to the results under any of the alternatives:

- occupational health (accident)
- occupational health (routine)
- offsite property
- onsite property
- general public
- regulatory efficiency
- safeguards and security considerations
- environmental considerations

4.2 Analytical Methodology

This section describes the process used to evaluate costs and benefits associated with the proposed alternatives. The benefits include any desirable changes in affected attributes (e.g., monetary savings, improved safety, and improved security). The costs include any undesirable changes in affected attributes (e.g., monetary costs, increased exposures).

Of the 10 affected attributes, the analysis quantitatively evaluated 5—industry implementation, industry operation, NRC implementation, NRC operation, and other government. Quantitative analysis requires a baseline characterization of the affected society, including factors such as the number of affected entities, the nature of the activities currently performed, and the types of systems and procedures that licensees would implement, or would no longer implement, because of the proposed alternatives. Where possible, the NRC calculated costs for these attributes using distributions to quantify the uncertainty in these estimates. The detailed cost tables used in this regulatory analysis are included in the individual sections for each of the provisions. The NRC evaluated the remaining five attributes qualitatively because the benefits relating to improvements in knowledge and the other considerations are not easily quantifiable or because the data necessary to quantify and monetize the impacts on these attributes are not available.

The NRC documents its assumptions throughout this regulatory analysis. Appendix A to this regulatory analysis summarizes the key assumptions and inputs.

4.2.1 Regulatory Baseline

This regulatory analysis provides the incremental impacts of the proposed rule relative to a baseline that reflects anticipated behavior if the NRC does not undertake regulatory or nonregulatory action. The regulatory baseline assumes full compliance with existing NRC requirements—all the current medical event reporting requirements contained in 10 CFR Part 35. This assumption is consistent with NUREG/BR-0058, which states that “in evaluating a new requirement…the staff should assume that all existing NRC and Agreement State requirements have been implemented.” This regulatory analysis presents the estimated incremental costs and benefits of the alternatives compared to the baseline. This regulatory baseline is the status quo alternative (i.e., Alternative 1).

4.2.2 Affected Entities

The NRC tracks the number of its licensees through its Web-Based Licensing (WBL) system. WBL is a materials licensing system that supports the NRC and Agreement States in managing the licensing information of businesses that use radioactive materials. WBL supports the entry of licensing information and license images that enables the NRC and Agreement States to manage the licensing life cycle from initial application through license issuance, amendment, reporting, and termination. The NRC licensees are grouped by program code. To determine the total number of licensees that would be affected by the proposed rule over the course of the analysis horizon, the NRC staff selected the relevant program codes in WBL for NRC medical licensees that perform radiopharmaceutical administrations and tracked the additions and retirement of licenses for each selected program code over a 10-year period. The NRC used the mean number of net changes in licenses for each program code to project the number of licensees over the analysis horizon, starting from the number of licensees in the base year. To project the number of Agreement State medical licensees, the NRC used a ratio of 9.8, based on the ratio between the number of NRC medical licensees and Agreement State medical

licensees reported in the most recent annual count of licensees. The NRC combined these amounts to estimate the total number of licensees that would be affected by the proposed rule.

Table 1 identifies the number of licensees that would be affected by the proposed regulation as of the base year.

Table 1 Affected Entities

License Title	Program Code	NRC	Agreement States	Total
Medical Institution Broad	02110	12	118	130
Medical Institution—Limited Scope—Written Directive Required	02120	147	1,447	1,594
Medical Institution—Limited Scope—Written Directive Not Required	02121	125	1,231	1,356
Medical Private Practice—Written Directive Required	02200	27	266	293
Medical Private Practice—Written Directive Not Required	02201	162	1,595	1,757
Mobile Medical Service—Written Directive Not Required	02220	23	226	249
Medical Therapy—Other Emerging Technology	02240	41	404	445
Medical Institution Broad—6–20 Locations	04710	5	49	54
Medical Institution Broad—More Than 20 Locations	04711	1	10	11
Medical Institution—Written Directive Required—6–20 Locations	04810	1	10	11
Medical Private Practice—Written Directive Not Required—6–20 Locations	04816	1	10	11
Mobile Medical Service—Written Directive Not Required—6–20 Locations	04820	2	20	22
Total		**547**	**5,386**	**5,933**

Totals differ within and across tables due to rounding.

4.2.3 Data

To project the number of radiopharmaceutical administrations and the associated number of extravasations over the analysis horizon for each alternative, the NRC staff used information provided by the public at the previous stage of the proceeding and during the public comment period to calculate the number of extravasations under both Alternatives 2 and 3.

For Alternative 2, the staff used criteria based on therapeutic intravascular administrations and chemotherapy because of the similarity between chemotherapy and therapeutic radiopharmaceutical administration. The staff estimated that there were 177,500 therapeutic intravascular administrations in 2022, a total extravasation rate of 0.18 percent, and that 25 percent of the extravasations of therapeutic radiopharmaceuticals would result in a radiation injury. Under Alternative 3, the staff estimated that there were 18,500,000 radiopharmaceutical

administrations in 2022, a total extravasation rate of 7.79 percent,[3] and a rate of 1 percent for extravasations that would exceed a 50 rem (0.5 sievert) localized dose to tissue. The staff estimated that extravasation rates would be lower for therapeutic administrations than diagnostic due to the additional precautions taken for these high-dose treatments. The potential radiation injury reporting criterion for Alternative 2 would likely screen out all but the most severe diagnostic extravasations, so the staff's estimated number of reportable extravasations under Alternative 2 is based only on the estimated number of therapeutic administrations per year. Conversely, the 50-rem reporting criterion for Alternative 3 could be triggered by diagnostic administrations (in addition to therapeutic administrations), so the staff's estimated number of reportable extravasations under Alternative 3 is based on the estimated total number of diagnostic and therapeutic administrations per year. Due to the difference in prescribed doses involved in therapeutic versus diagnostic administrations, the staff estimated that more therapeutic extravasations would require reporting (25 percent) than diagnostic extravasations (1 percent).

To project the number of extravasations over the analysis horizon, the staff assumed that the number of extravasations is proportional to the number of affected licensees. Table 2 summarizes projections over the analysis horizon.

Table 2 Reportable Extravasations over Analysis Horizon

Year	Extravasations (Alternative 2)	Extravasations (Alternative 3)
2026	149	23,661
2027	163	25,914
2028	177	28,167
2029	191	30,420
2030	205	32,673
2031	220	34,926
2032	234	37,179
2033	248	39,432
2034	262	41,685
2035	276	43,937
Total	**2,125**	**33,7993**

Totals differ within and across tables due to rounding.

4.2.4 Base Year

All monetized costs are expressed in 2023 dollars. The NRC staff expects that the agency would incur implementation costs in 2025 to prepare and issue a final rule and guidance, if a final rule is approved. Ongoing costs of operation related to Alternative 2 are assumed to begin no earlier than 30 days after publication of the final rule in the FR unless otherwise stated, and they are modeled on an annual cost basis. Estimates are made for recurring annual operating expenses. The values for annual operating expenses are modeled as a constant expense for

[3] The NRC staff calculated the extravasation rate based on a program evaluation and review technique (PERT) distribution. A PERT distribution is a curved density distribution with three points representing a specified minimum, most likely, and maximum values.

each year of the analysis horizon. The NRC staff performed a discounted cash flow calculation to discount these annual expenses to 2023 dollar values.

4.2.5 Discount Rates

In accordance with NRC guidance in NUREG/BR-0058, net present value (NPV) calculations are used to determine how much society would need to invest today to ensure that the designated dollar amount is available in a given year in the future. By using NPV calculations, costs and benefits, regardless of when the cost or benefit is incurred, are valued to a reference year for comparison. The choice of a discount rate and its associated conceptual basis is a topic of ongoing discussion within the Federal Government, and consistent with NRC past practice and guidance, present-worth calculations in this analysis use 3 percent and 7 percent real discount rates. A 3 percent discount rate approximates the real rate of return on long-term government debt, which serves as a proxy for the real rate of return on savings to reflect reliance on a social rate of time preference discounting concept.[4] A 7 percent discount rate approximates the marginal pretax real rate of return on an average investment in the private sector, and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector. A 7 percent rate is consistent with an opportunity cost[5] of capital concept to reflect the time value of resources directed to meet regulatory requirements.

4.2.6 Cost/Benefit Inflators

The NRC staff estimated the analysis inputs from sources as referenced in Appendix A, which are provided in prior-year dollars. To evaluate the costs and benefits consistently, these inputs are put into 2023 base-year dollars. The most common inflator is the consumer price index for all urban consumers (CPI-U) developed by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). Using the CPI-U, the prior-year dollars are converted to 2023 base-year dollars. For 2022, the currently reported CPI-U values have been averaged together; the BLS has not determined the entirety of CPI-U for 2023. The formula to determine the amount in 2023 dollars is as follows:

$$\frac{CPI - U_{2023}}{CPI - U_{2022}} \; x \; Value_{2022} = \; Value_{2023}$$

Table 3 summarizes the values of CPI-U used in this regulatory analysis.

