

---

~~CONFIDENTIAL~~

**\*A PROPOSED**  
**Nuclear and Bio-Terrorism**  
**Preparation Program**

CC: Chief Price - City of LaMarque Chief  
Burby - City of Texas City  
Chief Hurtt - City of Houston  
Chief of Staff - G. Garibay - City of Houston  
City Manager - City of LaMarque  
Mayor Pro Tern - City of Texas City  
Public Health Planner - Galveston County Health District - City of LaMarque  
Bill Kelly - Community Relations Specialist - City of Houston - Mayors citizens Assistance Office  
Phil Boriskie - Chief of Houston Fire Dept  
Larry Crow - City of LaMarque Mayor  
Congressman Nick Lampson - 9<sup>th</sup> Congressional District  
Stephen Williams - Director of City Health Department - Houston

\*Information provided by: Eniva Corp., in collaboration with International Dollar Works (IDW™)

In the wake of the 9-11 tragedy, nearly three years later, questions still loom as to what measures our government has implemented to help the masses of people protect themselves against real terrorist attacks, nuclear disasters, dirty bombs and/or nuclear waste. Countries such as Great Britain, Canada, Japan, Germany, and Sweden have already taken action by protecting thousands of households and emergency facilities. Yet this information, and simple steps to help ensure the safety and very life of your family and friends is heard virtually nowhere in America today.

Terrorists have spoken longingly of their desire to harm the United States' nuclear power plants and poison the land with radiation. And unfortunately, today the threat of a devastating "act of terror" is **MORE** real than ever. Already, the events of 9-11 brought home the sad fact that international boundaries bear no protection against the threats of evil to this nation **AND** there is no sign that this aggression will reverse its ugly tide.

CNN recently cited more than 200 nuclear "suitcase bombs" missing from Soviet nuclear inventory believed to be in the hands of international terrorists-with many **ALREADY** believed to be within US borders waiting to be detonated.

Threats of attack and/or sabotage on over 100 commercial and governmental nuclear reactors have all been identified by governmental protection agencies as "high risk" terrorist targets.

Unfortunately, if a nuclear disaster were to occur today, whether by terrorist strike or otherwise, Americans would be in the same position as in the 1979 Three Mile Island incident- unprotected and unprepared. However, the results of even a mild nuclear tragedy are well known and documented, as evidenced in the 1986 Chernobyl accident.

**United Nations Report** (*From Chernobyl, A Continuing Catastrophe*): *"It is years since the accident, and yet the worst may still come...The number of people with thyroid cancer began to increase about five years after the accident. This number continues to rise...the number of cases has exceeded expectations. Over 11,000 cases of thyroid cancer have already been reported."*

**The Chernobyl accident contributed to thousands of deaths, child birth defects, and a 10-fold increase in cancer rates specifically among children.**

Today, particularly in the wake of 9-11 and the reality of weapons of mass destruction, even the most common, unassuming citizens want more knowledge about how to protect themselves, their families and their pets against terrorist attacks, dirty bombs, nuclear accidents, or nuclear waste.

*Knowledge is power* and in this case it presents the power to save lives, even your own.

The question is, if there **WAS** a simple, affordable, yet highly effective way to help protect your family, your friends, pets, and loved ones against the damaging effects of radiation...would you take action?

## **Minimizing Radiation Damage -- Protect Your Thyroid**

Nuclear activity produces many radioactive substances that can harm people. One such substance -- radioactive iodine -- poses a particular threat because the human thyroid gland rapidly absorbs and uses iodine as a fundamental building block to maintain life. This vital gland, located on either side of the middle of your neck, is very important for producing hormones that influence nearly every organ, every tissue and every cell in your body. Thyroid hormones regulate the body's metabolism and organ function, affecting heart rate, cholesterol levels, body weight, energy levels, and muscle strength. The thyroid also controls your temperature, skin conditions, menstrual regularity, memory and even bowel function. Your thyroid is critical to your overall health, and without proper function, puts your entire body at risk!

Unfortunately, the human body cannot distinguish safe iodine from radioactive iodine. In a nuclear emergency, such as a nuclear attack or explosion, excessive amounts of radioactive iodine would be released to wreak havoc on living organisms. And, this toxic substance can travel thousands of miles through the air streams, from one continent to another, settling in land, water, and inhabitants with literally no warning or warning signs. As stated in the following documents:

**Report to the President's Council on Environmental Quality:** *"Exposure can be a concern more than 100 miles downwind from an accident...thyroid damage could affect more people than any other radiation effect."*

**The Bulletin of Atomic Scientists:** *"Following a catastrophic accident, hundreds of thousands of thyroid nodules cases could occur as well as tens of thousands of delayed cancer deaths."*

Even food sources can become contaminated, as evidenced in the Chernobyl incident where radioactive iodine fell on fields. Cows naturally ate the grass, and children then drank milk from the cows, resulting in additional harm to those children. Exposure to radioactive iodine is devastating --according to statistics put forth by the World Health Organization, over 50,000 expected cases of cancer amongst young people will have been attributed to the Chernobyl disaster.

And of great concern, is the fact that **CHILDREN** are especially susceptible to radioactive iodine absorption-resulting in increased rates of cancer, organ failure, birth defects, recurrent infections, impaired kidney function, infertility, fatigue, depression, digestive problems, weight irregularities, stunted growth, and even death.

Since the thyroid is programmed to take in iodine from the first available source -and it isn't able to distinguish good iodine from bad iodine, radioactive iodine will be absorbed and damage **WILL BEGIN** unless preventive steps have been taken.

