Review of National Policy Regarding Implementation of Iodine Thyroid Blocking in Nuclear Emergency

Jia Hao Tang [a,b,c], Sung-yeop Kim [a,b*]
[a]*Risk Assessment Research Division, Korea Atomic Energy Research Institute (KAERI), Daejeon, Korea*
[b]*Nuclear and Radiation Safety Division, University of Science and Technology (UST), Daejeon, Korea*
[c]*Singapore Nuclear Research and Safety Initiative (SNRSI), Singapore*
[*]*Corresponding author: sungyeop@kaeri.re.kr*
Keywords: Iodine thyroid blocking, Emergency protective action, Emergency response, Emergency planning, Nuclear accident

1. Introduction

Iodine Thyroid Blocking (ITB) is an important protective action that could be used to reduce radiation dose in the event of a nuclear emergency. The protective action involves the provision of stable iodine tablet that saturates the thyroid organ thus leading to a reduction in the amount of radioactive iodine absorbed by the thyroid organ in a nuclear emergency. This results in a significantly reduced internal radiation dose to the thyroid. While it has been recognized internationally that ITB should be utilized in a nuclear emergency, there is a lack of agreement over the exact implementation of ITB. This could be due to the complexity surrounding the efficacy of iodine tablets that are dependent on the time of radionuclide exposure and behavioral factors. As a result, there is a large variance within the implementation policy across the different countries in the world. This is exacerbated by the general recommendation from the World Health Organization [1] and International Atomic Energy agency [2]. Thus, this review will attempt to focus on reviewing the different national policies surrounding implementation of ITB in order to provide a reference point for decision-makers and encourage harmonization of the ITB policy.

2. Methods and Results

In this review, the focus is on the national implementation policy of ITB in different countries including Belgium, Canada, China, Czech Republic, Denmark, Finland, France, Japan, Poland, South Korea, The Netherlands, United States of America and United Kingdom. The information on ITB implementation policies was obtained from publicly available sources [3-8]. Three aspects of ITB implementation are identified from the available information and shown in the subsequent section. The three aspects are 1) the administration policy, 2) effectiveness duration and 3) second intake. Administration policy represents the official instruction to when stable iodine tablets should be ingested when a nuclear emergency occurs. Effectiveness duration represents the duration in which the iodine tablet would be effective and could be important for prolonged exposure to radionuclides. Second intake represents the stance of the nation on repeated intake of stable iodine pills. These three aspects are critical to the effective implementation of ITB and disparity in the national policy could lead to mistrust in the authority. As a reference point, the general international standards from IAEA and WHO will be illustrated before the provision of the national policies.

2.1. International Standards

As mentioned, recommendations from IAEA and WHO are shown in table I [1,2]. From table I, the administration policy recommended by the two international organizations is general and could result in difficulty in implementation during a nuclear emergency. While IAEA provides a wide range of general administration policies, there is a lack of detail on an optimal administration policy. On the other hand, WHO provides a more specific administration policy for ITB that is based on expected onset of exposure. However, it may be difficult to utilize this as it requires prediction or estimation of expected onset of exposure. Onset of exposure could be difficult to accurately determine in a nuclear accident scenario and result in uncertainty in execution of the protective action. Neither recommendations provide information on effectiveness duration and only WHO recommend the implementation of second intake for prolonged exposure.

Table I. Recommendations by international organizations

Organization	Administration policy	Effectiveness duration	Second intake
IAEA	If thyroid dose exceeds 50 mSv in the first 7 days. Administered either before or after release of radioiodine. Administered within a short period before or after intake of radioiodine	-	-

WHO	Less than 24 hours prior to, and up to two hours after, the expected onset of exposure	-	Yes except for neonates, pregnant and older adults (> 60 yrs) *

*Assume ITB is for prolonged exposure scenario

2.2. Administration Policy

Table II shows the administration policy for the different countries. Based on Table II, there is no clear agreement over the criterion and timing of the activation of ITB. Countries like China, Finland, France, Netherlands and United Kingdom utilize release based administration policy, while other countries like Belgium, Canada, Czech Republic, Denmark, Poland and United States of America utilize exposure based administration policy as recommended by WHO. South Korea utilizes the projected dose based administration policy recommended by IAEA. Japan administration policy utilizes a unique angle where the administration policy could potentially be tethered to evacuation.