Table 3 CPI-U Inflator

Year	CPI-U Annual Average [a]
2022	292.61
2023	305.84

[a] Statista, 2023

[4] The "social rate of time preference" discounting concept refers to the rate at which society is willing to postpone a marginal unit of current consumption in exchange for more future consumption.

[5] "Opportunity cost" represents what is foregone by undertaking a given action. If the licensee personnel were not engaged in revising procedures, they would be performing other work activities. Throughout the analysis, the NRC estimates the opportunity cost of performing these incremental tasks as the industry personnel's pay for the designated unit of time.

4.2.7 Labor Rates

For the purposes of this regulatory analysis, the NRC applied incremental cost principles to develop labor rates that include only labor and material costs that are directly related to the implementation and operation and maintenance of the proposed rule requirements. This approach is consistent with the guidance in NUREG/CR-3568, "A Handbook for Value-Impact Assessment," issued December 1983 (NRC, 1983), and general cost-benefit methodology. The NRC incremental labor rate is $143 per hour.[6]

The NRC used the 2022 BLS occupational employment and wages data (BLS, 2023), which provide labor categories and the mean hourly wage rate by job type, and used the inflator discussed above to inflate these labor rate data to 2023 dollars. The labor rates used in the analysis reflect total hourly compensation, which includes wages and nonwage benefits (using a fringe factor of 2.4, applicable for Agreement State and contractor labor rates). The NRC used the BLS data tables to select appropriate hourly labor rates for performing the anticipated tasks necessary during and following implementation of the proposed alternative. In establishing this labor rate, wages paid to the individuals performing the work plus the associated fringe benefit component of labor cost (i.e., insurance premiums, pension, and legally required benefits and the time for plant management exceeding those directly expensed) are considered incremental expenses and are included. The hourly wage rate for contractor labor was provided directly by the contracting entity, Pacific Northwest National Laboratory. Table 4 provides the mean labor rates for contractor and Agreement State labor. The NRC used BLS labor rates at the 25th percentile, 50th percentile, and 75th percentile and adjusted them to 2023 dollars as input into the uncertainty analysis, which is described in this section.

Table 4 Industry, Agreement State, and Contractor Labor Rates

Position Title	Occupation (SOC Code)	Hourly Mean Wage (2022 dollars)	Hourly 25th Percentile Wage (2022 dollars)	Hourly 75th Percentile Wage (2022 dollars)
Industry Labor Rates[a]				
National				
Health Information Technologists and Medical Registrars	299021	$29.75	$19.14	$38.17
Medical Dosimetrists	292036	$61.97	$53.54	$69.38
Miscellaneous Healthcare Support Occupations	299090	$20.11	$17.14	$22.37
Nuclear Medicine Technologist	292033	$43.20	$37.12	$48.50
Physician	291210	$124.26	$61.31	$251.84

[6] The NRC labor rates presented here differ from those developed under the NRC's license fee recovery program (10 CFR Part 170, "Fees for Facilities, Materials, Import and Export Licenses, and Other Regulatory Services under the AEA, as Amended"). NRC labor rates for fee recovery purposes are appropriately designed for full-cost recovery of the services rendered and thus include nonincremental costs (e.g., overhead, administrative, and logistical support costs).

Position Title	Occupation (SOC Code)	Hourly Mean Wage (2022 dollars)	Hourly 25th Percentile Wage (2022 dollars)	Hourly 75th Percentile Wage (2022 dollars)
Blended mean wage		**$55.86**	**$37.65**	**$86.05**
Agreement State Labor Rate				
State Government, Excluding Schools and Hospitals (OEWS Designation)				
Lawyers	231011	$49.71	$35.45	$61.04
Office and Administrative Support Occupations	430000	$22.63	$17.42	$26.88
Physicians	291210	$106.47	$77.19	$146.86
Blended mean wage		**$59.60**	**$43.35**	**$78.26**
Contractor Labor Rates				
Project Manager		$145.00		
Senior Key Staff		$168.00		
Key Staff		$133.00		
Support Staff		$105.00		
Technical Editor		$98.00		
Blended mean wage		**$133.68**		

Totals differ within and across tables due to rounding.
[a] The modeled industries and occupational classifications are calculated based on the BLS, "May 2022 National Occupational Employment and Wage Estimates" (OEWS) data using the 25 percentile, 50 percentile, and 75 percentile values (BLS, 2023).

4.2.8 Sign Conventions

The sign conventions used in this analysis are that all favorable consequences for the alternatives are positive and all adverse consequences are negative. Negative values are shown using parentheses (e.g., negative $500 is displayed as ($500)).

4.2.9 Analysis Horizon

The analysis horizon is 10 years, based on the term of a license for the affected entities provided in table 1.

4.3 Results

This section presents the quantitative and qualitative results by attribute for Alternatives 2 and 3, relative to the regulatory baseline (Alternative 1). As described in the previous sections, costs and benefits are quantified where possible and are shown to be either positive or negative, depending on whether the alternative has a favorable or adverse effect relative to the regulatory baseline (Alternative 1). Those attributes that are not easily represented in monetary values are discussed in qualitative terms. This "ex ante cost-benefit analysis"[7] provides helpful information that the NRC can use to decide whether to select an alternative.

[7] An "ex ante cost-benefit analysis" is prepared before the implementation of a policy, program, or alternative and can assist in deciding whether to allocate resources to that alternative.

The potential benefits and costs of the alternatives are analyzed for (1) licensees, (2) the NRC, and (3) Agreement States. The analyses in this section are based on the NRC's assessment and input from stakeholders.

4.3.1 Industry Implementation

Both Alternatives 2 and 3 would require industry medical licensees to develop and implement procedures to detect and report extravasations, consistent with the threshold for determining an extravasation associated with the respective alternative. This would include new or updated procedures to detect and characterize the extravasation and new or updated medical event reporting procedures. Because licensees already have procedures in place for medical event reporting, the costs for licensees to update their reporting procedures to include extravasations would be marginal. Licensees would incur costs to train their staff in the new procedures.

Under Alternative 2, licensees would independently develop procedures for detecting extravasations. These procedures could include using methods or equipment to verify extravasation dosages, which some licensees may already have access to, and may include, but are not limited to, a dosimetry model, specialized monitoring equipment, serialized imaging of the injection site, and the measurement of waste from an injection site post radiopharmaceutical administration. The cost of these methodologies varies widely. However, the NRC did not quantify this cost because licensees can meet the requirements of Alternative 2 without the specialized methodologies mentioned above. Additionally, Alternative 2 does not require the procedures to include a method to verify the dose of an extravasation. Thus, the NRC has not quantified this cost.

Conversely, under Alternative 3, to meet the requirements of the regulation that extravasations exceeding the 50 rem (0.5 sievert) reportable threshold for medical events, licensees would need to implement a method to verify the dosage of an extravasation. Similar to Alternative 2, licensees would independently develop their procedures and could include any methodology to verify the dose of an extravasation. Because every licensee would need to possess a method to meet the requirements of the regulation under Alternative 3, the NRC has quantified this cost. The NRC estimates that approximately 10 percent of all licensees already have the capability to verify extravasation doses via equipment that produces serialized imaging and would not need to procure an additional methodology.

Licensees would also incur costs to participate in the rulemaking process, including reading and understanding the regulation and providing public comments. Tables 5 and 6 present these costs.

Table 5 Industry Implementation (Alternative 2)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Licensees	Net Benefits (Costs)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2024	Attend public meetings; review and comment on proposed rule and guidance	1,210	$145	N/A	($176,000)	($164,000)	($170,000)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Licensees	Net Benefits (Costs)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026	Attend public meetings; review and comment on final rule and guidance	908	$145	N/A	($132,000)	($108,000)	($121,000)
2026	Compose procedures to implement new reporting requirement	8	$145	5933	($6,945,000)	($5,670,000)	($6,356,000)
2026	Train staff on new reporting requirement	8	$145	5933	($6,945,000)	($5,670,000)	($6,356,000)
Total Benefits (Costs)					($14,198,000)	($11,612,000)	($13,003,000)

Totals differ within and across tables due to rounding.

Table 6 Industry Implementation (Alternative 3)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Licensees	Net Benefits (Costs)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2024	Attend public meetings; review and comment on proposed rule and guidance	1,210	$145	N/A	($176,000)	($164,000)	($170,000)
2026	Attend public meetings; review and comment on final rule and guidance	908	$145	N/A	($132,000)	($108,000)	($121,000)
2026	Compose procedures to implement new reporting requirement	8	$145	5933	($6,945,000)	($5,670,000)	($6,356,000)
2026	Train staff on new	8	$145	5933	($6,945,000)	($5,670,000)	($6,356,000)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Licensees	Net Benefits (Costs)		
					Undiscounted	7% Discount Rate	3% Discount Rate
	reporting requirement						
2026	Train staff on applying dose verification method	6	$145	5334	($4,684,000)	($3,823,000)	($4,286,000)
2026	Cost to implement method to verify dose	N/A	N/A	5334	($302,283,000)	($246,753,000)	($276,632,000)
Total Benefits (Costs)					($321,165,000)	($262,187,000)	($293,922,000)

Totals differ within and across tables due to rounding.