*The good news is that the thyroid gland can only store so much iodine. Taking a highly concentrated form of potassium iodide before or immediately after exposure will "flood," or fill up, your thyroid gland with safe, stable iodine to a point where there is virtually NO more room for radioactive iodine -- the harmful iodine will be ignored and harmlessly excreted.*

Just how effective can incorporating specially designed protective iodine products be in the event of nuclear exposure?

#### **World Health Organization:**

*"Stable iodine administered before or promptly after intake of radioactive iodine can block or reduce the accumulation of radioactive iodine in the thyroid and significantly help to reduce damage from exposure."*

#### **U.S. Food and Drug Administration:**

*"The effectiveness of KI as a specific blocker of thyroid radioiodine uptake is well established (Il'in LA, et al., 1972) as are the doses necessary for blocking uptake. FDA maintains that potassium iodide is a safe and effective means by which to prevent radioactive iodine uptake by the thyroid gland, and thereby obviate the risk of thyroid cancer in the event of radiation emergency."*

*"As time is of the essence in optimal prophylaxis with potassium iodide, timely administration to the public is a critical consideration in planning the emergency response to a radiation accident."*

*"FDA also emphasizes that emergency response plans and any systems for ensuring availability of Potassium Iodide to the public should recognize the critical importance of such [distribution] in **advance** of exposure to radioiodine."*

#### **American Thyroid Association:**

*"KI floods the thyroid with safe iodine and prevents it from absorbing the radioactive form. Babies, children up to 18, and pregnant women are the most important to receive KI after exposure."*

*"It is essential that, one way or another, enough KI be available to protect the public, especially children, in the event of a nuclear accident or act of radiological terrorism."*

*Nuclear Regulatory Commission: "...only about 50% of the uptake of radioactive iodine is blocked if the iodine administration is delayed six hours after exposure, and little effect can be achieved if delayed more than 12 hours."*

*[States should] "...consider potassium iodide as a supplement to evacuation and sheltering." In December 2001, the NRC offered potassium iodide to states so that anyone living within 10 miles of a nuclear power plant would have enough supply to get out of town or wait for the radiation danger to pass."*

### **The US Food & Drug Administration has stated:**

"The effectiveness of Potassium Iodide as a specific blocker of radioactive iodine is well established. FDA maintains that potassium iodide is a safe and effective means by which to prevent radioactive iodine uptake by the thyroid gland, and thereby obviate the risk of thyroid cancer in the event of radiation emergency."

Across the world, this scientific, documented information is recognized and endorsed.

### **The World Health Organization in its 1999 Guidelines for Nuclear Accidents states:**

*"Stable iodine administered before or promptly after intake of radioactive iodine can block or reduce the accumulation of radioactive iodine in the thyroid and significantly help to reduce damage from exposure."*

Statements like these have led nations across the world including, Great Britain, Switzerland, Sweden, Norway, France, Austria, the Czech Republic, Slovakia, Poland, and even Japan and Canada to endorse aggressive distribution of potassium iodide to its citizens.

The grave news is administering potassium iodide must be done in a very immediate fashion in the event of nuclear exposure.

### **The Nuclear Regulatory Commission stated in July of 1998:**

*Potassium iodide, **if taken in time**, blocks the thyroid gland's uptake of radioactive iodine and thus could help prevent thyroid cancers and other diseases caused by exposure in a nuclear accident."*

Unfortunately, being "too late" can mean damaged, even lost, lives.

Remember, time is of the essence. ***Unless the government provides each household with adequate stock to have on hand before a nuclear radiation emergency, critical life-saving time would be needlessly wasted trying to distribute it. The delays would be in a word, CATASTROPHIC.***

But, there's one more critical piece of information you need to know, right now. More alarming than the timing issue, is the fact that *within the United States, there is not enough potassium iodide for the American population in the event of radiation exposure.*

### **The Nuclear Regulatory Commission admitted in Federal Register Notice 016:**

*"stockpiles of potassium iodide are limited, and not likely to provide enough potassium iodide for use by the general public." Let me repeat that, according to the Nuclear Regulatory Commission, "stockpiles of potassium iodide are limited, and not likely to provide enough potassium iodide for use by the general public."*

And should a nuclear disaster or attack occur anywhere in the world, the current, already limited inventory of high-dose, FDA approved potassium iodide pills would be very quickly depleted. In fact, a recent study of attempts to purchase the specialized form of potassium iodide from various pharmacies across the country demonstrated that it was virtually impossible to obtain locally.

All of this information can be summarized in one phrase: **The time for action is now.** The time to protect your family, friends, pets, and especially children and grandchildren is now.

**Would you be willing to spend pennies a day to ensure the safety of your family and the future of your children?**

**What can you do on a daily basis to protect yourself, your pets, and your family?**

**What can I do to take action NOW?**

The answer to this question is broken into a simple 3-step plan.

### **Step 1: Be informed, and have a plan.**

Be aware of any nuclear sites near where you live or if nuclear waste materials from a site are transported into your area. Form a family emergency action plan and have proper survival supplies stored on hand.

### **Step 2: Take a water-soluble form of potassium iodide as a dietary supplement each day to get 100% of the US RDA of Iodine.**

With this step, you are promoting the healthy functioning of the thyroid gland and conditioning your thyroid for efficient uptake of iodine. As mentioned earlier, in the event of contamination, if you have a properly functioning thyroid, it will take less time for a highly concentrated form of potassium iodide to fully saturate your thyroid, thus preventing the absorption of harmful radioactive iodine. It would be similar to watering your lawn. If you sprinkle it on a regular basis, the grass has a good, moist base. It doesn't take much at the next watering to saturate it. If you let your lawn turn dry and brown, it will take many waterings and a very long time before it returns to a moist, healthy state; and even worse, may not have the ability to absorb water when it needs the moisture most. The bottom line is: the healthier your thyroid, the better your chances of survival in an attack or accident.