Release based administration policy of ITB represents administration of ITB that is activated based on the release of radioiodine. It has the advantage of having high reliability as release of radionuclide are greatly scrutinized and monitored in a nuclear power plant site. As this administration policy is solely dependent on the nuclear power site condition, the iodine pills would be theoretically distributed at the same time for the surrounding populations without regard of actual exposure to radioiodine. This would result in varying efficacy of ITB and also require administration of ITB for the whole population around the nuclear power plant.

Exposure based administration policy of ITB represents administration of ITB that is activated based on exposure to radioiodine. This would theoretically guarantee a higher efficacy of ITB and reduce the unnecessary ingestion of ITB. In practice, this policy will be heavily dependent if the exposure to radioiodine can be identified in a timely manner. Without proper detection, it will be impossible for an individual to identify exposure to radioiodine. This will result in difficulty in determination of a time of exposure to radioiodine in a nuclear accident. As a result, this administration policy would be difficult to implement in an accident.

Projected dose based administration policy of ITB represents administration of ITB that is based on a projected thyroid radiation dose. The authority would simulate and estimate the offsite consequences from a release of radioiodine for the population around the nuclear power plant. This would allow authority to provide a targeted implementation of ITB based on the estimated atmospheric transport of the radioiodine from the nuclear power plant site. While this administration policy would minimize unnecessary distribution of stable iodine pills by providing an estimate of the plume exposure area and resulting radiation exposure, the estimation would require accurate onsite information such as atmospheric condition, source term of nuclear power plant and accident progression. As these information would be hard to determine accurately in a nuclear accident, the successful implementation of this would be heavily dependent on the supporting infrastructure for the estimation of radiation dose.

Lastly, Japan regulation has a unique factor which is the mention of potential tethering to evacuation. This evacuation tethered administration policy would ensure that all evacuees would have consumed iodine pills and reduce radiation dose due to radioiodine exposure during evacuation. This could be an adaptation from the lessons learned from the Fukushima Daiichi accident [9]. In the accident, it was found that implementation of ITB was met with mixed success mainly due to confusion over the administration policy and lack of integration with the evacuation plan. At the time of the accident, the adopted ITB administration policy was the projected dose based administration policy. Due to the site conditions, there was no available estimation of radiation dose and local authorities are confused if ITB should be administered due to the lack of detailed arrangement. In the Fukushima prefecture, the order for the administration of ITB was only given after the evacuation has been completed for the population within 20 km of the nuclear power plant. As such, the specified integration of ITB with evacuation could be a direct adaptation from the experience of Fukushima Daiichi accident.

Another thing of interest for all the administration policies would be that the administration policy deviates from the international standards in a conservative manner. The timeframe of implementation or the project dose requirement seem to be adjusted in a conservative manner for each of the national policy. This variance on the policies could have a substantial consequences in a nuclear emergency which would result in confusion, especially for neighboring countries that are simultaneously affected in a nuclear emergency.

Table II. Administration policy of ITB for different countries

Countries	Administration policy
Belgium	As soon as possible before exposure.
Canada	When instructed by relevant authority. Immediately before or after exposure.
China	When a release of radioiodine has occurred or is likely to occur.
Czech Republic	2 hours before exposure or as soon as possible and no later than 10 hours after.
Denmark	As soon as possible.
Finland	When there is prediction of a

	release.
France	Just before release or as soon as possible after start of radioiodine release.
Japan	When instructed by relevant authority, potentially tied to evacuation within protective action zone.
Poland	Before inhalation of radioactive iodine (several hours before).
South Korea	When projected thyroid dose exceed 100mGy.
Netherlands	6 hours prior to 6-8 hours after a release.
United States of America	Within 3-4 hours of exposure*.
United Kingdom	Promptly following a release (ideally within 3-4 hours).

*Policy is state dependent and varies across United States of America

2.3. *Effectiveness Duration*.