4.3.2 Industry Operation

Licensees could expect to incur costs over the analysis horizon associated with applying the procedures that they have developed to comply with the new regulations under Alternatives 2 and 3. Some procedures would apply to the total number of radiopharmaceutical administrations that a licensee performs, and some would apply solely to those administrations that result in an extravasation. For both Alternatives 2 and 3, those procedures could include posttreatment imaging and characterization and documentation of the event. Under Alternative 2, the costs include the labor hours for a physician to diagnose a potential radiation injury. For Alternative 3, the costs incurred by licensees would include monitoring of every radiopharmaceutical administration and the application of a method to measure the radiological extent of an extravasation. There may also be costs associated with the annual upkeep of the method to measure the radiological extent of an extravasation. The NRC assumes that under both alternatives, a certain number of events would be reported to licensees by patients as potential extravasations. These events, which would cause licensees to implement their extravasation procedures, may not meet the extravasation medical event reporting criteria under the respective alternative and may not result in a medical event report. Because of the lack of information on extravasation rates, the NRC has not quantified this cost.

After a qualifying extravasation, for both Alternatives 2 and 3, the costs would include the time to compose the medical event report and transmit it to the appropriate regional NRC office or Agreement State supervisory office. On a per-administration basis, the amount of additional labor incurred by licensees is similar. However, due to the difference in threshold versus criteria for an extravasation qualifying as a medical event under the two alternatives, the difference in costs incurred by licensees over the analysis horizon between the two alternatives is significant. Tables 7 and 8 present these costs.

Table 7 Industry Operation (Alternative 2)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Procedures to characterize and document qualifying event	2,125	28	$145	($626,000)	($374,000)	($498,000)
2026–2035	Report of radiation injury event to regional office or Agreement State office	2,125	40	$145	($918,000)	($549,000)	($730,000)
2026–2035	Annual recordkeeping for new procedure	N/A	6	$145	($805)	($494)	($647)
Total Benefits (Costs)					($1,545,000)	($923,000)	($1,229,000)

Totals differ within and across tables due to rounding.

Table 8 Industry Operation (Alternative 3)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Additional monitoring of administration	430,387,236	0.25	$145	($1,162,235,000)	($695,106,000)	($924,183,000)
2026–2036	Procedures to characterize and document qualifying event	337,993	28	$145	($99,571,000)	($59,551,000)	($79,176,000)
2026–2035	Application of dose verification method	33,519,993	3	$145	($905,187,000)	($541,372,000)	($719,785,000)
2026–2035	Report of 50 rem (0.5 sievert) threshold event to regional office or Agreement State office	337,993	10	$145	($36,509,000)	($21,835,000)	($29,031,000)
2026–2036	Annual recordkeeping for new procedure	N/A	6	$145	($800)	($500)	($600)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2036	Annual upkeep for dose verification method	N/A	N/A	N/A	($22,330,000)	($14,190,000)	($18,264,000)
Total Benefits (Costs)					($2,225,833,000)	($1,332,055,000)	($1,770,440,000)

Totals differ within and across tables due to rounding.

4.3.3 NRC Implementation

NRC development costs are the costs of preparing a regulation before its issuance and implementation. Such costs may include expenditures for research in support of this regulatory action, publishing notices, holding public meetings, responding to public comments, and preparing preliminary rule text. The NRC implementation costs are those "front-end" costs necessary to put into force the regulatory action and include tasks such as performing rulemaking or developing procedures and guidance to assist licensees in complying with the final action. Costs already incurred, including those activities performed by the NRC in making the regulatory decision (e.g., development of the proposed rule), are viewed as "sunk" costs and are excluded from this analysis.

Under both Alternatives 2 and 3, development and implementation costs within the scope of this analysis would include the costs of preparing a final rule, as well as efforts to develop guidance associated with the rule. The NRC would use contractor support to manage public comments on the proposed rule package. Under Alternative 3, the NRC would expand the scope of the NMED to process the large increase in the number of medical event reports, which may include developing a separate module within the NMED database and software solely for extravasations. Tables 9 and 10 present these costs.

Table 9 NRC Implementation (Alternative 2)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
				Undiscounted	7% Discount Rate	3% Discount Rate
2025	Contractor support	1,008	$134	($135,000)	($118,000)	($127,000)
2025	Preparation of final rule and supporting documents	1,979	$143	($283,000)	($247,000)	($267,000)
2025	Preparation and issuance of guidance	383	$143	($55,000)	($48,000)	($52,000)
Total Benefits (Costs)				($473,000)	($413,000)	($446,000)

Totals differ within and across tables due to rounding.

Table 10 NRC Implementation (Alternative 3)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
				Undiscounted	7% Discount Rate	3% Discount Rate
2025	Contractor support	1,008	$134	($135,000)	($118,000)	($127,000)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
				Undiscounted	7% Discount Rate	3% Discount Rate
2025	Preparation of final rule and supporting documents	1,979	$143	($283,000)	($247,000)	($267,000)
2025	Preparation and issuance of guidance	383	$143	($55,000)	($48,000)	($52,000)
2025	NMED software and database upgrade	N/A	N/A	($3,500,000)	($3,057,000)	($3,299,000)
Total Benefits (Costs)				($3,973,000)	($3,470,000)	($3,745,000)

Totals differ within and across tables due to rounding.

4.3.4 NRC Operation

Over the analysis horizon, the NRC expects it would incur additional costs associated with reviewing and processing extravasation medical event reports. Under both Alternatives 2 and 3, the amount of labor on a per report basis associated with reviewing and processing the medical event reports is identical. However, due to the difference in the extravasation medical event reportable threshold versus criteria, the difference in estimated costs is significant.

As part of its oversight, the NRC inspects facilities where medical events occur under the NRC medical event assessment program to determine whether further regulatory enforcement actions are necessary to ensure public health and safety. Under MD 8.10, the NRC will assess all medical events and incidents by its licensees in accordance with the medical event assessment program. Under both alternatives, the NRC expects that extravasations would be classified as medical events under the medical event assessment program. After processing a medical event report, the NRC makes an initial assessment of the event. As a next step, the NRC may conduct a reactive in-person inspection of the licensee's facility via an incident investigation team or an augmented inspection team. The inspection can vary in complexity and the number of inspectors involved. Once the inspection is completed, under both alternatives, the NRC would conduct follow-up activities, which may include enforcement actions for failure to follow required procedures or report the event in the timeframe required by regulations. Because Alternative 3 would result in a much larger number of medical event reports, the NRC expects there would be a significant increase in costs under this alternative. This increase in costs would include an increase in the amount disbursed annually under the NMED service contract, which may include the addition of contractors to review and process the increased number of medical event reports.[8] Tables 11 and 12 present these costs.

Table 11 NRC Operation (Alternative 2)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Review of radiation injury reports	871	3	$143	($31,000)	($19,000)	($25,000)

[8] The current NMED service contract costs approximately $1.2 million annually.

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Uploading report on radiation injury event to the NMED	871	13	$143	($157,000)	($96,000)	($126,000)
2026–2035	Initial assessment of medical event	871	50	$143	($623,000)	($380,000)	($500,000)
2026–2035	Inspection of facility associated with medical event	871	450	$143	($5,605,000)	($3,419,000)	($4,496,000)
2026–2035	Follow-up assessment of medical event, including enforcement	871	433	$143	($5,397,000)	($3,293,000)	($4,329,000)
2026–2035	Additional review time during license renewal to review inspection material	871	10	$143	($126,000)	($77,000)	($101,000)
Total Benefits (Costs)					($11,941,000)	($7,285,000)	($9,578,000)

Totals differ within and across tables due to rounding.

Table 12 NRC Operation (Alternative 3)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Review of report for extravasation exceeding 50 rem	31,164	3	$143	($1,123,000)	($664,000)	($889,000)
2026–2035	Uploading report on extravasation event exceeding 50 rem	31,164	13	$143	($5,617,000)	($3,319,000)	($4,443,000)
2026–2035	Initial assessment of medical event	31,164	50	$143	($22,282,000)	($13,165,000)	($17,625,000)
2026–2035	Inspection of facility associated with medical event	23,373	450	$143	($150,404,000)	($88,861,000)	($118,970,000)
2026–2035	Follow-up assessment of medical event,	23,373	433	$143	($144,833,000)	($85,570,000)	($114,564,000)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
	including enforcement						
2026–2035	Additional review time during license renewal to review inspection material	31,164	10	$143	($4,494,000)	($2,655,000)	($3,554,000)
2026–2035	NMED service contract marginal increase	N/A	N/A	N/A	($23,000,000)	($14,110,000)	($18,493,000)
Total Benefits (Costs)					($351,753,000)	($208,344,000)	($278,538,000)

Totals differ within and across tables due to rounding.

