

Literature Review:

Evaluation of Implementation Strategies for Potassium Iodide

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1 INTRODUCTION

Potassium iodide (KI) is effective for protecting the thyroid against the potential harmful effects of radioiodine. Federal KI policy (67 FR 1355, dated January 10, 2002) recommends using KI for emergency workers, institutionalized persons and the general public. Section 50.47 of Title 10 of the *Code of Federal Regulations* (CFR) establishes requirements for emergency plans for nuclear power reactors. Section 50.47(b) contains 16 planning standards, and specifically, § 50.47(b)(10) requires that emergency plans include “a range of protective actions” including the consideration of KI as a supplement to evacuation and sheltering. This rule is intended to ensure that the states are aware of and take into consideration the costs, risks, and benefits of KI in their decision making process in order to optimize emergency planning for the public health and safety (66 FR 5427, dated January 19, 2001).

Ingesting potassium iodide tablets in the immediate aftermath of a nuclear accident is part of many conventional protective action recommendations. Many emergency managers consider KI an essential component of emergency response to reduce radioactive iodine uptake to the thyroid. For example, KI is most effective for protecting special populations (e.g., nursing mothers and children) from the inhalation of radioiodine during the plume phase of a radiological emergency. However, the benefit of KI ingestion for the general public may be overstated and the ideal strategy for KI ingestion and distribution is unclear.

In a Decision Memorandum on Section 127(f) of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, the Director of the Office of Science and Technology Policy (OSTP) noted that “states distribute KI in diverse programs with disparate characteristics, suggesting that many are not based on best practices for prevention of adverse thyroid conditions” (OSTP, 2008). OSTP recommended that NRC, in conjunction with the Federal Emergency Management Agency (FEMA), the Department of Health and Human Services (HHS), and other relevant stakeholders develop and promulgate “best practice” guidelines for existing state-level KI distribution programs with the 10-mile emergency planning zone (EPZ). Yet there are limited quantitative analyses on the efficacy of various KI implementation strategies (e.g., pre-distribution, stored at a central location, available at shelters, sensitivity of ingestion timing). Thus, quantitative analyses and additional data are needed to inform the need for updating guidance and strategies in support of Federal KI policy. In addition, optimized KI implementation strategies for public protection are likely to be more cost-effective to Federal and state governments.

Consequence analysis models in the MELCOR Accident Consequence Code System (MACCS) can simulate KI ingestion in protective action modeling. The efficacy of KI ingestion depends on many factors including on the ability to find or obtain KI during an emergency, ingestion timing in relation to plume release, pre-existing stable iodine saturation of the thyroid gland, and the relative importance of KI compared to evacuation and sheltering. Uncertainty surrounding KI distribution and ingestion may lead to less-than-optimal protective action recommendations. The uncertainty surrounding KI distribution and ingestion warrants a review of recent literature and sensitivity analyses to understand the efficacy of KI ingestion and distribution strategies and assess the need for additional analyses.

Accordingly, the goal of this study was to investigate the available literature on KI effectiveness, evaluate its role in thyroid protection during radiological emergencies, and assess the factors influencing its efficacy, such as distribution strategies, timing of ingestion, and integration with other protective measures like evacuation and sheltering.

2 METHODOLOGY

This study began with a literature search to collect relevant information on the use of KI. The search was performed using a series of search strings on a database of publicly available, peer-reviewed literature, books and review of government organization webpages and news releases with pertinent information about the distribution of KI. This was followed by a thorough review of citations from relevant papers as well as studies they reference and studies that cite them. The search strings included both broad strings, such as ["potassium iodide" +"KI" + "thyroid uptake"], and more specific strings related to certain emergency events, health outcomes, or populations, such as the following:

- emergency event types, such as “nuclear accidents”
- specific emergency remediation strategies, such as “KI prophylaxis”
- health outcomes, such as “thyroid cancer”

Initially, staff identified 37 key academic publications and 21 government releases with insights on KI distribution. These publications focused on KI distribution from an emergency planning perspective and were published between 1967 and 2023. These academic publications included surveys, experimental results, guidelines and recommendations. Most government releases consisted of fact sheets available on government websites:

- Many U.S. states had unique factsheets; many other state Department of Health websites linked to available Federal fact sheets.
- Federal Organizations included the Nuclear Regulatory Commission (NRC), Food and Drug Administration (FDA), Federal Emergency Management Agency (FEMA), Centers for Disease Control and Prevention (CDC), and Department of Health and Human Services (HHS).

Staff focused on the most recent relevant research with insights on KI administration efficacy and KI distribution strategies and summarized the findings in the following sections. Section 3 discusses existing distribution plans for KI from Federal to state level, as well as international experience. Sections 4 and 5 discuss select studies evaluating the effectiveness of pre-distribution methods and Level 3 probabilistic risk assessment (PRA) modeling studies. These relevant papers include both experimental studies and studies primarily based on modeling or theoretical results.

3 EXISTING DISTRIBUTION PLANS FOR POTASSIUM IODIDE

3.1 Recommendations from Public Health Institutions

The American Thyroid Association (ATA) calls for pre-distribution of potassium iodide to individual households residing within a minimum of the 10-mile EPZ of an actively operating U.S. nuclear power plant. The ATA also calls for maintenance of a stockpile of KI in a 10-mile to 50-mile ring out from nuclear power plant locations. The stockpile is to be held in local public facilities such as schools, hospitals, clinics, post offices, and police as well as fire stations for distribution upon notification by local health officials (Leung, 2017). These recommendations are based on Lessons Learned from Three Mile Island, Chernobyl, and Fukushima accidents. The choice of radii and respective KI actions are based primarily on the likelihood of thyroid exposure to ¹³¹I through the inhalation route (i.e., within 10 miles). In areas beyond 10 miles and particularly beyond 50 miles of the nuclear facility, the most likely route of exposure will be through the ingestion pathway. In this instance, restricting the production and consumption of foodstuffs will be more effective.

3.2 Federal Agencies

In the U.S., potassium iodide policies are shaped by Federal regulations and guidance focused on nuclear emergency preparedness. The NRC requires the consideration of KI as a supplemental protective measure, primarily for large light water reactors. According to the "Federal Policy on Use of Potassium Iodide (KI)" (67 FR 1355, 2002), KI should be stockpiled for emergency workers, institutionalized individuals, and potentially for the public within the 10-mile EPZ. The Bioterrorism Act of 2002 expanded KI distribution requirements to a 20-mile radius around nuclear power plants. However, this requirement was waived due to the availability of more effective protective measures like evacuation and sheltering (FRPCC, 2007; OSTP, 2008). These policies emphasize targeted distribution and integration into broader emergency management strategies.

HHS, through its Office of Emergency Management, provides oversight and coordination for public health and medical preparedness, including the deployment and use of KI under the Public Health Service Act. HHS directives align with Federal emergency response frameworks to mitigate the health impacts of radiological exposure, prioritizing populations most vulnerable to thyroid-related radiation effects. HHS, in coordination with the FDA, underscores that KI is not a universal radio-protective agent. It is effective specifically for radioactive iodine but does not protect against other radionuclides. Public messaging stresses that KI should only be taken under official advisories after an incident to avoid misuse.

The FDA identifies KI as a thyroid-blocking agent effective in reducing the risk of thyroid cancer caused by radioactive iodine exposure. FDA recommends age-specific dosing thresholds based on projected thyroid radiation doses. For example, children and pregnant women, being at higher risk, should receive KI at lower radiation exposure thresholds compared to adults over 40, who should only take it at very high exposure levels due to potential side effects and lower risk of thyroid cancer.

FEMA requires state and local emergency preparedness plans, developed in collaboration with the NRC, to address KI stockpiling and distribution logistics as part of the overall protective action strategy. FEMA's Radiological Emergency Preparedness Program Manual emphasizes the importance of integrating KI distribution into comprehensive emergency management programs (FEMA, 2023). The manual provides guidance on planning, training, and exercises to ensure

effective implementation of KI strategies in conjunction with other protective actions. Overall, FEMA's KI strategies are designed to support state and local authorities in protecting public health during radiological emergencies, ensuring that KI distribution is effectively integrated into broader emergency preparedness and response plans.

CDC recommends the targeted distribution of KI as part of a comprehensive emergency preparedness and response strategy for radiological or nuclear emergencies involving the release of radioactive iodine. KI should be distributed to populations most at risk, including children, pregnant women, and individuals with pre-existing thyroid conditions, as these groups are particularly vulnerable to thyroid damage from radioactive iodine exposure. The CDC emphasizes that KI must be taken at the correct time—preferably shortly before or immediately after exposure—to effectively block the thyroid gland uptake of radioactive iodine. The CDC also stresses that KI is not a general antidote for radiation exposure and does not protect against other radioactive isotopes. Distribution efforts should be accompanied by public education campaigns to ensure that individuals understand when and how to use KI correctly, and these measures should be integrated with other protective actions, such as evacuation, sheltering, and controlling food and water supplies, to minimize overall radiation exposure.

3.3 States

As the responsible party for protecting the public in the event of a nuclear incident, a state must decide whether to obtain KI for distribution, the means of distribution, and other policies regarding KI distribution. A public data search was performed to update the National Academies of Science Report (NAS, 2004) of state KI distribution plans. In this report the categories were revised to highlight individual state KI distribution strategies to all population cohorts: emergency workers, institutionalized persons, or the general public:

- No KI distribution program
- KI distributed pre-incident and post-incident
- KI distributed post-incident

“Pre-distribution” is referred to as the supply of KI directly to individuals in the population within a defined area surrounding an operating NPP: this includes emergency workers, institutionalized persons and the general public. Presumably, in all cases, KI will also be available (i.e., stockpiled) within the same area. “Stockpiling” is defined as the availability of KI at key locations sufficient to protect the local population, such as schools, hospitals, clinics, post offices, pharmacies, and police and fire stations within a larger defined area around an operating nuclear facility.

