Establishing a National Isotope Program for Supply Chain Resilience in Korea

Gyu Hyeon Sim [a], Jae Chang Kim [a], Joo Hyung Kim [a], Yong Kyun Kim [a*]
[a]*Department of Nuclear Engineering, Hanyang University, Seoul, Korea*
[*]*Corresponding author: ykkim4@hanyang.ac.kr*

Keywords : Research Reactor, Radioisotopes, Supply Chain Management, National Isotope Program

1. Introduction

The global demand for RadioIsotope (RI) used in cancer diagnosis and therapy has been steadily increasing at an annual rate exceeding 5%, driven by the rapid transition toward aging societies and continuous advancements in nuclear medicine technologies. [1] However, the domestic RI supply chain has not been able to effectively respond to this growing demand. [1] The self-sufficiency rate of several key medical isotopes remains low, resulting in a heavy reliance on imports for the majority of critical radionuclides.

In particular, molybdenum-99 (Mo-99), the most widely used diagnostic RI worldwide, has demonstrated the vulnerability of the global supply system. In 2009, the unexpected shutdown of Canada's National Research Universal (NRU) reactor, which had been responsible for a significant portion of the global Mo-99 supply, led to a temporary disruption in cancer imaging services in many countries. [2] This incident highlighted the potential threat to national healthcare security posed by excessive dependence on specific countries or facilities for essential medical isotopes.

In this context, with the forthcoming operation of the new research reactor currently under construction in Ki-Jang, Busan, the establishment of a dedicated national-level organization has emerged as a critical policy priority. Such an institution would be responsible for ensuring a stable isotope supply chain and implementing an efficient and systematic management framework to enhance national medical and industrial resilience. This study proposes an institutional framework for a National Isotope Program in Korea through comparative analysis of international RI governance models.

2. Methods and Results

2.1 International RI Management Overview

A comparative institutional analysis was conducted for major RI governance models in the United States, Canada, and Japan. The comparison focused on governance structure, roles across the isotope lifecycle, supply and demand coordination mechanisms, and crisis response functions. Institutional gaps in Korea were then identified by structural comparison to these reference models.

Upon completion and operation of the Ki-Jang research reactor, Korea is projected to expand domestic production capacity for major medical and industrial RIs, including Mo-99 and Tc-99m generators. This development signifies that Korea will no longer remain a simple importing country but will instead establish the hardware foundation necessary to participate more actively in the global medical isotope market.

However, successful attainment of supply resilience requires not only physical production capabilities but also a comprehensive institutional and managerial framework to support their operation. International experience shows that advanced countries do not rely solely on production facilities, but instead operate national coordination systems that treat radioisotopes as strategic assets. In the United States, the Department of Energy (DOE) manages isotope production and distribution through the DOE Isotope Program, while the National Nuclear Security Administration has promoted the establishment of a reliable domestic Mo-99 supply chain in order to reduce dependence on foreign imports [3,4]. In particular, DOE/NNSA has provided more than $200 million in cooperative agreement support for domestic non-HEU Mo-99 commercialization, and SHINE's planned facility has been presented as having a capacity corresponding to more than 75% of U.S. Mo-99 demand, indicating that the U.S. program has contributed to the rebuilding of domestic production capability.

In Canada, recent policy developments indicate that isotope governance has been strengthened through public-private coordination rather than through the unilateral control of a single operator. The background for this approach was the institutional fragmentation of isotope-related policy and support functions across multiple federal departments. The Canadian Nuclear Isotope Council (CNIC) noted that no single department was responsible for the whole of the Canadian isotope industry, thereby necessitating a more integrated national strategy [5,6]. In response, the Canadian Medical Isotope Ecosystem was launched in 2023 with federal support of up to $35 million over five years, linking production, advancement, and distribution functions across multiple partners. In Japan, the Japan Radioisotope Association continues to perform intermediary roles in isotope distribution and supply-demand adjustment, demonstrating the importance of an institutional mechanism for stable isotope utilization

[7].