4.3.5 Agreement State Implementation

Agreement States would incur costs for development and implementation of compatible regulations. The costs could vary significantly by State because of differences in each state's procedures for developing regulations.[9]

The "Agreement State Program Policy Statement" approved by the Commission on October 2, 2017, and published in the *Federal Register* (82 FR 48535; October 18, 2017), sets forth the approach that the NRC uses to determine those program elements (including regulations) that must be adopted by an Agreement State to maintain an adequate and compatible program. Under the Policy Statement, NRC program elements can be placed into six categories (A, B, C, D, NRC, or health and safety (H&S)) to form the basis for evaluating and classifying the program elements.[10]

The proposed new addition of a definition for "extravasation" in 10 CFR 35.2, "Definitions," would be designated Compatibility Category B,[11] and the proposed new addition of a definition

[9] The NRC did not develop proposed rule language for Alternative 3. However, the NRC assumes the categories for such a rule would be similar to Alternative 2.

[10] For additional information on these categories, please see MD 5.9, " Adequacy and Compatibility of Program Elements for Agreement State Programs" (NRC, 2018), and State Agreements Procedure SA-200, "Compatibility Categories and Health and Safety Identification for NRC Regulations and Other Program Elements" (NRC, 2020b).

[11] Compatibility Category B pertains to program elements that cross jurisdictional boundaries and should be addressed to ensure uniformity of regulation on a nationwide basis. The Agreement State program element should be essentially identical to that of the NRC. Compatibility Category C includes those program elements that do not meet the criteria of Category A or B, but an Agreement State should adopt its essential objectives to avoid conflict, duplication, gaps, or other conditions that would jeopardize an orderly pattern in regulating Agreement State material on a national basis. An Agreement State should adopt the essential objectives of the Category C program elements. Compatibility Category D includes those program elements that do not meet any of the criteria of Category A, B, or C, above, and, thus, do not need to be adopted by Agreement States for purposes of compatibility. Compatibility Category NRC are those program elements that address areas of regulation that cannot be relinquished to the Agreement States under the Atomic Energy Act of 1954, as amended, or provisions of 10 CFR. These program elements should not be adopted by the Agreement States. Category H&S program elements are not required for purposes of compatibility; however, they do have particular health and safety significance. The Agreement State should adopt the essential objectives of such program elements to maintain an adequate program.

for “radiation injury” in 10 CFR 35.2 would be designated Compatibility Category C. The proposed revisions to add new requirements for procedures for evaluating and reporting extravasations in 10 CFR 35.42(a) and (b) would be designated Category H&S. The proposed revisions to add new requirements for procedures for evaluating and reporting extravasations in 10 CFR 35.42(c) would be designated Compatibility Category D. The proposed revisions to add new requirements for maintaining records for procedures for evaluating and reporting extravasations in 10 CFR 35.2042 would be designated Compatibility Category D. The proposed revisions to add new requirements for report and notification of a medical event in 10 CFR 35.3045(a)(3) would be designated Compatibility Category C.

To incorporate definitions designated as Compatibility Category B, Agreement States would need to make revisions that are essentially identical to the NRC regulation. To incorporate those requirements designated as Compatibility Category C, Agreement States may be more restrictive than the NRC, provided that the essential objective of the NRC regulation is met, and the State requirements do not jeopardize an orderly pattern of regulation of agreement material on a nationwide basis. For those requirements designated as Category H&S, which have health and safety significance, Agreement States must adopt the essential objectives of the definitions and requirements. An Agreement State has the flexibility to choose whether or not to adopt and implement requirements designated as Compatibility Category D. However, if an Agreement State chooses to adopt such requirements, they should be adopted in a manner such that 1) they are comparable with those of the NRC, 2) they do not preclude, or effectively preclude a practice in the national interest without adequate protection of public health and safety, security, or environmental basis related to radiation protection, and 3) they do not preclude, or effectively preclude the ability of the NRC to evaluate the effectiveness of the Agreement State program with respect to the protection of public health and safety. Table 13 presents these costs.

Table 13 Agreement State Implementation (Alternatives 2 and 3)

Fiscal Year	Activity	Labor (Hours)	Wage ($/Hour)	Agreement States	Net Benefits (Costs)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2024	Agreement State working group support	151	$151	N/A	($23,000)	($23,000)	($23,000)
2026	Agreement State development and implementation of compatible regulations	381	$151	41	($2,349,000)	($2,195,000)	($2,281,000)
Total Benefits (Costs)					($2,372,000)	($2,218,000)	($2,304,000)

Totals differ within and across tables due to rounding.

4.4 Agreement State Operation

Under both alternatives, Agreement States would incur additional operational costs over the analysis horizon associated with reviewing medical event reports and performing inspections. Similar to the NRC operational costs, the difference in reportable threshold versus criteria for determining an extravasation creates a much larger number of qualifying events under Alternative 3, which drives the difference in costs between the alternatives. For purposes of this

regulatory analysis, the NRC assumed the Agreement States would have compatible medical event reporting regulations to the NRC; they would also conduct inspections for each medical event report they receive and take the same steps as the NRC to perform the inspection of their licensee. However, the NRC assumed that, due to the difference in resources and personnel available to Agreement State health departments, each step of the inspection process would require approximately 50 percent more labor. Tables 14 and 15 present these costs.

Table 14 Agreement State Operation (Alternative 2)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Review of reports	1,929	9	151	($184,000)	($110,000)	($146,000)
2026–2035	Initial assessment of medical event	1,929	71	151	($1,518,000)	($908,000)	($1,207,000)
2026–2035	Inspection of facility associated with medical event	1,447	638	151	($10,249,000)	($6,130,000)	($8,150,000)
2026–2035	Follow-up assessment of medical event, including enforcement	1,447	608	151	($9,780,000)	($5,849,000)	($7,777,000)
2026–2035	Additional review time during license renewal to review inspection material	1,447	10	151	($162,000)	($97,000)	($129,000)
Total Benefits (Costs)					($21,893,000)	($13,094,000)	($17,409,000)

Totals differ within and across tables due to rounding.

Table 15 Agreement State Operation (Alternative 3)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Review of reports	306,830	9	151	($29,218,000)	($17,474,000)	($23,233,000)
2026–2035	Initial assessment of medical event	306,830	71	151	($241,468,000)	($144,417,000)	($192,010,000)

Fiscal Year	Activity	Events	Labor (Hours)	Wage ($/Hour)	Total Benefit (Cost)		
					Undiscounted	7% Discount Rate	3% Discount Rate
2026–2035	Inspection of facility associated with medical event	30,122	638	151	($1,629,912,000)	($974,814,000)	($1,296,070,000)
2026–2035	Follow-up assessment of medical event, including enforcement	230,122	608	151	($1,555,341,000)	($930,214,000)	($1,236,772,000)
2026–2035	Additional review time during license renewal to review inspection material	230,122	10	151	($25,780,000)	($15,419,000)	($20,500,000)
Total Benefits (Costs)					($3,481,719,000)	($2,082,338,000)	($2,768,585,000)

Totals differ within and across tables due to rounding.

4.5 Public Health (Accident) and Public Health (Routine)

Both Alternatives 2 and 3 could result in a reduction in the rate of extravasations that may be attributable to human error (Accident) and those extravasations that are not attributable to human error and would occur regardless (Routine). Any reduction in the number of extravasations could directly result in a decrease in radiation exposure to the public. Currently, this amount is difficult to quantify due to the lack of available data on extravasations. Further, all intravascular administrations of radiopharmaceuticals require some level of radiation exposure to patients to achieve the desired clinical outcome of the administration. Additional detailed data on extravasations, including the types of procedures, patient characteristics, and licensee practices that may contribute to individual extravasations, will inform the difference between radiation exposures necessary to achieve the desired diagnostic or therapeutic outcome and the radiation exposure that is in excess of that level and thus avoidable as a result of a reduction in extravasations. This avoidable level of radiation exposure would be considered a direct benefit of the alternatives.

In addition, as a result of either alternative, patients may become more aware of the existence of extravasations and their potential for harm. Patients may seek out medical attention sooner than they would have otherwise after a radiopharmaceutical administration. Any improvement in health outcomes for patients due to seeking medical attention at an earlier point after the administration would be considered a benefit of the alternatives.

4.6 Improvements in Knowledge

Both alternatives would lead to improvements in regulator's knowledge, which are not readily quantifiable. The NRC and Agreement States do not currently track extravasations or any of the data surrounding their circumstances and resultant effects on public health outcomes. The NRC

expects that as the use of radiopharmaceuticals increases, as access to treatment improves, and as new treatments are developed, information on patient outcomes will be critical to further inform regulatory decisions. Under both alternatives, the NRC could use the medical event reporting data on extravasations to form a broader understanding of extravasation rates and the underlying causes, which may be complex due to the broad range of factors that affect individual patient outcomes. The NRC could make the data and any findings based on the data publicly available through generic communications, which would lead to improvements in licensee awareness regarding extravasations and potentially improved public health outcomes. Licensees could make use of the data to strengthen their medical audit procedures, which could lead to improvements in public health outcomes. Additionally, the public availability of this information would allow patients to make informed medical decisions and better respond to adverse circumstances that may arise during the course of medical procedures. As noted above, these data may allow the NRC and interested stakeholders to quantify the radiation exposure from extravasations.