- At best, KI provides only partial protection, which may create a false sense of security among the public.
- Timely evacuation remains the most reliable and effective method of protection.

One state that opted not to distribute potassium iodide to the general population has implemented measures to protect specific groups that may be challenging to evacuate. For instance, these measures include plans to distribute KI to institutionalized individuals, homebound residents or those required to shelter-in-place. Some states stockpile KI at facilities designated for sheltering in place, while others plan for post-incident distribution to these vulnerable populations. An alternative approach to developing KI distribution plans, has focused on early evacuation strategies for non-ambulatory individuals.

Several states (i.e. Georgia, Missouri, and Nebraska) provide KI for emergency workers even if not used for the general public, often through local emergency operations centers. Some states require workers to sign forms acknowledging receipt and a briefing on exposure risks, while others mandate form completion only when KI is ingested. In most cases, taking KI during an emergency is voluntary for emergency personnel. Additionally, some states regularly offer training that includes guidance on distributing KI to special populations and emergency workers.

3.3.2 States with KI Distribution Programs

Figure 3-1 and Table 3-1 outline the states with potassium iodide distribution programs, which generally follow three main approaches for providing KI to the public. These strategies include stockpiling KI for distribution after an incident, pre-distributing KI to the general population before an event, and combining both methods. Stockpiling entails maintaining KI at designated locations, where it can be dispensed directly to the affected population during an emergency or transported to evacuation centers or public shelters for distribution. Pre-distribution, on the other hand, involves proactively providing KI to potentially affected populations as part of emergency preparedness. This is achieved through mail distribution, door-to-door delivery, voluntary pickup, or a combination of these methods.

States with pre-distribution programs typically also maintain post-incident distribution plans to ensure adequate coverage during emergencies. Many of these states emphasize that KI distribution is a supplemental measure to evacuation, which remains the primary protective strategy during a nuclear emergency. Programs are designed to ensure KI distribution does not interfere with evacuation efforts, highlighting the importance of integration into broader emergency response frameworks.

Seven states have adopted a strategy of stockpiling potassium iodide for distribution after an incident occurs. Each plan ensures comprehensive coverage of populations within the 10-mile radius of the NPP. All seven states intend to provide KI to evacuated populations at reception centers. Louisiana's plan includes the administration of KI at medical and nursing facilities under the supervision of physicians. Several states will distribute information sheets to recipients and offer support from public health nurses and educators to address questions. A few of the states which have post-incident distribution plans, have relatively small populations within the 10-mile EPZ.

Table 3-1 – Status of KI distribution in the 50 U.S. states and District of Columbia (*Subject to change based on state-specific policies, updates to emergency preparedness plans, and federal guidance)

	No KI Program	KI Post-distribution Only	KI Pre- and Post-distribution
Alabama			X
Alaska	X		
Arizona		X	
Arkansas		X	
California			X
Colorado	X		
Connecticut			X
Delaware			X
District of Columbia	X		
Florida		X	
Georgia	X		
Hawaii	X		
Idaho	X		
Illinois			X
Indiana	X		
Iowa	X		
Kansas	X		
Kentucky	X		
Louisiana		X	
Maine	X		
Maryland			X
Massachusetts			X
Michigan			X
Minnesota			X
Mississippi		X	
Missouri	X		
Montana	X		
Nebraska	X		
Nevada	X		
New Hampshire			X
New Jersey			X
New Mexico	X		
New York			X
North Carolina			X
North Dakota	X		
Ohio			X
Oklahoma	X		
Oregon	X		
Pennsylvania			X
Rhode Island	X		

South Carolina			X
South Dakota	X		
Tennessee			X
Texas	X		
Utah	X		
Vermont	X		
Virginia		X	
Washington	X		
West Virginia		X	
Wisconsin	X		
Wyoming	X		

3.4 International Experience with Potassium Iodide and Other Countermeasures in Nuclear Emergency

KI is recommended by several international organizations and has been adopted by several countries worldwide (EC, 2010). The International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA), and the World Health Organization (WHO) have taken positions on intervention action levels and target population in order to reinforce prevention measures for more sensitive groups. These recommendations are based primarily on the results from thyroid cancer studies in exposed children.

The WHO's *Iodine Thyroid Blocking: Guidelines* recommends KI for people at risk of being exposed to radioiodine, but the WHO notes that the quality of evidence for this recommendation is very low (WHO, 2017). The revised WHO guideline recommends the administration of KI to individuals aged less than 40 years based on previous knowledge obtained after the Chernobyl accident (WHO, 2017). The WHO emphasizes that the group most sensitive to radioactive iodine includes children, adolescents, and pregnant and breast-feeding women. Children are most likely to benefit from, and therefore should be the preferential target for, the pre-distribution of stable iodine.

Moreover, WHO provides evidence-based recommendations on timing, dosages, and repeat administration, especially for vulnerable groups such as children and pregnant women (WHO, 2017). The guidance integrates with international safety standards and aims to support member states' radiation emergency preparedness. It also addresses potential side effects of iodine prophylaxis and highlights areas for further research. WHO recommends further KI research including radioiodine biokinetics, optimal timing of intake, feasibility and acceptability and best practices for stockpiling or pre-distribution.

Many countries have adopted the recommendations provided by international organizations regarding iodine prophylaxis. Nevertheless, although the final objective is the same, these countries have not introduced identical practices to implement this preventive and protective measure, regarding the medicine itself (formulation, dosage, package insert) and decision making.

3.4.1 Poland

During the Chernobyl disaster in 1986, potassium iodide became a key intervention in efforts to mitigate the harmful effects of radioactive iodine exposure. The explosion and subsequent fire at

the Chernobyl NPP released vast quantities of radioactive materials into the atmosphere, including iodine-131, which posed a significant threat to the thyroid gland.

Despite the known benefits of KI, its distribution during the Chernobyl disaster was delayed and uneven. Many of the affected regions, particularly those in Belarus, Ukraine, and Russia, did not receive adequate KI supplies until after the radiation release had occurred, rendering it less effective. In the immediate aftermath, many individuals were not informed about the risks or the need to take KI, which significantly hampered its potential to reduce long-term health impacts.

One of the major lessons learned from the Chernobyl disaster was the importance of prompt KI distribution. Studies indicate that KI is most effective when taken within a few hours of exposure to radioactive iodine. However, due to the delay in distribution, many individuals, especially those in the most heavily contaminated areas, missed the critical window for taking KI. Furthermore, some studies suggest that the impact of KI on preventing thyroid cancer was limited due to other mitigating factors, such as the widespread restrictions on contaminated food and milk, which helped reduce overall radiation exposure to the population.

In terms of actual usage, millions of people in the affected regions were given KI (Nauman, 1993), and there were no significant side effects reported from the general population. However, the evidence on the overall impact of KI on thyroid cancer rates post-Chernobyl remains mixed. Some studies suggest that Poland, which received a lower radiation dose compared to areas like Belarus, did not see a significant increase in thyroid cancer cases among children who did not receive KI. This has led to debates on the actual contribution of KI to cancer prevention, as dietary measures, such as restricting contaminated milk, also played a crucial role in reducing exposure. Despite these controversies, the use of KI was shown to be safe and generally well-tolerated, with no serious side effects recorded in the general population.

The lack of a coordinated distribution system and delayed administration made it difficult to assess KI's full protective potential. Following Chernobyl, there was growing recognition of the need for better preparedness and the importance of timely KI distribution. In response to these shortcomings, international guidelines were updated, with organizations like the WHO and the IAEA emphasizing the need for KI to be included in national emergency preparedness plans.

3.4.2 Japan

In 2013 the Nuclear Regulatory Authority issued a new framework for iodine prophylaxis following nuclear accidents. This framework was revised in 2019 in accordance with revisions to the WHO guideline (WHO, 2017).

During the Fukushima Daiichi accident, KI was not broadly implemented due to the post disaster conditions, interrupted communication channels, and confusion with regard to practical implementation issues. But approximately 17,500 potassium iodide tablets were administered to about 2,000 workers involved in emergency work (UNSCEAR, 2013). Approximately 230 workers received health check-ups because either (a) they took potassium iodide tablets repeatedly for more than 14 days, or (b) they took more than 20 tablets. No side effects were reported by the workers, but changes to thyroid hormone levels were observed in eight workers. For three cases, the changes were temporary; for the other four cases, the changes could not be attributed to taking potassium iodide tablets because the observed rate of hypothyroidism was comparable with the baseline rate for a male population.

TEPCO workers involved in clean up and restoration works at the Fukushima Daiichi NPP, were reported to be overusing KI pills, taking up to 80 pills (WHO, 2017). Aside from transient changes in thyroid function no side effects of KI overdose were reported.

After the accident at the Fukushima Daiichi NPP, due to the prompt evacuation and food regulation policy implemented by Japanese government, thyroid doses are estimated to be relatively limited (UNSCEAR, 2013). Thyroid monitoring just after the accident in Fukushima Prefecture revealed that no children showed a level greater than 100 mSv and the highest level was less than 50 mSv (Nagataki, 2016). These results suggest that iodine prophylaxis was not absolutely necessary during the accident. Nevertheless, anxieties about iodine prophylaxis including its side effects were observed, especially in parents (Ojino, 2016).

Following the Fukushima Daiichi NPP accident, the Japanese government revised its policy on the distribution of stable iodine tablets, moving from an "after-the-fact" approach to a "before-the-fact" strategy. Local governments were instructed to pre-distribute stable iodine tablets to residents within a 5-kilometer radius of nuclear facilities. The first pre-distribution under this new policy took place in Kagoshima Prefecture in June and July of 2014 (Ojino, 2016).