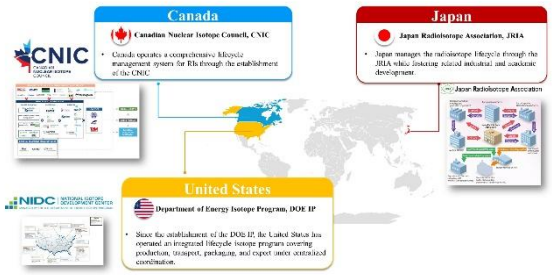

Fig. 1. Current Status of Global Radioisotope Management Institutions

2.2 Establishment of a National Isotope Program

To ensure the successful operation of the Ki-Jang Research Reactor and maximize its national utility, it is essential to establish a provisional National Isotope Program responsible for overseeing the domestic and international RI supply chain.

A review of operational models in advanced countries reveals that national-level isotope institutions typically assume responsibility for overall supply-demand coordination and crisis response, while simultaneously respecting the expertise and market role of existing private-sector distribution entities. Such cooperative governance models enable effective public oversight without undermining market efficiency.

This institutional need becomes more significant because medical isotopes are short-lived and cannot be stockpiled efficiently. As demonstrated by the 2009 shutdown of Canada's NRU reactor, excessive dependence on a limited number of major facilities can rapidly disrupt healthcare services across multiple countries [2,8]. International experience since that shortage has shown that supply resilience depends not only on production capacity itself but also on diversification in production, processing, and distribution, together with coordinated contingency planning.

In alignment with these international precedents, Korea should adopt a collaborative framework in which the newly established institution does not monopolize or directly control the market but instead coexists with and supports the existing private distribution ecosystem. The proposed program would function as a rational mediator among reactor operators as producers, medical and industrial sectors as end-users, and established private distribution networks. In this way, the program would strengthen national supply chain resilience while preserving the efficiency of market-based delivery systems.

3. Conclusions

With the introduction of the Ki-Jang research reactor, a structural foundation for domestic RI production has been established. However, international cases indicate that production capability alone does not guarantee supply stability. A resilient isotope supply chain requires an institutional framework capable of integrating demand forecasting, emergency response, logistics, and public-private coordination [3-6,8].

In this context, the establishment of a National Isotope Program is required not simply because a new reactor is being introduced, but because Korea must prevent the concentration of supply risk in a limited number of facilities and institutions. Rather than monopolizing or unilaterally regulating the market, the proposed institution should adopt a cooperative governance model that actively respects the expertise and autonomy of the existing private distribution ecosystem.

The program would function as a macro-level public control tower responsible for demand forecasting, emergency supply stabilization, diversification of production and processing infrastructure, and the development of international cooperation networks. In parallel, private distributors would continue to perform market-based distribution, thereby enabling a functional interface between public governance and operational efficiency.

REFERENCES

[1] Korea Association for Radiation Application. (2024). 2022 survey on the utilization status of radiation and radioisotopes: Final report.
[2] Korea Association for Radiation Application. (2021). Establishment of an integrated support system for isotope self-sufficiency and industrial utilization.
[3] U.S. Department of Energy, Office of Science. (2025). Isotope R&D and production (DOE IP).
[4] U.S. Department of Energy, National Nuclear Security Administration. (n.d.). NNSA's molybdenum-99 program: Establishing a reliable domestic supply of Mo-99 without the use of highly enriched uranium.
[5] Innovation, Science and Economic Development Canada. (2023). Government strengthens Canada's leadership role in medical isotope production. Government of Canada.
[6] Canadian Nuclear Isotope Council. (2023). Isotopes for hope: Update on recommendations for a Canadian national isotope strategy.
[7] Japan Radioisotope Association. (2025). Pamphlet 2025.
[8] International Atomic Energy Agency. (2009). Medical isotopes shortage reveals larger issue.