It is well documented that certain forms of iodine help your thyroid gland work properly. But since the thyroid can only hold a certain amount of iodine at one time, and gets regularly used up, **that supply must be continually made available-thus the need for consistent supplementation.** Some people may draw the conclusion they should simply consume more salt in their diet to increase their iodine level. Although individuals get iodine from foods, like iodized salt or fish, these raw forms are generally unstable and can be easily lost by oxidation.

So, a safe and effective means of daily supplementation is recommended. But more importantly, a FORM of supplementation that ensures cell-ready qualities for rapid absorption and assimilation.

Please be aware: the vast majority of manufactured powders, tablets and pills which supply maintenance levels of iodine are not in a proper form that the body can most effectively use.

When choosing an iodine supplement, the following three characteristics need to present for maximum effectiveness, **1) it needs to be water soluble; 2) it needs to be the correct particle size, or what we refer to as cell-ready"; and 3) it must have an ionic charge.** When these three characteristics are present, you have a supplement appropriate for maximum use and readiness of the thyroid should nuclear radiation exposure take place.

By taking in a daily supplement of potassium iodide, you will not only be on your way to a healthy thyroid, but on your way to protecting your body. However, please note, do not supplement with excessive amounts of potassium iodide above the US RDA for Iodine, as high doses can be detrimental to health when taken over a long period of time.

### **Step 3: Have on hand emergency potassium iodide pills.**

They should be high dose, FDA approved, and foil-packed for an extended 5-yr shelf life. The pill format makes them easily transported.

As you have heard, it is well established that taking high dose potassium iodide pills in **the event of a nuclear disaster can literally mean the difference between life or death. PLEASE NOTE: This high dose, pill form of potassium iodide should only be taken in the event of an emergency declaration by an official public authority.**

#### **What Is It?**

Potassium Iodide (KI) is a naturally occurring salt, made up of the minerals potassium and iodine. It is generally delivered in a granular form or a neutral aqueous solution.

### **Why Is It Needed?**

In the event of a nuclear attack or accident, radioactive iodine would be released in the air, and eventually deposited in the water and on the land. It would be primarily inhaled and absorbed into an inhabitant's thyroid gland, causing negative health effects and long-term bodily harm. Children are particularly susceptible.

### **How Does It Work?**

Certain forms of iodine help one's thyroid function properly. The thyroid is designed to absorb and store iodine, but it can only hold so much, and will readily absorb any type of iodine, regardless of whether it is radioactive or not. Because of this, Potassium Iodide, which is NOT harmful to the thyroid gland, works by "filling up" the gland so it cannot absorb any harmful radioactive iodine.

### **How Much Should Be Taken?**

There are two ways that KI should be taken. **Step One is a DAILY BASIS amount, and Step Two is a RADIATION EMERGENCY amount.**

### **Is It Safe To Take KI?**

A low dose of maintenance Potassium Iodide is safe to take on a regular basis to achieve 100% of the US RDA of Iodine. Excessive amounts, above the US RDA, as high doses can be detrimental when taken over long periods of time. Any FDA approved, high dose potassium iodide pills are safe for most people. Pregnant women and newborns should not take more than one dose of the concentrated form, and should check with their doctor soon after. People who are allergic to iodine should not take KI, and those who have rare disorders should consult their doctor first. Be informed that *Potassium IODATE is not FDA approved* and is not legally manufactured in the US to pharmaceutical standards.

### **When Should It Be Taken?**

Low dose, maintenance KI should be taken every day. High dose KI should be taken only at the instruction of public health or government emergency officials. Remember, taking high dose KI is not a substitute for evacuation. Citizens must leave the area immediately if they are instructed to do so.

Maintaining and supporting a healthy thyroid on a daily basis is extremely important. Take a bio-available thyroid care formula that includes potassium iodide as a dietary supplement EACH DAY to get 100% of the US RDA of Iodine. With this step, you are promoting the healthy functioning of the thyroid gland and conditioning it for efficient uptake of iodine in an emergency situation.

Scientific studies have demonstrated the importance of iodine, selenium, zinc, copper, and manganese in promoting the health of the thyroid. This vital gland, located on either side of the middle of your neck, is very important for producing hormones that influence nearly every organ and tissue in the body. Thyroid hormones regulate the body's metabolism, organ function, affect heart rate, cholesterol levels, body weight,

energy levels, muscle strength, body temperature, skin conditions, menstrual regularity, memory and even bowel function.

**Please remember, when it comes to nuclear readiness, there is no second chance. In an age when terrorism and nuclear mishaps are a distinct possibility, you need to be proactive. You need to be informed. You need to have resources on hand, in your homes and businesses.**

\*\*This information is meant to communicate the possibility of radiation contamination and its effect on a healthy thyroid. Proper nutritional supplementation may aid in supporting a healthy thyroid, and an oral prophylaxis approved by the FDA will assist in protecting against and/or minimizing radiation contamination.

This is not to be considered medical advice or replacement of the advice of a medical professional or an emergency government official. It is not intended to treat, diagnose, or cure any disease. People who are allergic to iodine should not take potassium iodide products.

The distributor for this product is the Enviva Corporation who provides this FDA approved, foil-packed, high-dose potassium iodide pills with a 5-yr shelf life that are manufactured in an FDA approved pharmaceutical facility. They are available as a part of its nuclear readiness program.

**PLEASE NOTE:** Since FDA approval is vital for protection of your family in the event of a nuclear disaster, it is critical you choose a credible and government approved form of high-dose potassium iodide.