3.4.2.1 Ojino (2016)

Authors documented Japan's first pre-distribution of stable iodine tablets under a new policy aimed at disaster preparedness. To ensure safety, health surveys were conducted to identify individuals at risk of side effects from KI tablets.

Results: Out of 4,715 residents in the area, 132 (2.8%) required a physician's evaluation, primarily to assess and exclude the potential for side effects. This process underscored the necessity of risk communication between physicians and residents. The involvement of local physicians from the Sendai City Medical Association was pivotal, facilitated by targeted education using a guidebook developed collaboratively by various national organizations, including the Japan Medical Association and the National Institute of Radiological Sciences.

Conclusions: The study highlighted the importance of collective and individualized health risk communication in the pre-distribution process. It demonstrated that effective physician training and collaboration are essential for the safe and informed administration of stable iodine tablets. To enhance preparedness nationwide, continuing medical education for all physicians on stable iodine tablets is recommended.

3.4.2.2 Nishikawa (2019)

In this retrospective observational study, the authors examined the rate and factors influencing the intake of stable iodine among children in Miharu Town, Fukushima, following the Fukushima nuclear disaster. The study aimed to understand why some children did not take stable iodine, despite its importance in preventing thyroid cancer during nuclear emergencies.

Results: The distribution rate of stable iodine was high at 94.9%, but the intake rate was significantly lower at 63.5%. Intake was particularly low among children aged 0 to 2 years compared to those aged 3 years or older. Parental intake strongly influenced children's intake. Regional factors had minimal impact, as individual factors played a more significant role. Concerns about the safety of stable iodine were the primary reason for non-intake. Additional barriers included issues with distribution methods, insufficient information on the effects and adverse effects of iodine, and unclear instructions on its usage. No symptomatic adverse effects were reported in the town.

Conclusions: The findings highlight gaps in the effective intake of stable iodine despite its distribution during a nuclear emergency. To improve preparedness, it is crucial to enhance communication with both children and parents about the necessity and safety of stable iodine intake, with a particular focus on addressing the needs of young children.

3.4.2.3 Matsunaga (2021)

This study evaluated guardians' perceptions of stable iodine administration for children around the Genkai NPP in Japan. A survey of 286 guardians revealed factors influencing stable iodine pre-distribution, including proximity to the plant and awareness of protective measures.

Results: Logistic regression showed that living within 5 km of the NPP, awareness of preferential administration, and knowledge of the local government's prophylaxis booklet were linked to higher likelihood of receiving stable iodine. The main reasons for not receiving KI were "anxiety about the side effects of stable iodine" (40.2%), "distrust of the effectiveness of KI" (23.5%), "complicated procedures for receiving stable iodine" (15.7%) and "missed the date for receiving stable iodine" (8.8%).

Conclusions: Effective risk communication and addressing guardians' concerns are crucial for improving iodine distribution during nuclear emergencies.

4 EVALUATION OF EFFECTIVENESS OF PRE-DISTRIBUTION OF POTASSIUM IODIDE

4.1 Tomažič (2020)

The authors review the logistics of KI distribution in Slovenia and other European countries, analyzing primary and secondary sources, including legislation, scientific studies, and data from various databases. The goal was to identify best practices and develop recommendations to improve KI distribution in Slovenia.

Results: The pre-distribution campaign for potassium iodide tablets in the 10 km zone around the Krško NPP began in June 2013, following a revision of the National Emergency Response Plan. By the end of 2013, 20% of residents (3,668 people) in the zone had collected tablets from pharmacies by presenting a coupon and a health insurance card. The campaign continued in 2014 for new residents. In 2016, the process was updated, requiring residents to obtain a prescription from a doctor before picking up tablets. In 2017, expired tablets from 2013 were replaced. A planned simplification of the distribution method, which would allow residents to pick up tablets only with a health insurance card, faced technical difficulties and was not implemented. In the four years from 2017 to 2020 (up to August 26), only 26 residents collected tablets, a drastic decline from the initial 3,668 in 2013. This indicates that the pre-distribution method has been ineffective in recent years.

Conclusions: The research identified varying practices across European countries regarding the recommended timing for potassium iodide tablet intake in the event of a nuclear accident. Generally, KI intake is advised before or as soon as possible after a release begins, with some countries recommending intake up to 12 hours prior to release, which is difficult to predict. Most countries consider KI effective within 24 hours of intake, but some allow only 2 to 10 hours. These

differences could pose challenges in cross-border coordination if neighboring countries issue KI intake orders at different times.

The European Commission has proposed improving coherence in protective measures during nuclear accidents, encouraging countries to establish conventions with neighboring nations for communication and information exchange. The HERCA-WENRA Approach aims to enhance cross-border coordination in the early phases of a nuclear accident. This harmonization is desirable as there are concerns that differences in iodine prophylaxis measures could undermine public trust if conflicting actions are taken. The approach suggests that iodine prophylaxis decisions should be based on dose assessments from the affected country. While most European countries share a common generic reference level for iodine tablet intake, full harmonization will take time.

The review of iodine tablet distribution practices in Slovenia highlights several areas for improvement. Current pre-distribution efforts have been insufficient, with only 20% of residents in the PAZ (Protection and Intervention Zones) in 2013 and just a few residents receiving tablets in the last four years (2016-2020). The existing process is seen as too complex, requiring residents to obtain a doctor's prescription and then visit pharmacies to pick up the tablets.

To improve distribution, the recommendation is to adopt a simpler approach used in other European countries: pre-distribution by mail. This method involves sending tablets directly to residents' homes, especially for those living within 10 km of the Krško NPP, and for individuals under 40 years old who move into these zones. The tablets should be mailed in a way that preserves their integrity (e.g., temperature control, original packaging) and ensures safety (inaccessibility to children). The distribution process should be continuous, with a regularly updated database of beneficiaries, ideally with annual updates or at least every three years if resources are limited.

The responsibility for distribution should lie with local pharmacies, in collaboration with local municipalities and civil protection authorities. Regarding stockpiling, Slovenia's current approach is effective, though concerns about the resources needed for timely distribution within a 6-hour window should be addressed through careful analysis. If these changes are implemented, Slovenia's regulations on potassium iodide distribution would need to be updated to reflect the new methods.

4.2 Desantis (2020)

Desantis (2020) evaluated resident demographics and resident understanding of the proper use of potassium iodide pills as a countermeasure in the event of a nuclear power plant emergency. The study design used a cross-sectional survey with a validated written questionnaire. The study participants were Canadian residents living within the primary emergency planning zone of the Fermi, Unit 2 nuclear power reactor in Michigan.

Results: Desantis (2020) found that residents in general had a very low overall comprehension of proper KI use. Most resident demographics (e.g., age, gender) did not significantly impact residents' knowledge of proper KI use. But households with children under 13 years of age tended to have higher comprehension scores than households without young children.

Conclusions: Desantis (2020) found that most residents reported that if they thought they were exposed to radiation they would go to the hospital or call 911. Moreover, few residents knew their evacuation routes, few were aware of the emergency siren, none knew where the reception center was located, and most did not have an emergency kit in their home. The majority of the survey

respondents did indicate that they would evacuate if told to do so by their government. The authors concluded that public health outreach is crucial for KI distribution programs because of the overall low pre-existing comprehension in communities.

4.3 Zwolinski (2012)

Zwolinski (2012) reported evaluation of Michigan's KI distribution program. In 2009, the Michigan Department of Community Health (MDCH) made KI a nonprescription radio-protective drug, available by mailing vouchers redeemable at local pharmacies for KI tablets, at no cost to residents living within 10 miles of Michigan's three NPPs. MDCH conducted an evaluation of this program to determine Michigan's KI coverage and to assess general emergency preparedness among residents living near the NPPs.

Methods: KI coverage was estimated based on redeemed voucher counts and the 2010 Census. Telephone surveys were administered to a random sample (N = 153) of residents living near Michigan's NPPs to evaluate general emergency preparedness, reasons for voucher use or nonuse, and KI knowledge.

Results: Only 5.3% of eligible residences redeemed KI vouchers. Most surveyed residents (76.5%) were aware of living near an NPP, yet 42.5% reported doing "nothing" to plan for an emergency. Almost half of surveyed voucher users did not know when to take KI or which body part KI protects. Among voucher nonusers, 48.0% were either unaware of the program or did not remember receiving a voucher.

Conclusions: Additional efforts are needed to ensure that all residents are aware of the availability of KI and that recipients of the drug understand when and why it should be taken. Minimal emergency planning among residents living near Michigan's NPPs emphasizes the need for increased awareness.

4.4 Blando (2007a)

Blando (2007a) evaluated a joint state and local government-sponsored KI distribution program in New Jersey. This program is part of a radiological emergency response system for residents living within the EPZs of nuclear power facilities. KI pills and an informational fact sheet were distributed locally at six different public clinics in the summer of 2002. In this study, a mailed survey was developed, pilot tested and sent to the general public to assess knowledge about KI use. The survey consisted of two groups of people, those who attended a KI distribution clinic and those that did not attend a clinic.

Results: Blando (2007a) found that there was a statistically significant difference in knowledge among the two groups of survey respondents regarding KI prophylaxis, with a mean of 46% of survey questions answered correctly by those who attended a clinic versus 15% by those who did not attend. Certain questions were problematic for the public to answer correctly indicating potential low compliance with government instructions for taking KI, confusion regarding where the public can obtain KI pills during an emergency, and the lack of awareness on the proper use of KI for children, pregnant women, and persons over the age of 40 years old.

Conclusions: Providing pre-emptive voluntary mass distribution of KI pills as a prophylactic agent may be a necessary component of nuclear emergency response plans since distribution during an incident may not be practical. This study demonstrated that distribution may be very effective in obtaining high coverage rates for some communities but may also result in very low coverage among other communities. This study also found that there was a highly variable geographic

pattern of homes that have a supply of KI pills, with some areas having 60% of the households supplied with pills from the clinic while other areas had as low as 1% of the homes supplied with KI pills. This study also showed that KI pill distribution requires a significant education and outreach component for it to be effective. The self-identified sources that the general public assumes will provide KI during an emergency, such as private physicians or hospital emergency rooms, must be prepared to handle or direct requests for pills during an incident.