4.7 Other Considerations

4.7.1 Public Confidence

The alternatives would lead to an increase in public confidence in the NRC's ability to address emerging issues in its regulation of radiopharmaceuticals to enhance protection of public health. Furthermore, the inclusion of extravasations reporting requirements in the NRC regulations would increase public confidence in the agency's ability to improve its regulations, adapt to regulatory needs identified by stakeholders, offer opportunities for stakeholders to provide input to the changes, and maintain the NRC's role as an effective regulator. The rulemaking process also provides an opportunity for Commission and public engagement on issues related to extravasations.

Because the proposed rule in Alternative 2 does not include a dose threshold for extravasations, it may lead initially to a decrease in public confidence in the NRC's ability to protect public health. Stakeholders may find the implementation of a dose threshold as an objective standard for extravasations more desirable for protecting public health outcomes, which Alternative 2 does not include. However, it is unlikely that the potential unquantifiable cost to the NRC associated with this initial loss in public confidence would outweigh the quantifiable cost associated with implementing a dose threshold for extravasations associated with Alternative 3.

Under Alternative 3, the 50 rem (0.5 sievert) reportable threshold for extravasations would lead to a large increase in the number of reportable medical events, which could negatively affect the ability of the NRC and Agreement States to respond to events with higher radiation safety significance.

4.7.2 Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 et seq.), enacted in September 1980, requires agencies to consider the impact of their regulatory proposals on small entities, analyze alternatives that minimize small entity impacts, and make their analyses available for public comment. The NRC uses the following size standards, codified at 10 CFR 2.810, "NRC size standards," to qualify a licensee as a small entity:

- A small business is a concern that provides a service or a concern not engaged in manufacturing with average gross receipts of $8 million or less over its last 5 completed fiscal years; or a manufacturing concern with an average number of 500 or fewer

employees based upon employment during each pay period for the preceding 12 calendar months.

- A small organization is a not-for-profit organization that is independently owned and operated and has annual gross receipts of $8 million or less.

- A small governmental jurisdiction is a government of a city, county, town, township, village, school district, or special district with a population of less than 50,000.

- A small educational institution is one that is (1) supported by a qualifying small governmental jurisdiction or (2) not State or publicly supported and has 500 or fewer employees.

Small entities include small businesses, small governments, small nonprofits, and small educational institutions. Small governments, small nonprofits, and small educational institutions are not expected to be affected by this proposed rule; however, many of the licensees affected by the proposed rule are small businesses under the NRC's size standards, based on their average gross receipts.

Because NRC licensees with annual gross receipts below $8 million pay reduced fees, the NRC has data on the number of licensees who certified that they qualified as small entities for reduced fee purposes. Based on data from the NRC Financial Accounting and Integrated Management Information System in December 2023, 789 licensees reported that their annual gross receipts were below $8 million (NRC, 2023a). Based on the number of NRC materials licensees from the most recent count (NRC, 2023b), approximately 37 percent of materials licensees qualify as small entities. Including Agreement State licensees, this proposed rule would affect 5,933 total licensees, of which an estimated 2,195 are small entities.

The NRC has not established a quantitative definition of the number or proportion of licensees that constitutes a substantial number. However, for the purpose of this rulemaking, the NRC assumes that 37 percent of all licensees constitutes a "substantial number" of small entities likely to be impacted by this rule. The rule would affect a substantial number of each of the two categories of licensees considered, medical institutions and individual private medical practitioners.

To evaluate the impact that a small entity would be expected to incur as a result of the proposed rule, the ratio of annualized costs was calculated as a percentage of estimated gross receipts. The NRC has not established a quantitative cutoff for "significant impact." For the purpose of this rulemaking, the NRC assumes "significant" impact if the ratio of annualized costs to estimated annual gross receipts for a licensee exceeds 1 percent.

The proposed rule would have an estimated $14.2 million implementation cost impact on the industry. This cost would be spread over the 5,933 impacted licensees or an average implementation cost of approximately $2,400 per licensee. The industry would also incur an estimated $1.55 million in operation costs over the 10-year licensing period (table 7), which would result in an estimated average annual cost of $155,000 for the total 5,933 impacted licensees or an estimated average annual cost of $26 per licensee.

The NRC assumes that all affected licensees have annual revenues greater than $110,000; therefore, the estimated cost impacts do not exceed the 1 percent criterion for "significant

impacts." Even though the rule would affect a substantial number of licensees that are small entities, it would not have a significant economic impact on these entities.

The NRC has taken a number of actions in this rule to ensure that the selected alternative is the least costly alternative that adequately protects public health. As the regulatory analysis prepared for this rule demonstrates, the alternative selected is limited in scope and does not impose a dose threshold for determining an extravasation, which would otherwise impose significant costs on all licensees.

5 SUMMARY OF THE RESULTS

5.1 Summary

This regulatory analysis identifies both quantifiable and nonquantifiable costs and benefits that would result from the alternatives. Although quantifiable costs and benefits appear to be more tangible, decision-makers should not discount costs and benefits that cannot be quantified. Such benefits or costs can be as important as or even more important than benefits or costs that can be quantified and monetized.

5.1.1 Quantified Net Benefits

Table 16 summarizes the estimated quantified benefits and costs for the alternatives, compared to the regulatory baseline (Alternative 1). The quantitative analysis used best estimate values.

5.1.2 Nonquantified Benefits

In addition to the quantified costs, the NRC analyzed numerous benefits and costs that could not be monetized but would affect the general public, the industry, and the NRC. Table 16 summarizes these benefits.

Table 16 Summary of Totals

Net Monetary Savings or (Costs)—Total Present Value	Nonquantified Benefits or (Costs)
Alternative 1: No Action $0	**Benefits:** • **Public Health (Accident and Routine):** Alternative 1 would continue to rely on the NRC's existing medical use regulations to protect public health and safety and on physicians to continue to address significant extravasations. **Costs:** • **Other Considerations:** Alternative 1 would not position the NRC to address the potential and expected increase in the use of radiopharmaceuticals, which could lead to an increase in the occurrence of extravasations, including those that are radiation safety significant; it would not result in improvements to public health and would not increase knowledge on the occurrence and impact of extravasations.
Alternative 2:	**Benefits:** • **Public Health (Accident and Routine):** Alternative 2 could result in an increase in focus on

Net Monetary Savings or (Costs)—Total Present Value	Nonquantified Benefits or (Costs)
Industry: ($12,535,000) using a 7% discount rate ($14,232,000) using a 3% discount rate **NRC:** ($1,510,000) using a 7% discount rate ($1,945,000) using a 3% discount rate **Agreement States:** ($15,312,000) using a 7% discount rate ($19,712,000) using a 3% discount rate **Net Benefit (Cost):** ($29,357,000) using a 7% discount rate ($35,889,000) using a 3% discount rate	quality control during radiopharmaceutical administration by licensees, which could reduce the number of extravasations that occur and the associated excess radiation exposure to the public. • **Improvements in Knowledge:** Alternative 2 would allow the NRC and Agreement States to collect data on extravasations, which could be used to further protect public health. • **Other Considerations:** Alternative 2 could lead to an increase in public confidence in the NRC and its ability to respond to stakeholder concerns and developing trends in the industry it regulates. **Costs**: • **Other Considerations:** Alternative 2 could lead to a decrease in public confidence in the NRC's ability to protect public health because it does not include a dose for a reportable threshold for extravasations.
Alternative 3: **Industry:** ($1,594,243,000) using a 7% discount rate ($2,064,361,000) using a 3% discount rate **NRC:** ($211,814,000) using a 7% discount rate ($282,283,000) using a 3% discount rate **Agreement States:** ($2,084,556,000) using a 7% discount rate ($2,770,889,000) using a 3% discount rate **Net Benefit (Cost):** ($3,890,613,000) using a 7% discount rate ($5,117,533,000) using a 3% discount rate	**Benefits:** • **Public Health (Accident and Routine):** Alternative 3 could result in an increase in focus on quality control during radiopharmaceutical administration by licensees, which could reduce the number of extravasations that occur and the associated excess radiation exposure to the public. • **Improvements in Knowledge:** Alternative 3 would allow the NRC and Agreement States to collect data on extravasations, which could be used to further protect public health. • **Other Considerations:** Alternative 3 would lead to an increase in public confidence in the NRC and its ability to respond to stakeholder concerns and developing trends in the industry it regulates. **Costs**: • **Other Considerations:** The 50 rem (0.5 sievert) reportable threshold for extravasations under Alternative 3 would lead to a large increase in the number of reportable medical events, which could negatively affect the ability of the NRC and Agreement States to respond to events with higher radiation safety significance.