**Potassium Iodide as a Thyroid Blocking  
Agent in Radiation Emergencies  
U.S. Department of Health and Human  
Services  
Food and Drug Administration  
Center for Drug Evaluation and Research  
(CDER)  
November 2001  
Procedural**

# TABLE OF CONTENTS

## I. INTRODUCTION

## II. BACKGROUND

## III. DATA SOURCES

A. Reliance on Data from Chernobyl

B. Thyroid Cancers in the Aftermath of Chernobyl

## IV. CONCLUSIONS AND RECOMMENDATIONS

A. Use of KI in Radiation Emergencies: Rationale, Effectiveness, Safety

B. Use of KI in Radiation Emergencies: Treatment Recommendations

## V. ADDITIONAL CONSIDERATIONS IN PROPHYLAXIS AGAINST THYROID RADIOIODINE EXPOSURE

## VI. SUMMARY

## ACKNOWLEDGEMENTS

## BIBLIOGRAPHY

## **Guidance: Potassium Iodide as a Thyroid Blocking Agent in Radiation Emergencies**

This guidance represents the Food and Drug Administration's (FDA's) current thinking on this topic. It does not create or confer any rights for or on any person and does not operate to bind FDA or the public. An alternative approach may be used if such approach satisfies the requirements of the applicable statutes and regulations.

## **INTRODUCTION**

The objective of this document is to provide guidance to other Federal agencies, including the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC), and to state and local governments regarding the safe and effective use of potassium iodide (KI) as an adjunct to other public health protective measures in the event that radioactive iodine is released into the environment. The adoption and implementation of these recommendations are at the discretion of the state and local governments responsible for developing regional emergency-response plans related to radiation emergencies.

This guidance updates the Food and Drug Administration (FDA) 1982 recommendations for the use of KI to reduce the risk of thyroid cancer in radiation emergencies involving the release of radioactive iodine. The recommendations in this guidance address KI dosage and the projected radiation exposure at which the drug should be used.

These recommendations were prepared by the Potassium Iodide Working Group, comprising scientists from the FDA's Center for Drug Evaluation and Research (CDER) and Center for Devices and Radiological Health (CDRH) in collaboration with experts in the field from the National Institutes of Health (NIH). Although they differ in two respects (as discussed in Section IV.B), these revised recommendations are in general accordance with those of the World Health Organization (WHO), as expressed in its Guidelines for Iodine Prophylaxis Following Nuclear Accidents: Update 1999 (WHO 1999).

## **BACKGROUND**

Under 44 CFR 351, the Federal Emergency Management Agency (FEMA) has established roles and responsibilities for Federal agencies in assisting state and local governments in their radiological emergency planning and preparedness activities. The Federal agencies, including the Department of Health and Human Services (HHS), are to carry out these roles and responsibilities as members of the Federal Radiological Preparedness Coordinating Committee (FRPCC). Under 44 CFR 351.23(f), HHS is directed to provide guidance to state and local governments on the use of radio protective substances and the prophylactic use of drugs (e.g., KI) to reduce the radiation dose to specific organs. This guidance includes information about dosage and projected radiation exposures at which such drugs should be used.

The FDA has provided guidance previously on the use of KI as a thyroid-blocking agent. In the Federal Register of December 15, 1978, FDA announced its conclusion that KI is a safe and effective means by which to block uptake of radioiodines by the thyroid gland in a radiation emergency under certain specified conditions of use. In the Federal Register of June 29, 1982, FDA announced final recommendations on the administration of KI to the general public in a radiation emergency. Those recommendations were formulated after reviewing studies relating radiation dose to thyroid disease risk that relied on estimates of external thyroid irradiation after the nuclear detonations at Hiroshima and

Nagasaki and analogous studies among children who received therapeutic radiation to the head and neck. Those recommendations concluded that at a projected dose to the thyroid gland of 25 cGy or greater from ingested or inhaled radioiodines, the risks of short-term use of small quantities of KI were outweighed by the benefits of suppressing radioiodine-induced thyroid cancer.<sup>1</sup> The amount of KI recommended at that time was 130 mg per day for adults and children above 1 year of age and 65 mg per day for children below 1 year of age. The guidance that follows revises our 1982 recommendations on the use of KI for thyroid cancer prophylaxis based on a comprehensive review of the data relating radioiodine exposure to thyroid cancer risk accumulated in the aftermath of the 1986 Chernobyl reactor accident.

## **DATA SOURCES**

### **A. Reliance on Data from Chernobyl**

In epidemiological studies investigating the relationship between thyroidal radioiodine exposure and risk of thyroid cancer, the estimation of thyroid radiation doses is a critical and complex aspect of the analyses. Estimates of exposure, both for individuals and across populations, have been reached in different studies by the variable combination of (1) direct thyroid measurements in a segment of the exposed population; (2) measurements of <sup>131</sup>I (iodine isotope) concentrations in the milk consumed by different groups (e.g., communities) and of the quantity of milk consumed; (3) inference from ground deposition of long-lived radioisotopes released coincidentally and presumably in fixed ratios with radioiodines; and (4) reconstruction of the nature and extent of the actual radiation release.

All estimates of individual and population exposure contain some degree of uncertainty. The uncertainty is least for estimates of individual exposure based on direct thyroid measurements. Uncertainty increases with reliance on milk consumption estimates; is still greater with estimates derived from ground deposition of long-lived radioisotopes, and is highest for estimates that rely heavily on release reconstruction.

Direct measurements of thyroid radioactivity are unavailable from the Hanford, Nevada Test Site, and Marshall Islands exposures. Indeed, the estimates of thyroid radiation doses related to these releases rely heavily on release reconstructions and, in the former two cases, on recall of the extent of milk consumption 40 to 50 years after the fact. In the Marshall Islands cohort, urinary radioiodine excretion data were obtained and used in calculating exposure estimates.