4.5 Blando (2007b)

The New Jersey Department of Health and Senior Services, in collaboration with other state and local partners, distributed KI tablets in clinics in July 2002. Intended recipients of KI pills lived or worked within EPZs, which represent areas encompassing an approximate 10-mile radius around the state's two nuclear power generating stations. Blando studied the fate of the KI tablets that were distributed and assessed knowledge regarding KI prophylaxis and nuclear emergency preparedness among the general public, health professionals and emergency responders.

Results: Of the 421 KI recipients, 401 (95%) reported knowing where they had stored their tablet (approximately 2.5 years after the KI distribution clinics were held), 16 (4%) indicated that they did not recall where they stored their tablet(s), and 2 (<1%) had already taken their tablets. Among the survey respondent groups, health professionals answered the highest percentage of knowledge-based questions about KI usage correctly. Questions about KI use during pregnancy and the proper KI dosage for children had the lowest number of correct responses among all of the groups. Sixty percent of the school nurses answered the question about dosage for children correctly.

Figure 4-1 demonstrates the behaviors that respondents would adopt if they thought they were exposed to radiation or radioactive materials from a NPP release; 63% reported that they were likely to go to their hospital emergency department, 59% reported that they were likely to call or visit their personal doctor, and 44% said that they were likely to go to an emergency reception center.

Conclusions: Blando (2007) concluded that gaps exist in knowledge of emergency preparedness. Questions about KI use during pregnancy and the proper dosage for children were the questions most frequently answered incorrectly among all of the groups that we surveyed, which indicates the need to clarify those specific points. The question about dosage for children is particularly important for school nurses, because during an event they may be asked to administer KI to a large number of children in school.

The results of the general public survey indicated that a significant number of residents would likely attempt to leave the area during an event, which could be problematic because many do not know the proper evacuation route or where to find this information. Emergency response plans call for individuals to be directed to emergency reception centers, but this survey data suggest that the general public may be more likely to go to emergency departments or private physicians if they thought that they had been exposed to radioactive materials. Emergency departments and personal care physicians must be prepared to handle or direct contaminated persons to proper management facilities.

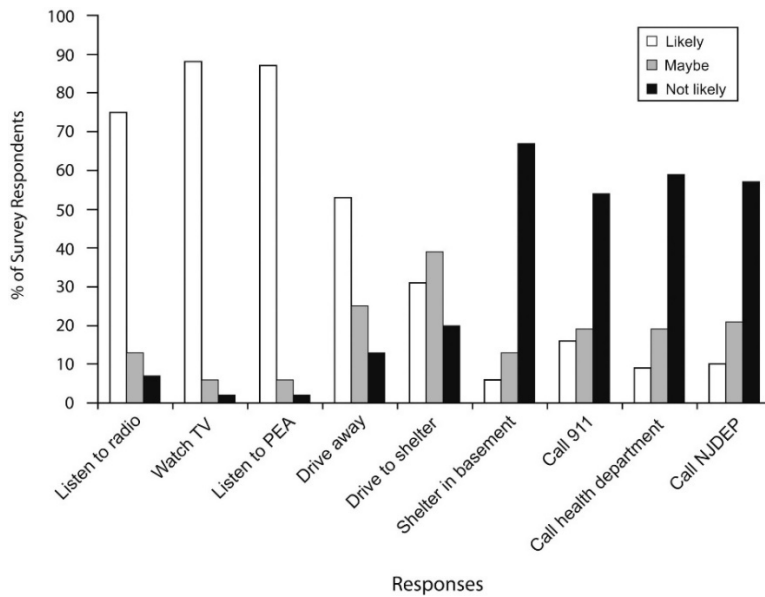


Figure 4-1 – (Blando, 2007). Responses to question 4 of the General Public Survey: “If you heard there was a major accident at a nuclear power plant, please rate the likelihood that you would. . . .”

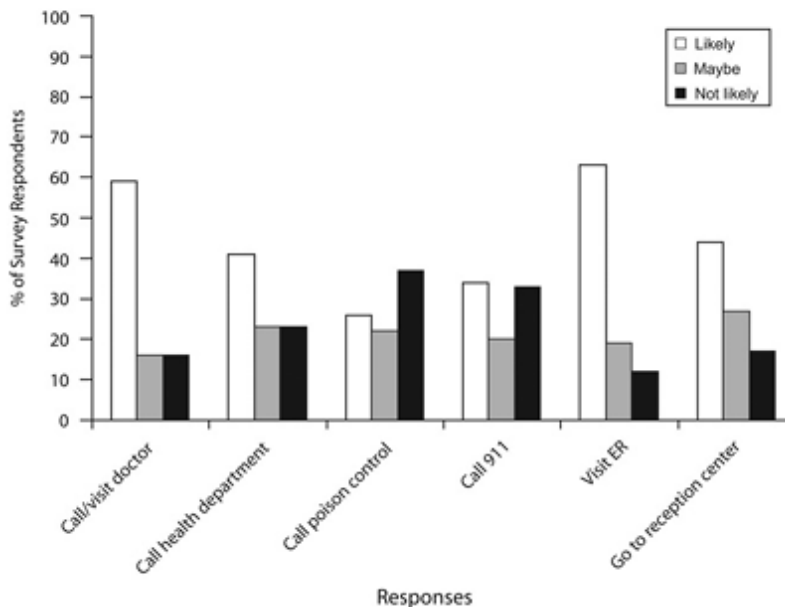


Figure 4-2 – (Blando, 2007). Responses to question 5 of the General Public Survey: “If you felt you were exposed to radiation or radioactive materials, please rate the likelihood that you would. . . .”

4.6 Moss (2005)

The New York City Department of Health and Mental Hygiene sought the assistance of Brookhaven National Laboratory to develop a “Feasibility Study for Potassium Iodide” distribution in the event of a significant radioactive iodine release near or within New York City.

Results: Recommending potassium iodide distribution after a nuclear incident in an urban environment, such as New York City, presents significant challenges. Distributing KI through public points like firehouses, schools, and police stations would be hazardous, as it would expose people to higher radiation levels while they attempt to access the tablets. The logistical difficulty of distributing KI in such a chaotic environment, especially within a critical 3-hour window, makes this approach nearly impossible. Furthermore, pre-distribution of KI is ineffective, as many people either lose or forget to carry the tablets.

Distributing KI in an urban environment during a radiological event would be impractical due to severe traffic congestion and the need for people to shelter-in-place, which would expose them to less radiation than trying to obtain KI. Pre-distribution methods have been shown to be ineffective, as most people fail to keep their tablets or carry them consistently. To make pre-distribution effective, regular redistribution and frequent reminders would be necessary. The feasibility of distributing KI to a large population in a short amount of time, especially in the midst of a chaotic event, is considered highly unlikely due to logistical and workforce constraints.

Conclusions: There is no credible radiological scenario in New York City that would require large-scale KI distribution for the general population, even in the event of exposure to radioactive iodine reaching the lowest thyroid dose threshold. Instead, KI should be stockpiled in amounts sufficient for use by emergency responders and evacuees in the event of a localized radiological incident. Public education about the limited use of KI, as well as alternatives, should be prioritized. Pharmacies should also be encouraged to increase the availability of KI for individuals who choose to obtain it proactively.

4.7 NAS (2004)

Discussion: Relying exclusively on pre-distribution to residences is insufficient to guarantee comprehensive public protection in the event of a radiological or nuclear incident, as it does not ensure that all individuals in the affected area will receive the necessary potassium iodide tablets. To enhance the effectiveness of KI distribution, local stockpiling is recognized as a critical component of all distribution programs, providing an additional layer of preparedness. Several states have implemented pre-distribution programs, but these have often been limited in scope, with less than 10% of the affected population receiving the tablets. This highlights the challenges of relying on this method alone, especially when the goal is to reach a large and diverse population.

Voluntary pickup programs, where individuals are responsible for obtaining the tablets, can reach more than 50% of the population, but success heavily depends on active community involvement. This requires strong public engagement, educational efforts, and support from local authorities to encourage participation. Without this active engagement, voluntary pickup programs may fall short of their coverage goals.

Another approach, door-to-door delivery, has shown to be more effective in ensuring that people receive their KI tablets. However, this method comes with higher costs, both in terms of logistics and human resources, which can limit its widespread implementation. Despite its higher cost, door-to-door delivery ensures a more personalized and efficient method of reaching individuals who may otherwise be missed by other distribution strategies.

Mass mailing, on the other hand, can provide greater coverage than pre-distribution alone. This method has the advantage of reaching a broad population quickly and efficiently, especially when it does not require recipients to complete additional forms or requests. By eliminating extra steps,

mass mailing can streamline the distribution process and ensure that more individuals are reached within a critical time frame. However, this approach still depends on the accuracy of the mailing lists and the ability to distribute a large volume of tablets in a timely manner.

5 LEVEL 3 PRA MODELING STUDIES

5.1 Burt (2020)

The study models thyroid cancer risk following hypothetical nuclear accidents at Ontario's Darlington NPP using the MELCOR Accident Consequences Code System. This code simulates radioactive plume dispersion and dose assessments, factoring in protective actions like evacuation, sheltering, and KI administration.