5.2 Uncertainty Analysis

The NRC completed a Monte Carlo sensitivity analysis for this regulatory analysis using the specialty software program @Risk.[12] As described in the sections below, the Monte Carlo approach answers the question, "What distribution of net costs and benefits results from multiple draws of the probability distribution assigned to key variables?"

[12] Information about this software is available at https://www.palisade.com.

5.2.1 Uncertainty Analysis Assumptions

The NRC provides the following analysis of the variables with the greatest uncertainty on estimates of values. To perform this analysis, the staff performed a Monte Carlo simulation analysis using the @Risk software program. Monte Carlo simulations involve introducing uncertainty into the analysis by replacing the point estimates of the variables used to estimate base-case costs and benefits with probability distributions. By defining input variables as probability distributions instead of point estimates, the influence of uncertainty on the results of the analysis (i.e., the net benefits) can be effectively modeled.

The probability distributions chosen to represent the different variables in the analysis were bounded by the range-referenced input and the staff's professional judgment. When defining the probability distributions for use in a Monte Carlo simulation, summary statistics are needed to characterize the distributions. These summary statistics include the minimum, most likely, and maximum values of a PERT distribution.

Appendix A identifies the data elements, the distribution, and the low, most likely, and high estimates of the distribution that were used in the uncertainty analysis.

5.2.2 Uncertainty Analysis Results

The NRC performed the Monte Carlo simulation by repeatedly recalculating the results 10,000 times. For each iteration, the values identified in appendix A were chosen randomly from the probability distributions that define the input variables. The values of the output variables were recorded for each iteration, and these values were used to define the resultant probability distribution.

For the analysis shown in each figure below, 10,000 simulations were run in which the key variables were changed to assess the resulting effect on costs and benefits. Figures 1 through 4 display the histograms of the incremental costs and benefits from the regulatory baseline (Alternative 1) for each affected entity and the total net benefit of the rule. The analysis shows that all affected entities would incur costs if this rule were issued.