Because of the great uncertainty in the dose estimates from the Hanford and Nevada Test Site exposures and due to the small numbers of thyroid cancers occurring in the populations potentially exposed, the epidemiological studies of the excess thyroid cancer risk related to these radioiodine releases are, at best, inconclusive. As explained below, the dosimetric data derived in the studies of individual and population exposures following the Chernobyl accident, although not perfect, are unquestionably superior to data from previous releases. In addition, the results of the earlier studies are inadequate to refute cogent case control study evidence from Chernobyl of a cause-effect relationship between thyroid radioiodine deposition and thyroid cancer risk.<sup>2</sup>

The Chernobyl reactor accident of April 1986 provides the best-documented example of a massive radio nuclide release in which large numbers of people across a broad geographical area were exposed acutely to radioiodines released into the atmosphere. Therefore, the recommendations contained in this guidance are derived from our review of the Chernobyl data as they pertain to the large number of thyroid cancers that occurred. These are the most comprehensive and reliable data available describing the relationship between thyroid radiation dose and risk for thyroid cancer following an environmental release of <sup>131</sup>I. In contrast, the exposures resulting from radiation releases at the Hanford Site in Washington State in the mid-1940s and in association with the nuclear detonations at the Nevada Test Site in the 1950s were extended over years, rather than days to weeks, contributing to the difficulty in estimating radioactive dose in those potentially exposed (Davis et al., 1999; Gilbert et al., 1998). The exposure of Marshall Islanders to fallout from the nuclear detonation on Bikini in 1954 involved relatively few people, and although the high rate of subsequent thyroid nodules and cancers in the exposed population was likely caused in large part by radioiodines, the Marshall Islands data provide little insight into the dose-response relationship between radioactive iodine exposure and thyroid cancer risk (Robbins and Adams 1989).

Beginning within a week after the Chernobyl accident, direct measurements of thyroid exposure were made in hundreds of thousands of individuals, across three republics of the former Soviet Union (Robbins and Schneider 2000, Gavrilin et al., 1999, Likhtarev et al., 1993, Zvonova and Balonov 1993). These thyroid measurements were used to derive, in a direct manner, the thyroid doses received by the individuals from whom the measurements were taken. The thyroid measurements were also used as a guide to estimate the thyroid doses received by other people, taking into account differences in age, milk consumption rates, and ground deposition densities, among other things. The thyroid doses derived from thyroid measurements have a large degree of uncertainty, especially in Belarus, where most of the measurements were made by inexperienced people with detectors that were not ideally suited to the task at hand (Gavrilin et al., 1999 and UNSCEAR 2000). However, as indicated above, the uncertainties attached to thyroid dose estimates derived from thyroid measurements are, as a rule, lower than those obtained without recourse to those measurements.

It is also notable that the thyroid radiation exposures after Chernobyl were virtually all **internal**, from radioiodines. Despite some degree of uncertainty in the doses received, it is reasonable to conclude that the contribution of external radiation was negligible for most individuals. This distinguishes the Chernobyl exposures from those of the Marshall Islanders. Thus, the increase in thyroid cancer seen after Chernobyl is attributable to ingested or inhaled radioiodines. A comparable burden of excess thyroid cancers could conceivably accrue should U.S. populations be similarly exposed in the event of a nuclear accident. This potential hazard highlights the value of averting such risk by using KI as an adjunct to evacuation, sheltering, and control of contaminated foodstuffs.

## **B. Thyroid Cancers in the Aftermath of Chernobyl**

The Chernobyl reactor accident resulted in massive releases of  $^{131}\text{I}$  and other radioiodines. Beginning approximately 4 years after the accident, a sharp increase in the incidence of thyroid cancer among children and adolescents in Belarus and Ukraine (areas covered by the radioactive plume) was observed. In some regions, for the first 4 years of this striking increase, observed cases of thyroid cancer among children aged 0 through 4 years at the time of the accident exceeded expected number of cases by 30- to 60-fold. During the ensuing years, in the most heavily affected areas, incidence is as much as 100-fold compared to pre-Chernobyl rates (Robbins and Schneider 2000; Gavrilin et al., 1999; Likhtarev et al., 1993; Zvonova and Balonov 1993). The majority of cases occurred in children who apparently received less than 30 cGy to the thyroid (Astakhova et al., 1998). A few cases occurred in children exposed to estimated doses of < 1 cGy; however, the uncertainty of these estimates confounded by medical radiation exposures leaves doubt as to the causal role of these doses of radioiodine (Souchkevitch and Tsyb 1996).

The evidence, though indirect, that the increased incidence of thyroid cancer observed among persons exposed during childhood in the most heavily contaminated regions in Belarus, Ukraine, and the Russian Federation is related to exposure to iodine isotopes is, nevertheless, very strong (IARC 2001). We have concluded that the best dose-response information from Chernobyl shows a marked increase in risk of thyroid cancer in children with exposures of 5 cGy or greater (Astakhova et al., 1998; Ivanov et al., 1999; Kazakov et al., 1992). Among children born more than nine months after the accident in areas traversed by the radioactive plume, the incidence of thyroid cancer has not exceeded pre-accident rates, consistent with the short half-life of  $^{131}\text{I}$ .

The use of KI in Poland after the Chernobyl accident provides us with useful information regarding its safety and tolerability in the general population. Approximately 10.5 million children under age 16 and 7 million adults received at least one dose of KI. Of note, among newborns receiving single doses of 15 mg KI, 0.37 percent (12 of 3214) showed transient increases in TSH (thyroid stimulating hormone) and decreases in FT4 (free thyroxine). The side effects among adults and children were generally mild and not clinically significant. Side effects included gastrointestinal distress, which was reported more frequently in children (up to 2 percent, felt to be due to bad taste of SSKI solution) and rash (~1 percent in children and adults). Two allergic reactions were observed in adults with known iodine sensitivity (Nauman and Wolff 1993).