Assumptions on the effectiveness of mitigation measures: The authors applied protective actions starting with evacuation, then sheltering, followed by iodine thyroid blocking based on centerline doses. Evacuation was assumed to be 100% effective with evacuated individuals receiving no radiation dose. This assumption was supported by the latest evacuation time estimate study which considered 700 unique evacuation runs (KLD Engineering P.C., 2019). The report indicates that the 100th percentile (i.e. worst case) could take approximately 12 h to evacuate the designated planning zone (i.e. 10 km from the NPP), which has 130 781 permanent residents. The evacuation time estimate of 12 h falls well within the 24 h hold-up time assumed for this study. A 20% dose reduction factor was applied to the thyroid dose to account for sheltering; this value is consistent with the MACCS2 emphasis on the pathways of most relevance in the first seven days following a release. Despite being sheltered, those individuals in addition to some individuals where sheltering was not necessary, would be advised to take KI pills as their projected thyroid doses exceeded the generic criteria for iodine thyroid blocking. In this study, iodine thyroid blocking is required in both accident scenarios outside of the detailed planning zone (i.e. beyond 10 km of the NPP) and does not exceed the ingestion planning zone (up to 50 km from the NPP). For those with KI pills in their possession due to pre-distribution within the detailed planning zone, ingestion was assumed to occur within one hour of the exposure (as instructed by the medical officer of health) and therefore to be 100% effective in blocking the uptake of radioactive iodine.

Results: The MACCS2 model was used to assess radioactive plume dispersion and calculate radiation doses for hypothetical single- and multi-unit nuclear accidents. Within the 10 km zone, protective actions such as evacuation, sheltering, and pre-distribution of potassium iodide effectively eliminated thyroid cancer risks. However, in zones beyond 10 km, significant risks remained, particularly for children. At 12 km, the excess risk for children reached up to 600% above the baseline for single-unit scenarios, decreasing with distance. Without timely KI distribution, risks persisted up to 50 km.

Conclusions: MACCS2 modeling reveals that extending KI pre-distribution to zones beyond 10 km could effectively eliminate thyroid cancer risks, especially for children, emphasizing the need for broader emergency preparedness plans.

5.2 Kimura (2020)

The authors developed an evaluation method for planning urgent protection strategies in a nuclear emergency in Japan by using the Level 3 PRA code, Off-Site Consequence Analysis Code for Atmospheric Releases in Reactor Accidents (OSCAAR). For a given accident scenario, OSCAAR can calculate received doses in the early phase of a nuclear accident and the dose reduction

effect of implementing urgent protective actions such as evacuation, sheltering, and iodine thyroid blocking. The authors considered the combination of these urgent protective actions within a precautionary action zone (PAZ) within 5 km and an urgent protective action planning zone (UPZ) within 30 km for an accident scenario and then calculated received doses after implementing these protective actions using the OSCAAR. After that, the authors performed sensitivity analysis for protective action models of the OSCAAR and then optimized the protection strategy by reducing doses to below generic criteria of the IAEA. Consequently, the effective urgent protection strategy for the accident scenario could be designed, such as precautionary evacuation within the PAZ, and the combination of evacuation after sheltering, sheltering in concrete building, or in normal housing and thyroid blocking within the UPZ. The developed evaluation method will be very useful in developing effective urgent protection strategies for an accident scenario.

Assumptions: The iodine thyroid blocking model uses a dose reduction factor (RF) to estimate the equivalent dose to the thyroid for the administration of stable iodine (SI). The effect of the dose reduction for iodine thyroid blocking can be evaluated by multiplying the RF by the equivalent dose to the thyroid without taking SI. The RF depends on dosage of SI, different iodine isotopes (^{131}I - ^{135}I), and age groups. Therefore, a database of the RFs for these parameters was made by using the metabolic model (Kimura, 2017). The intake timing of the SI was also evaluated when iodine thyroid blocking was implemented. It was assumed that the breathing rate was $2.57 \times 10^{-4} \text{ m}^3/\text{s}$ for an adult.

For the accident scenario, the authors evaluated several urgent protective actions, including no protective measures, sheltering in normal housing, sheltering in place, evacuation following sheltering in a concrete building, precautionary evacuation, and iodine thyroid blocking. The "no protective action" scenario assumed that individuals would continue their daily routines without any intervention. Under normal daily activities, it was assumed that individuals spend 90% of their time indoors (70% in regular housing and 20% in concrete buildings) and 10% outdoors. Sheltering was defined as individuals remaining inside their residences following a directive to shelter in place. However, sheltering is not recommended for more than two days, as it is considered impractical to expect the population to remain indoors for extended periods. Consequently, it was assumed that sheltering would last for two days, after which individuals would resume their normal daily activities. Evacuation after sheltering was defined as people moving to and remaining at the nearest designated facility, followed by a radial evacuation. The designated facility (e.g. a school or government building) provides greater shielding protection than a personal residence. It was additionally assumed that sheltering was implemented for 2 days, after which people immediately evacuate and stay at designated facilities 30 km from the release point for 5 days.

Precautionary evacuation was defined as the condition in which the preliminary evacuation is implemented before release to avoid a major portion of the external dose from radioactive cloud and internal dose from inhalation. It was assumed that the evacuation was completed before the release began, and the people subsequently remained at designated facilities 30 km from the release point for 7 days. Furthermore, the effect of iodine thyroid blocking was also evaluated by changing the SI administration timing. In the present study, the release start time was designated as 0 hours, and the intake times considered were within 12 hours before or after the release start.

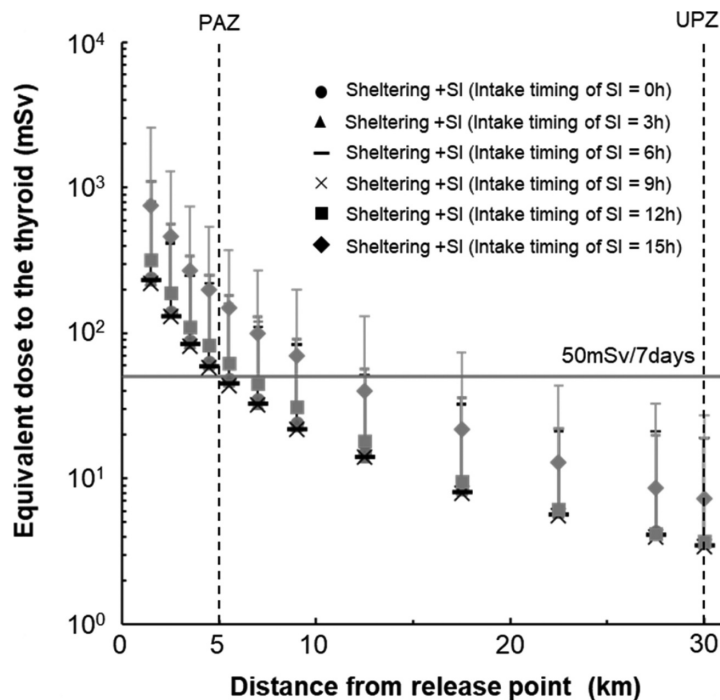


Figure 5-1 – (Kimura, 2020). Evaluation results of the equivalent dose to the thyroid for varying intake timing of stable iodine in the accident scenario.

Results: Figure 5-1 shows the evaluation results of the equivalent dose to the thyroid for varying the intake timing of stable iodine in the accident scenario. In this study, the release start time was designated as 0 hours, and the intake times considered were within 12 hours before or after the release start. The intake timing of 0 hours means that the people took SI simultaneously to the release start. The equivalent dose to the thyroid was almost the same value at 0 h, 6 h, and 9 h of intake timing from release start. The minimum values showed at 9 h of intake timing. It was found that taking SI at the time of the major release (9 hr after the release start) was most effective. After that, the later intake timing of SI was, the higher the equivalent dose to the thyroid was. The result implies that the start time of the major release is more important than the release start time in determining the appropriate SI administration time. However, it is not possible to predict the time of an accident's major release. It will be realistically useful to decide the appropriate timing for taking SI based on the emergency action level.

Conclusions: For an accident scenario, the authors evaluated the received doses in the early phase of a nuclear accident and the dose reduction effect achieved by implementing urgent protective actions including evacuation, sheltering, and iodine thyroid blocking. The results suggest that a combination of these protective actions is required to reduce the radiation doses below the generic criteria of the IAEA. It was found that precautionary evacuation within the PAZ, and the combination of sheltering and evacuation within the UPZ were effective for the accident scenario. The developed evaluation method will be very useful in optimizing protective actions and then in planning the effective urgent protection strategies for an accident scenario.

5.3 Tang (2024)

The authors used existing literature and MACCS to construct an alternative method for determination of iodine thyroid blocking. In this study, the authors implemented a pre-processor for MACCS to determine KI efficacy with technical inputs. The workflow of this approach includes: 1)

running MACCS code with desired inputs without the KI ingestion model, 2) calculating KI administration time, 3) estimating efficacy based on administration time, and 4) re-running MACCS and computing radiation dose of a cohort with the new KI efficacy. This alternative methodology to KI efficacy in MACCS allowed the authors to experiment with various KI distribution strategies.