Effectiveness duration represents the duration in which the iodine tablet would be effective and could be important for prolonged exposure to radionuclides. Overall, the difference over the effectiveness duration is less pronounced among the different nations despite the lack of international recommendation as seen in Table 3. Only countries such as Poland and The Netherlands deviate from this with a lower duration of 6 hours. China, Czech Republic & Japan does not provide an official stance on this matter. While not all countries specify the type of stable iodine pills used for ITB, most of the countries follow the international recommended dosage of 100 mg of stable iodine for adults. Effectiveness duration would be potentially important for a prolonged exposure scenario and benefit for harmonization of the policy.

Table III. Effectiveness duration of iodine tablets for different countries

Countries	Effectiveness Duration (h)
Belgium	24 or more depending on release characteristic
Canada	24
Denmark	24
Finland	24 - 48
France	24
Poland	6
South Korea	24
The Netherlands	6 - 8
United States of America	24
United Kingdom	24

*China, Czech Republic and Japan have no official statement for effectiveness duration

2.4. *Second Intake*

In scenarios of prolonged exposure to radioiodine, it may be important to define if a secondary intake of radioiodine is acceptable. Table IV displays the stance on the second intake of stable iodine tablets which shows that the topic is a divisive one. WHO recommendation explicitly states that a single administration will be sufficient for most scenarios, and multiple administration should only be for scenarios of prolonged exposure. Among the included countries, Canada, Czech Republic, Denmark, Poland and United States of America indicate the possibility of second intake of iodine tablets. The rest of the countries seem to assume implementations are designed for short exposure thus do not recommend second intake of stable iodine tablets. The WHO recommendations also specify that repeated intake of ITB should not be provided for population groups including neonates, pregnant, breast feeding and adults of 60 years or older. This exception for older adults seems to not be included for the countries allowing for secondary intake. This recommendation could be potentially due to concerns about the increase in risk of side effects from stable iodine tablets. However, there is a lack of definitive study as mentioned in WHO recommendations [1] for the impact of multiple intake of Iodine pills and more research is required to assess the impact.

Table IV. Stance on second intake of iodine tablets

Countries	Second Intake
Belgium	NO
Canada	YES
Czech Republic	YES
Denmark	YES
Finland	NO
France	NO
Poland	YES
South Korea	NO
The Netherlands	NO
United States of America	YES
United Kingdom	NO

*China and Japan have no official statement for stance on second intake

3. Conclusions

In conclusion, the review showcased the various national policies regarding the implementation of Iodine Thyroid Blocking in nuclear emergencies. The varying implementation of ITB such as administration policy, effectiveness duration and second intake would benefit greatly from harmonization as these differences could potentially lead to confusion during an emergency. Among the administration policy, which is instrumental for the successful implementation of ITB, lessons could be learnt from the different national policies. Of interest would be Japan change in administration policy to potentially integrate ITB with evacuation based on the experience in Fukushima Daiichi accident. The

information above could serve as a potential basis for decision-makers to harmonize and enhance the implementation of ITB in a nuclear emergency.

ACKNOWLEDGEMENT

This work was supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety (KoFONS) using financial resources granted by the Nuclear Safety and Security Commission (NSSC) of Korea (No. RS-2023-00240452).

REFERENCES

[1] World Health Organization, Iodine thyroid blocking: guidelines for use in planning for and responding to radiological and nuclear emergencies, 2016.
[2] International Atomic Energy Agency. Preparedness and Response for a Nuclear or Radiological Emergency GSR Part 7, Vienna 2015.
[3] Jourdain J, Herviou K, Betrand R, Celemente M, Petry A. Medical Effectiveness of Iodine Prophylaxis in a Nuclear Reactor Emergency Situation and Overview of European National Practices, Fountenay-aux-Roses, 2010.
[4] Health Canada. Canadian Guidelines for Intervention During a Nuclear Emergency, Canada, 2023.
[5] China Atomic Energy Authority. China Nuclear Emergency Response White paper, China, 2016.
[6] Japan Cabinet Office. National Report of Japan for Joint convention on the safety of spent fuel management and safety of radioactive waste management, Japan, 2020.
[7] Act on Physical Protection and Radiological Emergency Article 15-1 원자력시설 등의 방호 및 방사능 방재 대책법 시행규칙, South Korea, 2021.
[8] Food and Drug Administration. Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies, USA, 2001.
[9] International Atomic Energy Agency. The Fukushima Daiichi Accident Technical Volume 3/5 Emergency Preparedness and Response, Vienna 2015.