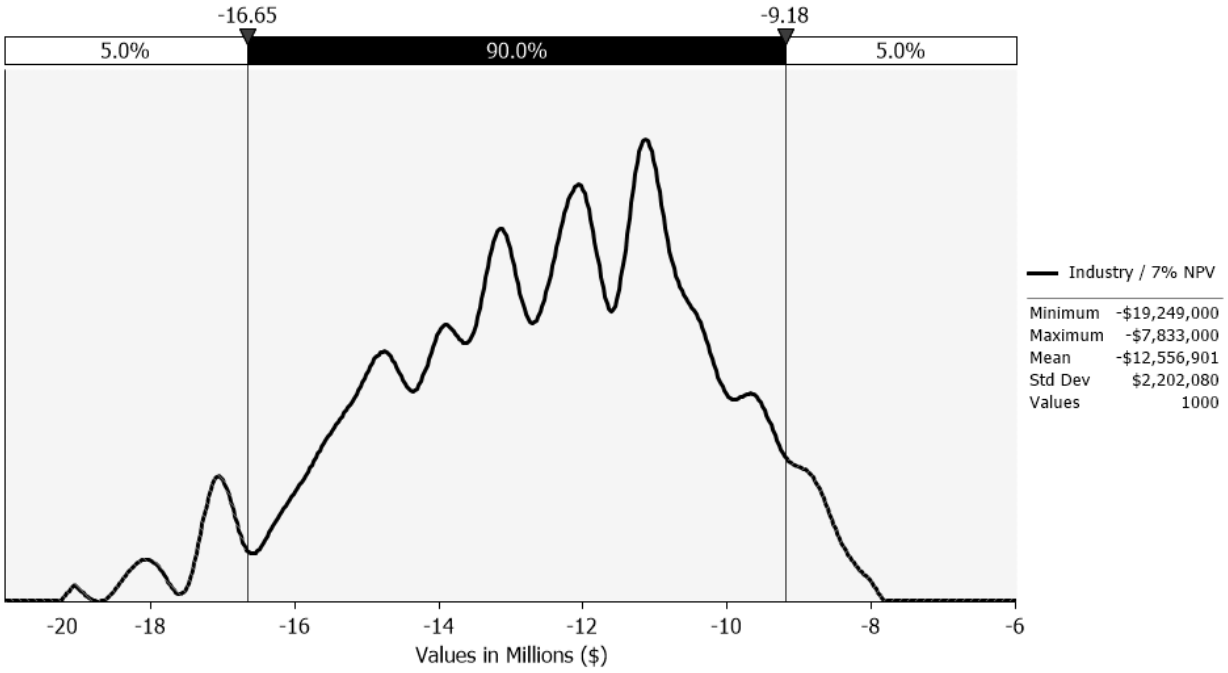

Figure 1 Total industry costs (7 percent NPV)—Alternative 2

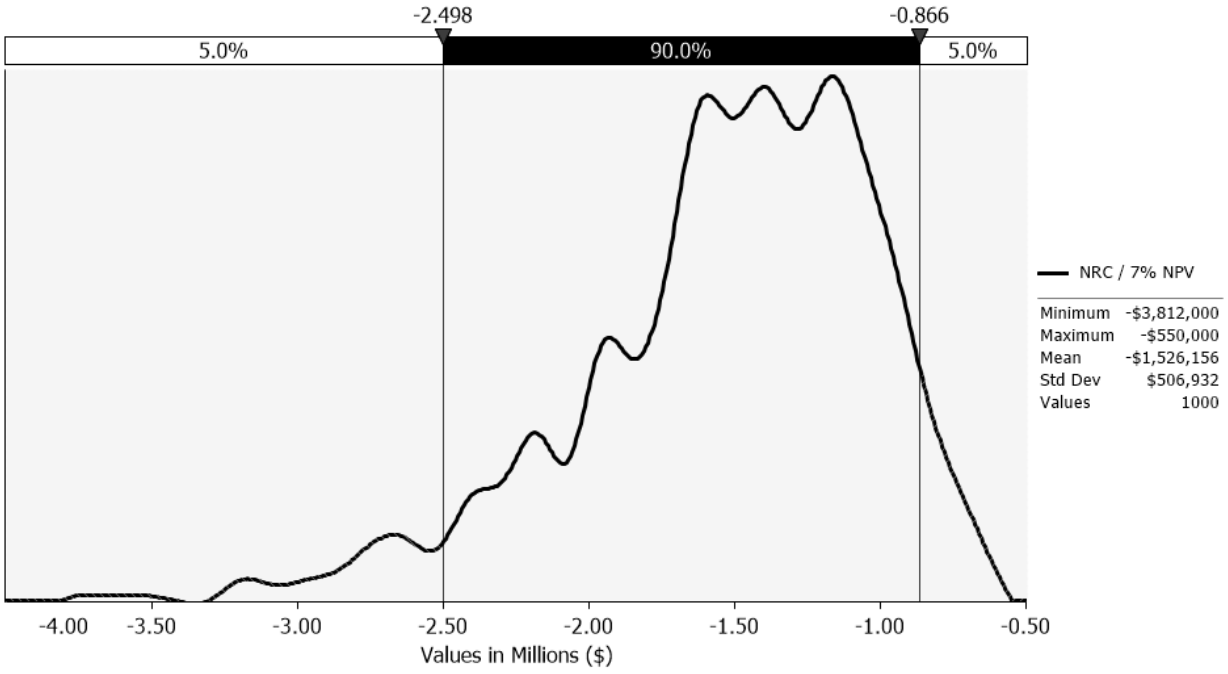

Figure 2 Total NRC costs (7 percent NPV)—Alternative 2

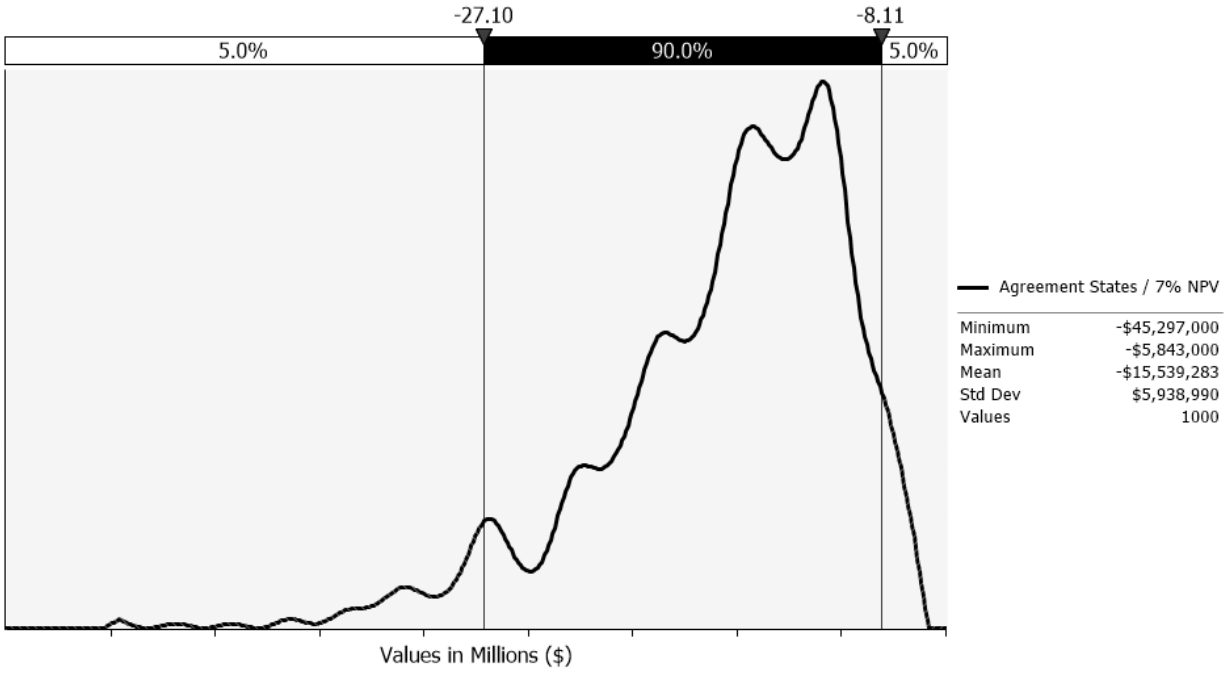

Figure 3 Total Agreement State costs (7 percent NPV)—Alternative 2

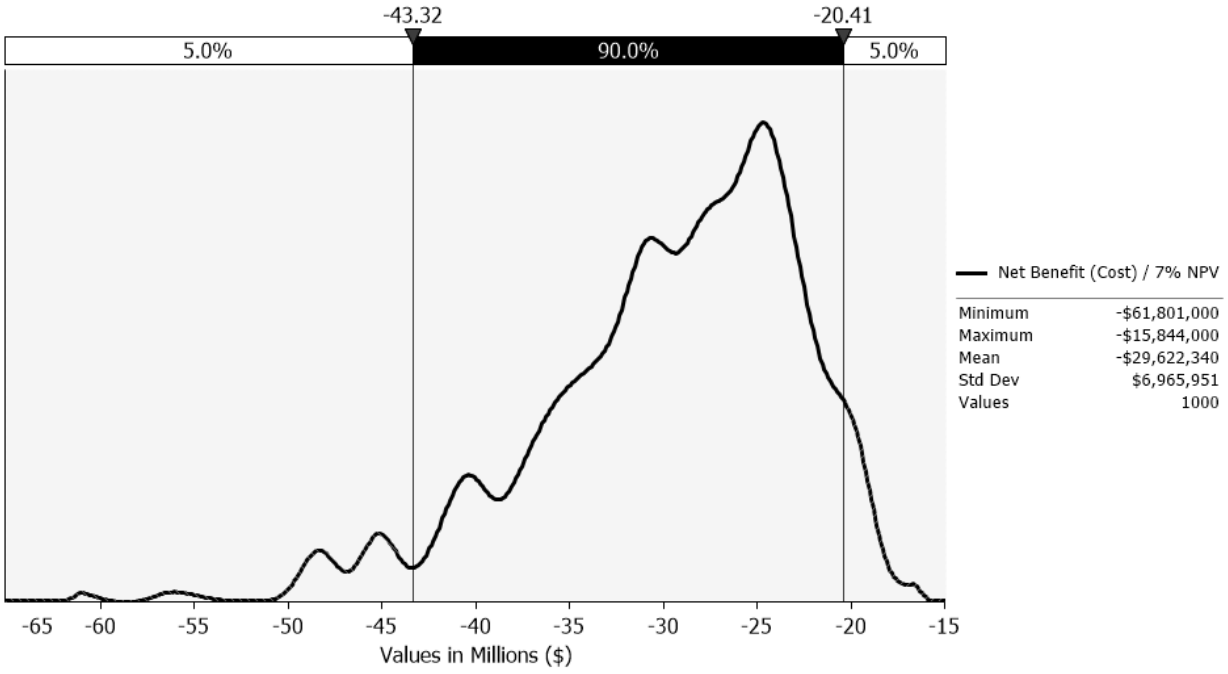

Figure 4 Total net benefit (cost) (7 percent NPV)—Alternative 2

Table 17 presents descriptive statistics for the uncertainty analysis.

Table 17 Descriptive Statistics for Uncertainty Results (7 percent NPV)

Uncertainty Result	Incremental Cost-Benefit (2023 Million Dollars)				
	Min	Mean	Max	5%	95%
Net Industry Benefit (Cost)	($19.2)	($12.6)	($7.8)	($16.7)	($9.2)
Net NRC Benefit (Cost)	($3.8)	($1.5)	($0.6)	($2.5)	($.9)
Net Agreement State Benefit (Cost)	($45.3)	($15.5)	($5.8)	($27.1)	($8.1)
Total Net Benefit (Cost)	($61.8)	($29.6)	($15.8)	($43.3)	($20.4)

This table displays the key statistical results, including the 90 percent confidence interval in which the net benefits would fall between the 5 percent and 95 percent values.

Figure 5 shows a tornado diagram that identifies the cost drivers for this proposed rulemaking. This figure ranks the cost drivers based on their contribution to the uncertainty in cost. The largest cost driver is the rate of extravasations that result from therapeutic intravascular administrations. This acts in conjunction with the fifth largest cost driver, the rate of radiation injury that results from therapeutic intravascular administration extravasations, and the eighth largest cost driver, therapeutic intravascular administrations per year, to drive a large portion of the costs. The mean rate of change to the number of licensees in the program codes 2120 Medical Institution—Limited Scope—Written Directive Required, 2201 Medical Private Practice—Written Directive Not Required, 2121 Medical Institution—Limited Scope–Written Directive Not Required, and 2240 Medical Therapy—Other Emerging Technology are the second, third, fourth, and tenth largest cost drivers, respectively. Based on the historical data, the NRC expects these programs to gain the highest number of additions in licensees over the analysis horizon and contribute a proportionally greater amount of costs related to extravasations. The other cost drivers shown all relate to Agreement State costs and the industry labor rate. The remaining cost drivers show diminishing variation on the total net benefit and have been suppressed from the figure.

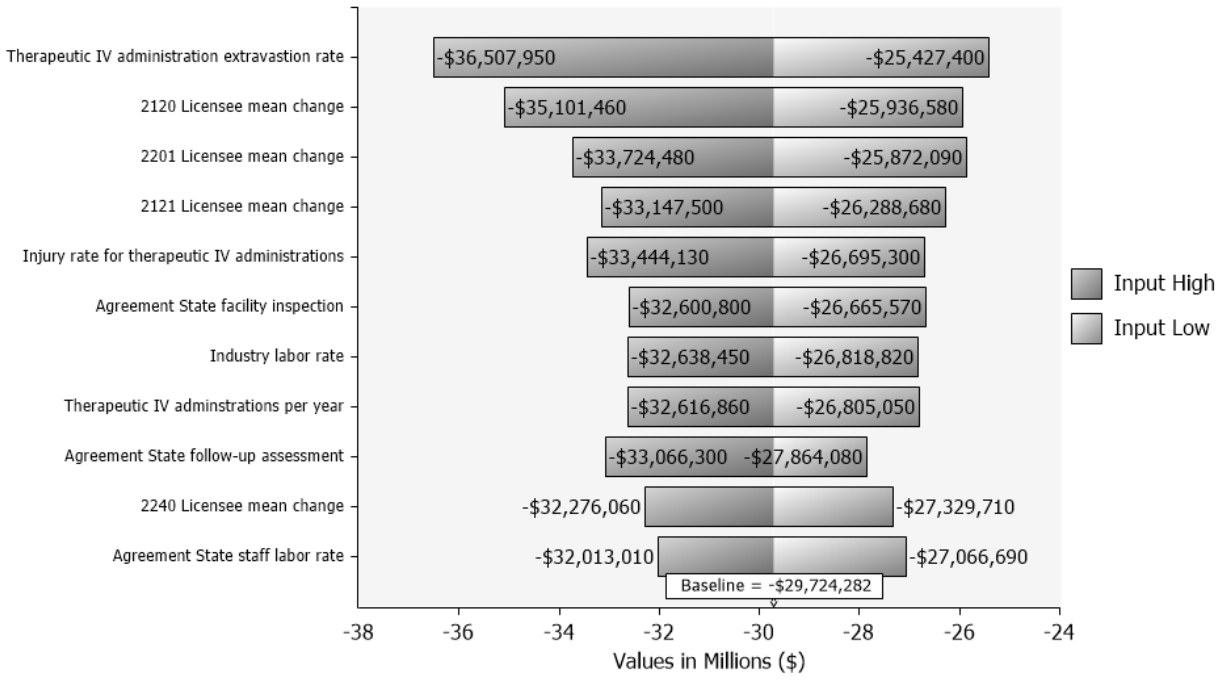

Figure 5 Top cost drivers for which uncertainty impacts the total net costs (7 percent NPV)—Alternative 2

5.2.3 Summary of Uncertainty Analysis

The simulation analysis shows that the estimated mean cost for this proposed rule is ($29,700,000) with 90 percent confidence that the net benefit is between ($43,100,000) and ($20,100,000) using a 7 percent discount rate. The NRC, the industry, and Agreement States would all incur costs under the proposed rule.