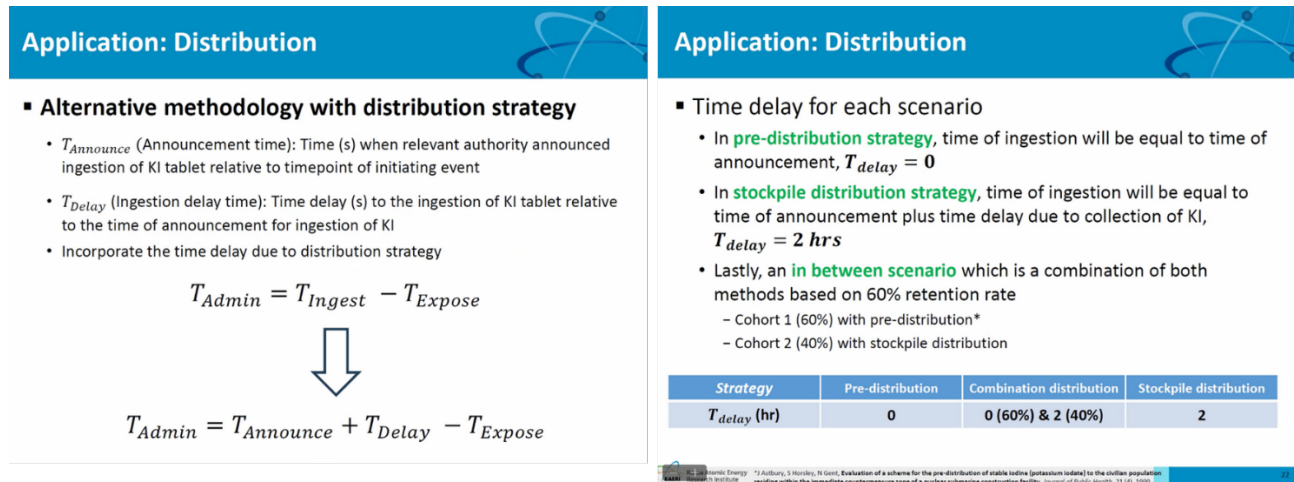


Figure 5-2 – (Tang, 2024). Alternative methodology to representing various KI distribution strategies within the MACCS code.

Conclusions: The authors demonstrated a preliminary example of using MACCS to optimize distribution strategies and highlighted the importance of early administration. The authors concluded that pre-distribution should be utilized at close proximity to the NPP facility. For populations outside of EPZ, timely activation of KI may be of greater importance than establishing an optimized distribution strategy.

6 DISCUSSION AND CONCLUSION

Potassium iodide is effective for protecting the thyroid against the potential harmful effects of radioiodine. This literature review was initiated to assess the most up to date research related to effectiveness of potassium iodide distribution strategies with respect to its efficacy. This study began with a literature search to collect relevant information on the use of KI. The search was performed using a series of search strings on a database of publicly available, peer-reviewed literature, books and review of government organization webpages and news releases with pertinent information about the distribution of KI.

Federal agencies, including the NRC, HHS, CDC, FDA, and FEMA, emphasize that potassium iodide is not a universal radio-protective agent. It is specifically effective in blocking the thyroid's uptake of radioactive iodine and does not offer protection against other radionuclides. Public communication advises that KI should only be used under official guidance following a radiological incident to ensure appropriate and safe administration, thereby preventing misuse.

The WHO has noted that there is limited evidence supporting the effectiveness of various implementation strategies for potassium iodide programs. Additionally, there is no clear consensus on what constitutes a well-defined or standardized potassium iodide program. This lack of agreement complicates efforts to design, implement, and evaluate these programs effectively, especially in contexts where they may prove critical for public health preparedness and response. WHO recommends further KI research in radioiodine biokinetics, optimal timing of intake, feasibility and acceptability and best practices for stockpiling or pre-distribution.

Public education is a crucial component of potassium iodide distribution strategies, ensuring that individuals understand its purpose, limitations, and proper use during nuclear emergencies. Educational efforts stress that KI specifically protects the thyroid from radioactive iodine and does not offer protection against other radionuclides or general radiation exposure. Clear communication on when and how to take KI, age-specific dosing, and potential side effects prevents misuse and maximizes its effectiveness. These initiatives also address misconceptions, such as using KI preemptively without exposure, which could lead to health risks or reduced availability for those who truly need it. Public education also helps mitigate practical issues, such as the common occurrence of people misplacing pre-distributed KI tablets in their homes, which can delay timely administration during an emergency.

Pre-distribution of KI enhances preparedness by ensuring that at-risk populations have immediate access to the drug, particularly in communities near nuclear facilities where the risk of exposure is higher. However, its effectiveness is only partial due to factors like limited shelf life, the need for regular stockpile updates, and the logistical challenges of ensuring tablets remain accessible and not lost in households. Pre-distribution efforts must be supported by strong public education campaigns to address these issues and align with broader emergency response plans. However, these efforts require a significant investment in resources. Even then, emergency distribution systems may still be necessary to supplement pre-distribution, especially in unforeseen circumstances or areas outside of predetermined risk zones. Combining public education with pre-distribution and emergency distribution creates a comprehensive KI distribution strategy.

Relying solely on pre-distributing potassium iodide tablets to residences is inadequate for ensuring comprehensive public protection during a radiological or nuclear incident, as it cannot guarantee that all individuals in the affected area will receive the necessary tablets. To improve the effectiveness of KI distribution, local stockpiling is considered an essential addition to distribution

strategies, providing an extra layer of preparedness. While some states have implemented pre-distribution programs, these efforts have typically been limited in scope, with fewer than 10% of the at-risk population receiving the tablets. This limitation underscores the challenges of relying exclusively on this approach, especially when trying to reach a large and diverse population. Voluntary pickup programs, where individuals collect KI tablets themselves, have the potential to reach over 50% of the population. However, their success depends heavily on active community engagement, robust public education efforts, and strong support from local authorities. Without these critical components, voluntary pickup programs may fail to achieve their desired coverage goals.

While the efficacy of potassium iodide tablets is well understood, there has been little attention given to evaluating or improving KI distribution strategies. Developing a more robust understanding of how to enhance these strategies could be achieved through the use of consequence analysis modeling, offering a pathway to refine and optimize implementation.

Numerical studies often indicate a net benefit that may not be fully realized in real-world scenarios. Consequence analysis models attempting to simulate KI distribution to the general public face several significant limitations, which can impact their ability to accurately assess real-world effectiveness. Modeling studies reviewed here assume that KI tablets can be efficiently distributed to the entire at-risk population. These studies do not account for logistical constraints such as supply chain disruptions, potential breakdowns in emergency communication, storage conditions, and the ability of public health officials to rapidly mobilize KI during a crisis. Models often assume full or near-full compliance with KI administration guidelines. In reality, factors such as public awareness, trust in authorities, and willingness to take the tablets can vary significantly, reducing overall effectiveness. Moreover, the effectiveness of KI depends on timely ingestion relative to radiation exposure. Models may not fully capture delays in distribution, variations in individual access, or challenges in reaching populations in rural or underserved areas. In addition, population-wide models often overlook disparities in access to healthcare and socioeconomic factors that could influence the successful distribution and administration of KI. While some plans advocate for pre-distribution of KI to households in high-risk areas, models may not reflect the real-world challenges of maintaining stockpiles, ensuring proper public education on use, and addressing expiration and replenishment of KI supplies.

To improve the accuracy of consequence analysis models, greater realism must be incorporated by integrating data on real-world logistical constraints, human behavior, and emergency response effectiveness. The KI model in MACCS can be used to simulate certain accident scenarios and develop test cases for KI distribution in the event of a radiological release. Special consideration can be taken to enhance the realism of modeled scenarios to better align with real-world accident progression.

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9 APPENDIX A

Table A-1 – Status of KI distribution in the 50 U.S. states and District of Columbia

State	Distribution Method	Reference
Alabama	Emergency Support Function is the decision making organization for protection of public health and safety during a radiological emergency in Alabama. The Alabama Department of Public Health will declare or implement the necessary protective actions to protect the public, including distribution of KI. The state health officer shall consider ordering that KI be made available to all evacuees who are believed to have been exposed to a time averaged concentration of radioiodine that would result in a projected thyroid dose commitment in excess of 5 rem. Initial supplies of KI will be stored in the county health departments in the 10-mile EPZ around the nuclear power plants in Alabama. In the event protective actions are ordered for areas containing persons institutionally confined, these persons and those individuals required for their supervision and care will initially be given radio-protective drugs and be instructed to remain in the institution under shelter conditions with building air intakes closed.	https://www.alabamapublichealth.gov/radiation/assets/rep-plan-full.pdf
Alaska	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Arizona	<p><i>Targeted Stockpiling and Distribution:</i> KI is stockpiled for emergency workers, first responders, institutionalized populations, and potentially residents within the 10-mile Emergency Planning Zone around nuclear facilities.</p> <p><i>Public Availability:</i> Residents within the EPZ may access KI through local health departments or designated distribution points during emergencies.</p> <p><i>Public Education:</i> Arizona emphasizes educating the public about the proper use of KI, its benefits, and its limitations, ensuring that the population understands it is a supplemental measure to evacuation and sheltering.</p> <p><i>Coordination with Federal Policies:</i> The state strategy integrates the NRC and FEMA guidelines for KI distribution during emergencies.</p>	<p>https://dema.az.gov/sites/default/files/publications/EM-PLN_SERRP.pdf</p> <p>https://ein.az.gov/sites/default/files/2024-12/2310487_2024_PV_Emergency_Prepared_Broch_Final_Proof.pdf</p>

Arkansas	Arkansas provides KI tablets to residents located within a 10-mile radius of nuclear power plants. Distribution typically occurs post-incident, as a protective measure against radioactive iodine exposure. Arkansas follows FEMA and NRC guidelines, which involve stockpiling KI and ensuring its availability when needed, including replacing expired tablets. This strategy aligns with the federal recommendations, though specific details on the frequency of pre-distribution (if any) or stockpiling practices beyond the immediate emergency response are not extensively covered in public resources	https://www.dps.arkansas.gov/wp-content/uploads/2023-ARCEMP-Final.pdf
California	<p><i>Pre-Distribution in Emergency Planning Zones:</i> KI is pre-distributed to residents, schools, and businesses within the 10-mile EPZ of nuclear power plants, such as Diablo Canyon and the now-decommissioned San Onofre Nuclear Generating Station.</p> <p><i>Stockpiling for Emergency Use:</i> The state maintains KI stockpiles for emergency workers, institutionalized individuals, and members of the public who may not have received pre-distributed KI but require it during an emergency.</p> <p><i>Public Awareness and Accessibility:</i> California provides information on KI's use and availability through public education campaigns. Information includes instructions for proper administration and clarification that KI is not a substitute for evacuation or sheltering.</p> <p><i>Emergency Distribution Centers:</i> During an incident, KI is distributed through emergency centers established outside of the affected zones, ensuring timely access to the protective agent.</p> <p><i>Integration with Protective Actions:</i> KI distribution is part of a broader emergency response strategy that prioritizes evacuation and sheltering as primary protective measures, with KI as a supplementary thyroid protection measure.</p>	https://www.slocounty.ca.gov/departments/health-agency/public-health/all-public-health-services/emergency-medical-services-and-public-health-emerg/potassium-iodide-(ki)-pre-distribution
Colorado	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found