Thus, the studies following the Chernobyl accident support the etiologic role of relatively small doses of radioiodine in the dramatic increase in thyroid cancer among exposed children. Furthermore, it appears that the increased risk occurs with a relatively short latency. Finally, the Polish experience supports the use of KI as a safe and effective means by which to protect against thyroid cancer caused by internal thyroid irradiation from inhalation of contaminated air or ingestion of contaminated food and drink when exposure cannot be prevented by evacuation, sheltering, or food and milk control.

## **CONCLUSIONS AND RECOMMENDATIONS**

### **A. Use of KI in Radiation Emergencies: Rationale, Effectiveness, Safety**

For the reasons discussed above, the Chernobyl data provide the most reliable information available to date on the relationship between internal thyroid radioactive dose and cancer risk. They suggest that the risk of thyroid cancer is inversely related to age, and that, especially in young children, it may accrue at very low levels of radioiodine exposure. We have relied on the Chernobyl data to formulate our specific recommendations below.

The effectiveness of KI as a specific blocker of thyroid radioiodine uptake is well established (Il'in LA, et al., 1972) as are the doses necessary for blocking uptake. As such, it is reasonable to conclude that KI will likewise be effective in reducing the risk of thyroid cancer in individuals or populations at risk for inhalation or ingestion of radioiodines.

Short-term administration of KI at thyroid blocking doses is safe and, in general, more so in children than adults. The risks of stable iodine administration include sialadenitis (an inflammation of the salivary gland, of which no cases were reported in Poland among users after the Chernobyl accident), gastrointestinal disturbances, allergic reactions and minor rashes. In addition, persons with known iodine sensitivity should avoid KI, as should individuals with dermatitis herpetiformis and hypocomplementemic vasculitis, extremely rare conditions associated with an increased risk of iodine hypersensitivity.

Thyroidal side effects of stable iodine include iodine-induced thyrotoxicosis, which is more common in older people and in iodine deficient areas but usually requires repeated doses of stable iodine. In addition, iodide goiter and hypothyroidism are potential side effects more common in iodine sufficient areas, but they require chronic high doses of stable iodine (Rubery 1990). In light of the preceding, individuals with multinodular goiter, Graves' disease, and autoimmune thyroiditis should be treated with caution, especially if dosing extends beyond a few days. The vast majority of such individuals will be adults.

The transient hypothyroidism observed in 0.37 percent (12 of 3214) of neonates treated with KI in Poland after Chernobyl has been without reported sequel to date. There is no question that the benefits of KI treatment to reduce the risk of thyroid cancer outweigh the risks of such treatment in neonates. Nevertheless, in light of the potential consequences of even transient hypothyroidism for intellectual development, we recommend that neonates (within the first month of life) treated with KI be monitored for this effect by measurement of TSH (and FT4, if indicated) and that thyroid hormone therapy be instituted in cases in which hypothyroidism develops (Bongers-Schokking 2000; Fisher 2000; Calaciura 1995).

## B. KI Use in Radiation Emergencies: Treatment Recommendations

After careful review of the data from Chernobyl relating estimated thyroid radiation dose and cancer risk in exposed children, FDA is revising its recommendation for administration of KI based on age, predicted thyroid exposure, and pregnancy and lactation status (see Table).

Threshold Thyroid Radioactive Exposures and Recommended Doses of KI for Different Risk Groups				
	Predicted Thyroid Exposure(cGy)	KI dose (mg)	# of 130 mg tablets	# of 65 mg tablets
-Adults over 40 yrs	>500			
-Adults over 18 through 40 yrs	>10	130	1	2
-Pregnant or lactating women	> 5			
-Adoles. over 12 through 18 yrs*		65	1/2	1
-Children over 3 through 12 yrs				
-Over 1 month through 3 years		32	1/4	1/2
-Birth through 1 month		16	1/8	1/4

\*Adolescents approaching adult size (> 70 kg) should receive the full adult dose (130 mg).

The protective effect of KI lasts approximately 24 hours. For optimal prophylaxis, KI should therefore be dosed daily, until a risk of significant exposure to radioiodines by either inhalation or ingestion no longer exists. Individuals intolerant of KI at protective doses, and neonates, pregnant and lactating women (in whom repeat administration of KI raises particular safety issues, see below) should be given priority with regard to other protective measures (i.e., sheltering, evacuation, and control of the food supply).

Note that adults over 40 need take KI only in the case of a projected large internal radiation dose to the thyroid (>500 cGy) to prevent hypothyroidism.

These recommendations are meant to provide states and local authorities as well as other agencies with the best current guidance on safe and effective use of KI to reduce thyroidal radioiodine exposure and thus the risk of thyroid cancer. FDA recognizes that, in the event of an emergency, some or all of the specific dosing recommendations may be very difficult to carry out given their complexity and the logistics of implementation of a program of KI distribution. The recommendations should therefore be interpreted with flexibility as necessary to allow optimally effective and safe dosing given the

exigencies of any particular emergency situation. In this context, we offer the following critical general guidance: ***across populations at risk for radioiodine exposure, the overall benefits of KI far exceed the risks of overdosing, especially in children, though we continue to emphasize particular attention to dose in infants.***

These FDA recommendations differ from those put forward in the World Health Organization (WHO) 1999 guidelines for iodine prophylaxis in two ways. WHO recommends a 130-mg dose of KI for adults and adolescents (over 12 years). For the sake of logistical simplicity in the dispensing and administration of KI to children, FDA recommends a 65-mg dose as standard for all school-age children while allowing for the adult dose (130 mg, 2 X 65 mg tablets) in adolescents approaching adult size. The other difference lies in the threshold for predicted exposure of those up to 18 years of age and of pregnant or lactating women that should trigger KI prophylaxis. WHO recommends a threshold of 1 cGy for these two groups. As stated earlier, FDA has concluded from the Chernobyl data that the most reliable evidence supports a significant increase in the risk of childhood thyroid cancer at exposures of 5 cGy or greater.