5.3 Disaggregation

The NRC performed a screening review to determine whether any of the individual requirements (or set of integrated requirements) of the rule would be unnecessary to achieve the objective of the rulemaking. The NRC concludes that each of the rule's requirements would be necessary to achieve the objective of the rulemaking and found that the requirements considered separately would not mask the inclusion of other unnecessary requirements. Table 18 provides the results of this review.

Table 18 Disaggregation

Regulatory Requirements for Proposed Rule	Objective 1: Include Extravasations under Medical Event Reporting Requirements
Definitions	X
Procedures for evaluating and reporting extravasations	X
Recordkeeping requirements	X
Medical event criteria	X

6 DECISION RATIONALE AND IMPLEMENTATION

The decision rationale is based on the main analysis. Based solely on quantified costs and benefits, neither alternative under consideration would be quantitatively beneficial. However, Alternative 2 would be least costly to implement. The estimated net benefit for Alternative 2 would be ($29,357,000), assuming a 7 percent discount rate, or ($35,889,000), assuming a 3 percent discount rate. Alternative 3 would not be cost beneficial, with net costs of ($3,890,612,500), assuming a 7 percent discount rate, or ($5,117,532,600), assuming a 3 percent discount rate. However, the assessment of total costs and benefits discussed previously leads the NRC to conclude that the proposed rule in Alternative 2, if implemented, would be justified, and would outweigh the quantitative costs to implement the rule.

As noted above, the NRC expects the use of radiopharmaceutical administrations to continue to increase, particularly with respect to therapeutic administrations that could lead to radiation-safety-significant extravasations. Ensuring that the agency's medical event reporting regulations are comprehensive and dispositioned to anticipate that increase would position the NRC to provide reasonable assurance of adequate protection of public health. Without implementation of the proposed rule, the NRC cannot decisively determine the rate of occurrence for extravasations, nor can it analyze the factors that may lead to those rates. Implementing the rulemaking would further the NRC's efforts to be an effective, risk-informed regulator by obtaining this information. Alternative 2 would allow the NRC to obtain necessary data that would lead to an increase in knowledge for the NRC and its stakeholders, which would improve the agency's ability to protect public health. The data and operational experience that the NRC would obtain under Alternative 2 would also support any further action to regulate extravasations, should the data or operational experience show that more stringent action is necessary. While Alternative 2 would impose quantitative costs on the NRC and its stakeholders, these costs are outweighed by the qualitative benefits of the rulemaking. Additionally, as demonstrated in the uncertainty analysis, the rate of extravasations is a main driver of costs for the proposed rule. Changes in either direction for the rate of extravasations would have large effects on the quantitative costs of the proposed rule.

Alternative 3 would largely provide the same benefits, but the quantitative costs of Alternative 3 would be far more than those under Alternative 2, with licensees and Agreement States bearing much of the cost. These costs are significant, and their imposition could have a negative impact on the disposition of medical care to the public. Furthermore, Alternative 3 would lead to reporting of many medical events that have no safety significance and would impose significant costs on the reporting and inspection functions of the NRC and the Agreement States.

The NRC assumed for this analysis that the effective date of the final rule, if approved, would be in 2026. Full implementation by the Agreement States would be approximately 3 years later. The NRC would also issue a final guidance with the final rule.

Agreement States have 3 years to make changes to their affected regulations.

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APPENDIX A

UNCERTAINTY ANALYSIS VARIABLES

Activity	Mean Estimate	Distribution	Low Estimate	Best Estimate	High Estimate
General					
Base year	2023				
Year rule is active	2026				
Year Agreement State rule is active	2029				
Analysis horizon	2035				
Discount rate	7%				
Supplemental discount rate	3%				
NRC staff labor rate	$143				
NRC full-time equivalent hours	1,510				
Contractor labor rate	$134				
Labor rate multiplier	2.4				
Learning curve	90%				
Number of Agreement States	41				
Number of medical licensees in 2023	5,933				
Rate of reactive inspections	75%				
Agreement State staff labor rate	$151	PERT	$108.75	$149.52	$196.31
Industry labor rate	$145	PERT	$94.45	$140.12	$215.86
Radiopharmaceutical administrations per day and extravasation rates					
Total extravasation rate (Alternative 3)	7.79%	PERT	0.37%	7.79%	15.20%
Estimated rate of extravasations exceeding 50 rem (Alternative 3)	1.01%	PERT	0.75%	1.00%	1.30%
Extravasation rate for therapeutic intravascular administrations (Alternative 2)	0.20%	PERT	0.14%	0.18%	0.37%
Injury rate for therapeutic intravascular administrations that result in extravasations (Alternative 2)	25.21%	PERT	18.75%	25.00%	32.50%
Number of radiopharmaceutical administrations per year	18,654,167	PERT	13,875,000	18,500,000	24,050,000
Therapeutic intravascular administrations per year	178,979	PERT	133125	177500	230750
NRC Implementation					
Rulemaking					
Preparation of proposed rule and supporting documents	2,323 hours	PERT	1,980	2,265	2,895
Preparation of draft guidance	383 hours	PERT	285	380	494
Preparation of final rule and supporting documents	1,979 hours	PERT	1,472	1,963	2,552
Preparation and issuance of guidance	383 hours	PERT	285	380	494
Contractor support	1,008 hours	PERT	750	1000	1300
NMED software and database upgrade	$3,500,000	PERT	$2,000,000	$3,500,000	$5,000,000

Activity	Mean Estimate	Distribution	Low Estimate	Best Estimate	High Estimate
NMED service contract marginal increase	$2,300,000	PERT	$1,800,000	$2,300,000	$2,800,000
NRC Operation					
Reporting					
Review of radiation injury reports	0.20 hour	PERT	0.15	0.20	0.26
Uploading report on radiation injury event to NMED	1.01 hours	PERT	0.75	1	1.30
Review of report for extravasation exceeding 50 rem	0.25 hour	PERT	0.19	0.25	0.33
Uploading report on extravasation event exceeding 50 rem (0.5 sievert)	1.26 hours	PERT	0.94	1.25	1.63
Inspections					
Initial assessment of medical event	5 hours	PERT	2	5	8
Inspection of facility associated with medical event	45 hours	PERT	10	45	80
Follow-up assessment of medical event, including enforcement	43 hours	PERT	20	40	80
Additional review time during license renewal to review inspection material	1 hour	PERT	0.75	1	1.30
Industry Implementation					
Rulemaking					
Attending public meetings; reviewing and commenting on proposed rule and guidance	1,210.00 hours	PERT	900	1,200	1,560
Attending public meetings; reviewing and commenting on final rule and guidance	907.50 hours	PERT	675	900	1,170
Composing procedures to implement new reporting requirement	8.07 hours	PERT	6	8	10
Training staff on new reporting requirement	8.07 hours	PERT	6	8	10
Cost to implement method to verify dose	$56,667	PERT	$0	$10,000	$300,000
Percentage of licensees that already have dose verification method	10%	PERT	8%	10%	13%
Training staff on applying dose verification method	6.05 hours	PERT	5	6	8
Industry Operation					
Documentation and Reporting					
Procedures to characterize and document qualifying event	2.75 hours	PERT	0.50	2.00	8.00
Reporting 50 rem (0.5 sievert) threshold event to regional office or Agreement State office	1.01 hours	PERT	1	1	1
Reporting radiation injury event to regional office or Agreement State office	4.03 hours	PERT	3	4	5
Procedures					
Additional monitoring of administration	0.03 hour	PERT	0.02	0.03	0.03
Application of dose verification method	0.25 hour	PERT	0.19	0.25	0.33
Annual upkeep for dose verification method	$2,500	PERT	$0	$2,500	$5,000
Annual recordkeeping for new procedure	0.55 hour	PERT	0.4125	0.55	0.715
Agreement State Implementation					
Rulemaking					
Agreement State working group support	151 hours	PERT	113	150	195

Activity	Mean Estimate	Distribution	Low Estimate	Best Estimate	High Estimate
Agreement State development and implementation of compatible regulations	381 hours	PERT	283	378	491
Agreement State Operation					
Reviewing reports	1 hour	PERT	0.64	0.85	1.11
Initial assessment of medical event	7 hours	PERT	2.50	7.50	10.00
Inspection of facility associated with medical event	64 hours	PERT	12.50	67.50	100.00
Follow-up assessment of medical event, including enforcement	61 hours	PERT	25.00	60.00	100.00
Additional review time during license renewal to review inspection material	1 hour	PERT	0.75	1.00	1.30