Connecticut	<p><i>Pre-Distribution in EPZs:</i> KI tablets are pre-distributed to residents, schools, and emergency workers within the 10-mile EPZ around the Millstone Power Station.</p> <p><i>Stockpiling for Emergency Use:</i> The state maintains reserves of KI for distribution during an emergency to ensure availability for those who may not have pre-stocked it.</p> <p><i>Public Education and Awareness:</i> Connecticut provides information to residents on KI's purpose, correct usage, and its role as a supplemental protective measure to evacuation and sheltering.</p> <p><i>Emergency Distribution Plans:</i> During an incident, KI is made available through designated distribution centers located outside of affected zones. These centers are activated to ensure rapid access to KI for those in need.</p>	<p>https://portal.ct.gov/demhs/emergency-management/resources-for-officials/radiological-emergency-preparedness/ki-potassium-iodide</p>
Delaware	<p><i>Pre-Distribution in EPZs:</i> KI tablets are pre-distributed to residents, schools, and businesses located within the 10-mile EPZ around the nuclear facilities.</p> <p><i>Stockpiling and Emergency Distribution:</i> Delaware maintains state stockpiles of KI for emergency responders and individuals who may not have received pre-distributed KI. Distribution centers are activated in emergencies to provide KI to affected populations.</p> <p><i>Public Awareness and Education:</i> The state conducts outreach programs to educate the public on the use of KI, emphasizing its role as a supplemental protective measure. Instructions include proper timing and dosages and clarifications that KI does not replace evacuation or sheltering.</p> <p><i>Accessibility Through Local Health Departments:</i> Residents within the EPZ can obtain KI through local health departments, ensuring readiness before an emergency occurs.</p> <p><i>Focus on Vulnerable Populations:</i> Special attention is given to protecting children, pregnant women, and other vulnerable groups who are at higher risk of thyroid damage from radioactive iodine exposure.</p>	<p>https://preparede.org/event/potassium-iodide-ki-distribution/</p>
District of Columbia	<p>Not within 10 miles vicinity of NPP; do not distribute KI</p>	<p>No public reference found</p>

Florida	County health departments near nuclear power plants maintain supplies of KI for use in an emergency. In the event of a power plant accident, the health department will set up distribution centers where KI can be picked up by residents of the affected counties (those within a 10 mile radius of the power plant). These reception centers will be located outside of the evacuated areas, thereby ensuring that residents and the community will not be delayed from evacuating a contaminated area. Strategically stockpiling KI allows the greatest flexibility in distributing it to the populations at greatest risk of exposure to radioiodine. In the case of a radiological emergency, the locations of the centers will be broadcast on local emergency broadcast systems.	https://www.floridahealth.gov/environmental-health/radiation-control/envrad/documents/ki-fact-sheet.pdf
Georgia	NPP within 10 miles vicinity; KI not pre- or post-distributed	No public reference found
Hawaii	Not within 10 miles vicinity of NPP; do not distribute KI to general public. Hawaii has a stockpile of emergency supplies, including KI tablets for emergency responders.	https://health.hawaii.gov/about/files/2013/06/radiationfaq.pdf
Idaho	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Illinois	The Illinois Emergency Management Agency offers KI pills to Illinois residents living within the 10-mile EPZs around the Braidwood, Byron, Clinton, Dresden, LaSalle and Quad Cities NPPs. A supply of KI pills is available at designated pharmacies in EPZ area with a completed KI voucher that can be created through an online application.	https://public.iema.state.il.us/KiProcessing/Home/About
Indiana	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Iowa	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Kansas	Kansas does not have a widespread pre-distribution plan for KI tablets for the general public. However, the state does have emergency preparedness protocols in place for those living near the Wolf Creek Generating Station. It is Kansas policy to evacuate the public prior to an exposure of radioactive iodine from a nuclear power plant incident and not to provide KI to the public.	https://www.kdhe.ks.gov/DocumentCenter/View/9610/KDHE-Hospital-Guidelines-PDF
Kentucky	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found

Louisiana	<p>The decision to use KI to protect the public rests with the State and local health authorities. The LDEQ Secretary shall seek the advice of the State Health Officer at the time of an accident to discuss the administration of KI to emergency workers and institutionalized persons. Attending physicians at medical and nursing facilities must approve administration of KI for their patients.</p>	<p>https://deq.louisiana.gov/assets/docs/EmergencyResponse/Radiological_Emergency/LPR_RP_BasicPlan_Revision-16.pdf</p>
Maine	<p>The Maine Center for Disease Control & Prevention (MCDCP) is not recommending that the Maine Emergency Management Agency maintain a state supply (stockpile) of Potassium Iodide (KI) for distribution to Maine citizens in the event of a terrorist attack or other unexpected nuclear event. With the closure and dismantling of Maine Yankee, there are no current sources in the State of Maine for radiologic accidents that would necessitate the use of KI on an emergency basis. There are two nearby nuclear plants (one in New Hampshire and one in New Brunswick). However, Maine people are not within a 10 mile radius of either of these plants, which is recommended for the use of KI. Furthermore, any persons in New Hampshire or New Brunswick at the time of any incident at those plants would be evacuated by a pre-arranged route that would not include Maine. MCDCP is not recommending that individual citizens in any part of Maine maintain a supply of KI for personal use for the same reasons. However, should individuals wish to disregard this advice and maintain a supply of KI, this medication is available without a prescription. Dose recommendations can be obtained from a private physician.</p>	<p>https://www.maine.gov/dhhs/mecdc/environmental-health/rad/me-ki-policy.htm</p>
Maryland	<p>KI will be pre-distributed to schools located within 10 miles of each plant. One dose per student and faculty member will be maintained at the schools for distribution in an emergency when schools are in session. Members of the general public who live within 10 miles of the plants will be able to obtain KI to maintain at their home or place of business. This pre-distribution will occur through a series of availability sessions planned by county officials. After initial distribution, new residents or others who did not already obtain KI will be able to do so by contacting their respective county health department. Any remaining doses of KI will be made available to citizens at existing emergency reception facilities as a supplement to evacuation in the event of any emergency.</p>	<p>https://mde.maryland.gov/programs/pressroom/Pages/74.aspx</p>

<p>Massachusetts</p>	<p>The Pilgrim Nuclear Plant ceased operating on May 31, 2019. As of August 2019, there is no longer a risk of exposure to radioactive iodine from the plant. As a result, the U.S. NRC and FEMA informed the Massachusetts Department of Public Health that KI is no longer necessary. Given this, DPH will not replenish KI for the communities in the Pilgrim EPZ, Cape Cod, or Islands. The nearest operational nuclear plant affecting some residents of Massachusetts is: Seabrook Station – Located in Seabrook, New Hampshire, near the Massachusetts border. Some Massachusetts residents, particularly in northeastern areas, fall within the 10-mile Emergency Planning Zone for this plant.</p>	<p>https://www.mass.gov/lists/potassium-iodide-ki</p>
<p>Michigan</p>	<p><i>Pre-Distribution in EPZs:</i> KI tablets are pre-distributed to residents, schools, and institutions within the 10-mile EPZ around nuclear power plants. This ensures that at-risk populations have access to KI before an emergency occurs. <i>Stockpiling and Emergency Distribution:</i> Michigan maintains stockpiles of KI for emergency workers, vulnerable populations, and residents who may not have received pre-distributed KI. Emergency distribution centers are set up in affected areas during radiological incidents. <i>Public Education and Information:</i> The state provides information to residents on the proper use of KI, including the correct dosage and the timing of ingestion to maximize its effectiveness. This education also clarifies that KI is not a substitute for evacuation or sheltering, but a complementary measure. <i>Vulnerable Populations:</i> Special focus is given to protecting vulnerable groups, such as children, pregnant women, and those with thyroid issues, who are at a higher risk of thyroid damage from radioactive iodine exposure. <i>Coordination with Federal and Local Agencies:</i> Michigan's KI distribution strategy follows federal guidelines and is coordinated with local emergency management agencies to ensure rapid distribution and effective response during a radiological emergency.</p>	<p>https://www.michigan.gov/-/media/Project/Websites/mdhhs/Folder2/Folder2/Folder1/Folder102/KI_Why_Now_QA.pdf?rev=7e1b02948c0f45ffb470d808e156ad7e</p>