The downward KI dose adjustment by age group, based on body size considerations, adheres to the principle of minimum effective dose. The recommended standard dose of KI for all school-age children is the same (65 mg). However, adolescents approaching adult size (i.e., >70 kg) should receive the full adult dose (130 mg) for maximal block of thyroid radioiodine uptake. Neonates ideally should receive the lowest dose (16 mg) of KI. Repeat dosing of KI should be avoided in the neonate to minimize the risk of hypothyroidism during that critical phase of brain development (Bongers-Schokking 2000; Calaciura et al., 1995). KI from tablets (either whole or fractions) or as fresh saturated KI solution may be diluted in milk, formula, or water and the appropriate volume administered to babies. As stated above, we recommend that neonates (within the first month of life) treated with KI be monitored for the potential development of hypothyroidism by measurement of TSH (and FT4, if indicated) and that thyroid hormone therapy be instituted in cases in which hypothyroidism develops (Bongers-Schokking 2000; Fisher 2000; Calaciura et al., 1995).

Pregnant women should be given KI for their own protection and for that of the fetus, as iodine (whether stable or radioactive) readily crosses the placenta. However, because of the risk of blocking fetal thyroid function with excess stable iodine, repeat dosing with KI of pregnant women should be avoided. Lactating females should be administered KI for their own protection, as for other young adults, and potentially to reduce the radioiodine content of the breast milk, but not as a means to deliver KI to infants, who should get their KI directly. As for direct administration of KI, stable iodine as a component of breast milk may also pose a risk of hypothyroidism in nursing neonates. Therefore, repeat dosing with KI should be avoided in the lactating mother, except during continuing severe contamination. If repeat dosing of the mother is necessary, the nursing neonate should be monitored as recommended above.

## **ADDITIONAL CONSIDERATIONS IN PROPHYLAXIS AGAINST THYROID RADIOIODINE EXPOSURE**

Certain principles should guide emergency planning and implementation of KI prophylaxis in the event of a radiation emergency. After the Chernobyl accident, across the affected populations, thyroid radiation exposures occurred largely due to consumption of contaminated fresh cow's milk (this contamination was the result of milk cows grazing on fields affected by radioactive fallout) and to a much lesser extent by consumption of contaminated vegetables. In this or similar accidents, for those residing in the immediate area of the accident or otherwise directly exposed to the radioactive plume, inhalation of radioiodines may be a significant contributor to individual and population exposures. As a practical matter, it may not be possible to assess the risk of thyroid exposure from inhaled radioiodines at the time of the emergency. The risk depends on factors such as the magnitude and rate of the radioiodine release, wind direction and other atmospheric conditions, and thus may affect people both near to and far from the accident site.

For optimal protection against inhaled radioiodines, KI should be administered before or immediately coincident with passage of the radioactive cloud, though KI may still have a substantial protective effect even if taken 3 or 4 hours after exposure. Furthermore, if the release of radioiodines into the atmosphere is protracted, then, of course, even delayed administration may reap benefits by reducing, if incompletely, the total radiation dose to the thyroid.

Prevention of thyroid uptake of ingested radioiodines, once the plume has passed and radiation protection measures (including KI) are in place, is best accomplished by food control measures and not by repeated administration of KI. Because of radioactive decay, grain products and canned milk or vegetables from sources affected by radioactive fallout, if stored for weeks to months after production, pose no radiation risk. Thus, late KI prophylaxis at the time of consumption is not required.

As time is of the essence in optimal prophylaxis with KI, timely administration to the public is a critical consideration in planning the emergency response to a radiation accident and requires a ready supply of KI. State and local governments choosing to incorporate KI into their emergency response plans may consider the option of predistribution of KI to those individuals who do not have a medical condition precluding its use.

## **SUMMARY**

FDA maintains that KI is a safe and effective means by which to prevent radioiodine uptake by the thyroid gland, under certain specified conditions of use, and thereby obviate the risk of thyroid cancer in the event of a radiation emergency. Based upon review of the literature, we have proposed lower radioactive exposure thresholds for KI prophylaxis as well as lower doses of KI for neonates, infants, and children than we recommended in 1982. As in our 1982 notice in the Federal Register, FDA continues to recommend that radiation emergency response plans include provisions, in the event of a radiation emergency, for informing the public about the magnitude of the radiation hazard, about the manner of use of KI and its potential benefits and risks, and for medical contact, reporting, and assistance systems. FDA also emphasizes that emergency response plans and any systems for ensuring availability of KI to the public should recognize the critical importance of KI administration in advance of exposure to radioiodine. As in the past, FDA continues to work in an ongoing fashion with manufacturers of KI to ensure that high-quality, safe, and effective KI products are available for purchase by consumers as well as by state and local governments wishing to establish stores for emergency distribution.

KI provides protection only for the thyroid from radioiodines. It has no impact on the uptake by the body of other radioactive materials and provides no protection against external irradiation of any kind. FDA emphasizes that the use of KI should be as an adjunct to evacuation (itself not always feasible), sheltering, and control of foodstuffs.

## **ACKNOWLEDGEMENTS**

The KI Taskforce would like to extend special thanks to our members from the NIH: Jacob Robbins, M.D., and Jan Wolff, Ph.D., M.D., of the National Institute of Diabetes, Digestive, and Kidney Diseases and Andre Bouville, Ph.D., of the National Cancer Institute. In addition, we would like to thank Dr. David V. Becker of the Department of Radiology, Weill Medical College (WMC) of Cornell University and The New York Presbyterian Hospital-WMC Cornell Campus, for his valuable comments on the draft.