Minnesota	Vouchers for free KI are included within the emergency planning guide, which Xcel Energy mails out to residents living within the 10-mile Emergency Planning Zone. Residents can bring this voucher to CVS Pharmacies located in participating Target stores.	https://dps.mn.gov/divisions/hsem/radiologica-l-emergency-preparedness/Documents/!2015%20REP%20Spiral%20Tab%20Handbook%20-%20FINAL.pdf
Mississippi	Mississippi's potassium iodide distribution strategy primarily involves post-incident distribution, with KI stockpiled for emergency workers and institutionalized individuals who may not be able to evacuate promptly. This approach aligns with the state's evacuation-focused policy, where KI is distributed to emergency workers for voluntary use during radiological emergencies. KI in tablet form is available to emergency management agencies, police departments, fire companies, ambulance services, farmers keeping livestock, and selected industrial workers and to hospitals and nursing homes located within the 10-mile EPZ. Claiborne County will specify in their plan those facilities, municipalities, agencies, and teams that receive KI for use by emergency workers. KI will only be made available to evacuees in the shelter in the event of a rapidly escalating event and only upon authorization of the State Health Officer.	https://www.msema.org/wp-content/uploads/2021/03/2020-MREPP.pdf
Missouri	NPP within 10 miles vicinity; KI not pre- or post-distributed	No public reference found
Montana	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Nebraska	NPP within 10 miles vicinity; KI not pre- or post-distributed	http://govdocs.nebraska.gov/epubs/M2000/B006-2015.pdf
Nevada	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
New Hampshire	<p><i>Pre-Distribution in EPZs:</i> KI tablets are pre-distributed to residents, schools, and healthcare facilities within the 10-mile EPZ surrounding the Callaway NPP. This ensures that individuals in the highest risk areas have access to KI before an incident occurs.</p> <p><i>Stockpiling for Emergency Use:</i> The state maintains KI stockpiles for emergency workers, vulnerable populations, and residents who may not have received the pre-distributed tablets. These stockpiles are accessible during an emergency at designated distribution points.</p> <p><i>Public Education and Awareness:</i> Missouri provides public information on the proper use of KI, including the correct dosage, timing, and limitations. The state emphasizes that KI is not a substitute for evacuation or</p>	https://prd.blogs.nh.gov/dos/hsem/?page_id=18912

	<p>sheltering and should be used in conjunction with these primary protective actions.</p> <p><i>Emergency Distribution Centers:</i> During a radiological emergency, Missouri sets up distribution centers outside of the affected area where KI can be provided to the public. These centers ensure timely access to KI for those who may need it.</p> <p><i>Vulnerable Populations:</i> Special attention is given to children, pregnant women, and other vulnerable groups who are at greater risk from thyroid damage caused by radioactive iodine exposure. These groups are prioritized for KI distribution.</p>	
New Jersey	<p>KI is available for distribution to residents living within the 10-mile EPZ around the Salem/Hope Creek Nuclear Generating Station. The distribution is voluntary and provided to help protect the thyroid gland in case of a radiological emergency. KI is typically distributed through public health departments in affected counties, such as Salem and Cumberland counties, and may also be distributed at reception centers during evacuation situations. Residents can obtain KI from locations such as the Salem County Department of Health or the Cumberland County Department of Health during regular hours, or on designated distribution days for the public.</p>	<p>https://health.salemcountynj.gov/emergency-preparedness/points-of-dispensing-ki-distribution/</p>
New Mexico	<p>Not within 10 miles vicinity of NPP; do not distribute KI</p>	<p>No public reference found</p>
New York	<p>New York State maintains a Radiological Emergency Preparedness (REP) program that includes potassium iodide distribution as part of its emergency response plan. KI is stockpiled by the state and distributed to specific populations within 10 miles of nuclear power plants in the event of a radiological emergency. The state's REP plan ensures effective communication, training, and planning to protect residents in case of incidents, including providing KI as a protective measure.</p>	<p>https://www.dhSES.ny.gov/radiological-emergency-preparedness</p>
North Carolina	<p>North Carolina KI distribution is focused on the 10-mile EPZs around certain NPPs, including the McGuire, Shearon Harris, Brunswick, and Catawba (in South Carolina). The state initiated the KI program in 2003, ensuring that KI pills are available for those living or working within these zones. Local health departments distribute the tablets, and schools and childcare facilities within the EPZs are also included. The distribution is voluntary, and KI is provided free of charge to residents and workers in these areas.</p>	<p>https://epi.dph.ncdhhs.gov/phpr/ki/ki.html</p>

North Dakota	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Ohio	KI distribution program involves distributing KI to populations within a 10-mile radius of NPPs. The Perry NPP involves Lake, Geauga, and Ashtabula counties; the EPZ of the Davis-Bessie Nuclear Power Station includes residents in Ottawa and Lucas counties; and the 10-mile radius of the Beaver Valley NPP in Pennsylvania affects Columbiana County and the city of East Liverpool. This effort is supported by the U.S. NRC, in coordination with the Ohio Department of Health, local health departments, local emergency management coordinators, and other emergency personnel.	https://www.ohiopharmacists.org/aws/OPA/pt/sd/news_article/1471/PARENT/layout_interior_details/true
Oklahoma	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Oregon	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Pennsylvania	KI tablets are distributed free of charge to residents and workers within a 10-mile radius of the state's active NPPs. The state's active plants are the Beaver Valley Power Station, Limerick Generating Station, Peach Bottom Atomic Power Station, and Susquehanna Steam Electric Station. KI distribution occurs annually at designated locations around these plants, with tablets available for anyone living or working within the 10-mile radius. Schools and businesses can also request supplies for their communities or employees. The tablets are distributed with instructions for their use, and individuals are advised to take KI only when directed by state health authorities during a radiological incident.	https://co.lancaster.pa.us/2951/Potassium-Iodide-KI-Distribution
Rhode Island	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found

South Carolina	<p>The State of South Carolina Department of Health and Environmental Control (DHEC) has taken advantage of an offer made by the U.S. NRC to receive a supply of Potassium Iodide tablets for free distribution to South Carolina residents living and or working within a 10-mile radius of the five (5) Nuclear Power Plant sites that affect areas near South Carolina residents. Those counties include: Aiken, Allendale, Barnwell, Chesterfield, Darlington, Fairfield, Lee, Lexington, Newberry, Oconee, Pickens, Richland and York. DHEC public health officials have stockpiled KI tablets in strategic locations for distribution to the general public. These locations are in close proximity to each of the state’s nuclear power plants and would be used in the event of a radiological emergency where there is a risk of exposure to radioiodine. Individuals living or working within the 10-mile EPZ can receive a two-day supply of tablets to store in a convenient place. If a nuclear disaster occurs and a decision is made to distribute KI because of the event, distribution will occur at pre-designated shelters and reception centers that are located outside of the evacuated areas as part of local plans for nuclear power plant emergencies. Residents and community members will be aided in evacuating contaminated areas through detailed emergency evacuation plans. Strategically stockpiling KI allows emergency officials the greatest flexibility in distributing it to the populations at greatest risk of exposure to radioiodine. In the case of a radiological emergency, the locations of the centers can be found in the annual emergency calendars distributed to residents living and working in the 10-mile EPZ.</p>	<p>https://scdhec.gov/sites/default/files/media/document/2020-Potassium-Iodide-FAQs.pdf</p>
South Dakota	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Tennessee	<p>Tennessee has a KI distribution plan in place due to the presence of the Sequoyah Nuclear Power Plant. In response to potential radiation exposure from a nuclear emergency, Tennessee implemented a program for pre-distributing KI tablets to households within a 10-mile radius of the plant. The plan was developed after simulation drills revealed that post-incident distribution could be too slow to protect people effectively. The pre-distribution aimed to ensure that residents would have prompt access to KI, preventing radioactive iodine from accumulating in the thyroid gland.</p>	No public reference found
Texas	NPP within 10 miles vicinity; KI not pre or post-distributed	No public reference found
Utah	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found

Vermont	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Virginia	Virginia Department of Health will recommend distribution and use of KI for members of the public at the Evacuation Assembly Centers when the projected radiation dose to the thyroid gland exceeds 5 rem.	https://www.vdh.virginia.gov/radiological-health/radiological-health/emergency-response/potassium-iodide/ https://www.vdh.virginia.gov/content/uploads/sites/7/2016/02/Potassium-Iodide-KI-Fact-Sheet-11Jan13.pdf
Washington	The Washington State Department of Health, in collaboration with local authorities, does not stockpile or pre-distribute KI for public use. Instead, evacuation is emphasized for those within the 10-mile radius of the plant in case of a nuclear incident. The state's emergency preparedness plan encourages evacuating residents before any radioactive exposure occurs, with KI being considered only for specific use in limited circumstances.	https://doh.wa.gov/sites/default/files/legacy/Documents/Pubs/320-073_ki_fs.pdf
West Virginia	West Virginia coordinates emergency preparedness for radiological events with neighboring states and facilities, including the Beaver Valley Power Station in Pennsylvania, which is within proximity to the state. The state distributes potassium iodide (KI) during emergencies if authorized by state health officials. However, KI distribution is post-incident, and residents are instructed to only take KI when advised by authorities.	https://emd.wv.gov/Preparedness/REP%20Program/Pages/default.aspx
Wisconsin	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found
Wyoming	Not within 10 miles vicinity of NPP; do not distribute KI	No public reference found

10 APPENDIX A – ADDITIONAL REFERENCES

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11 ABBREVIATIONS AND ACRONYMS

ATA	American Thyroid Association
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
DHEC	Department of Health and Environmental Control
EAC	Evacuation Assembly Centers
EAL	Emergency Action Level
EPZ	Emergency Planning Zone
ESF	Emergency Support Function
FDA	Food and Drug Administration
FEMA	Federal Emergency Management Agency
HHS	Department of Health and Human Services
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IEMA	Illinois Emergency Management Agency
KI	Potassium Iodide
MACCS	MELCOR Accident Consequence Code System
MCDCP	Maine Center for Disease Control & Prevention
MDCH	Michigan Department of Community Health
MEMA	Maine Emergency Management Agency
NAS	National Academies of Science
NPP	Nuclear Power Plant
NRA	Nuclear Regulatory Authority
NRC	Nuclear Regulatory Commission

OSCAAR	Off-Site Consequence Analysis Code for Atmospheric Releases in Reactor
OSTP	Office of Science and Technology Policy
PAZ	Protection and Intervention Zones
PRA	Probabilistic Risk Assessment
RAMP	Radiation Protection Computer Code Analysis and Maintenance Program
RF	Dose Reduction Factor
REP	Radiological Emergency Preparedness
SHO	State Health Officer
SI	Stable Iodine
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UPZ	Urgent Protective Action Planning Zone
WHO	World Health Organization