## **BIBLIOGRAPHY**

Astakhova LN, Anspaugh LR, Beebe GW, Bouville A, Drozdovitch VV, Garber V, Gavrillin YI, Khrouch VT, Kuvshinnikov AV, Kuzmenkov YN, Minenko VP, Moschik KV, Nalivko AS, Robbins J, Shemiakina EV, Shinkarev S, Tochitskaya VI, Waclawiw MA. "Chernobyl-Related Thyroid Cancer in Children in Belarus: A Case-Control Study." *Radiat Res* 1998; 150:349-356.

Baverstock K, Egloff B, Pinchera A, Ruchti C, Dillwyn W. "Thyroid Cancer After Chernobyl" (letter to the editor). *Nature* 1992; 359:21-22.

Becker DV, Robbins J, Beebe GW, Bouville AC, Wachholz BW. "Childhood Thyroid Cancer Following the Chernobyl Accident: A Status Report." *Endocrinol Metab Clin North Am* 1996; 25(1): 197-211.

Bongers-Schokking JJ, Koot HM, Wiersma D, Verkerk PH, de Muinck Keizer-Schrama SMPF. "Influence of timing and dose of thyroid hormone replacement on development in infants with congenital hypothyroidism." *J Pediatrics* 2000; 136(3): 292-297.

Calaciura F, Mendoria G, Distefano M, Castorina S, Fazio T, Motta RM, Sava L, Delange F, Vigneri R. "Childhood IQ Measurements in Infants With Transient Congenital Hypothyroidism." *Clin Endocrinol* 1995;43:473-477.

Davis S, Kopecky KJ, Hamilton T, Amundson B, Myers PA. Summary Final Report of the Hanford Thyroid Disease Study. Seattle: Fred Hutchinson Cancer Research Center, 1999.

Fisher DA. "The importance of early management in optimizing IQ in infants with congenital hypothyroidism." *J Pediatrics* 2000; 136(3): 273-274.

Gavrilin YI, Khrouch VT, Shinkarev SM, Krysenko NA, Skryabin AM, Bouville A, Anspaugh LR. "Chernobyl Accident: Reconstruction of Thyroid Dose for Inhabitants of the Republic of Belarus." *Health Phys* 1999; 76(2):105-119.

Gilbert ES, Tarone R, Bouville A, Ron E. "Thyroid Cancer Rates and 131I Doses From Nevada Atmospheric Nuclear Bomb Tests." *J Natl Cancer Inst* 1998; 90(21): 1654-60.

Harrison JR, Paile W, Baverstock K. Public Health Implications of Iodine Prophylaxis in Radiological Emergencies. In: "Thomas G, Karaoglou A, Williams ED.", eds. *Radiation and Thyroid Cancer*. Singapore: World Scientific, 1999; 455-463.

IARC- International Agency for Research on Cancer. IARC Monographs non the evaluation of carcinogenic risk to humans. Volume 78- Ionizing radiation, Part 2: Some internally deposited radionuclides. IARC Press, Lyon, France; 2001.

Il'in LA, Arkhangel'skaya GV, Konstantinov YO, Likhtarev IA. Radioactive Iodine in the Problem of Radiation Safety. Moscow, Atomizdat 1972; 208-229.  
Ivanov VK, Gorski AI, Pitkevitch VA, Tsyb AF, Cardis E, Storm H. "Risk of Radiogenic Thyroid Cancer in Russia Following the Chernobyl Accident." In: Thomas G, Karaoglou A, Williams ED., eds. *Radiation and Thyroid Cancer*. Singapore: World Scientific, 1999; 89-96.

Jacob P, Goulko G, Heidenreich WF, Likhtarev I, Kairo I, Tronko ND, Bogdanova TI, Kenigsberg J, Buglova E, Drozdovitch V, Goloneva A, Demidchik EP, Balonov M, Zvonova I, Beral V., "Thyroid Cancer Risk to Children Calculated." *Nature* 1998; 392:31-32.

Kazakov VS, Demidchik EP, Astakhova LN. "Thyroid Cancer After Chernobyl" (letter

to the editor). *Nature* 1992; 359:21.

Likhtarev, IA, Shandala NK, Gulko GM, Kairo IA, Chepurny NI, "Ukrainian Thyroid Doses After The Chernobyl Accident." *Health Physics* 1993; 64(6):594-599.

Likhtarev IA, Sobolev BG, Kairo IA, Tronko ND, Bogdanova TI, Olelnic VA, Epshtein EV, Beral V. "Thyroid Cancer in the Ukraine." *Nature* 1995; 375:365.  
Mettler FH, Becker DV, Walchholz BW, Bouville AC., "Chernobyl: 10 Years Later." *J Nucl Med* 1996; 37:24N-27N.

Nauman J, Wolff J. " Iodide Prophylaxis in Poland After the Chernobyl Reactor Accident: Benefits and Risks." *Am J Med* 1993; 94: 524-532.

Robbins J, Adams WH. "Radiation Effects in the Marshall Islands." In: Nagataki S, ed. *Radiation and the Thyroid. Proceedings of the 27th Annual Meeting of the Japanese Nuclear Medicine Society.* Amsterdam, Excerpta Medica, 1989; 11-24.

Robbins J, Schneider AB. "Thyroid Cancer following Exposure to Radioactive Iodine." *Reviews in Endocrine and Metabolic Disorders* 2000; 1:197-203.

Rubery ED. "Practical Aspects of Prophylactic Stable Iodine Usage." In: Rubery E, Smales E., eds. *Iodine Prophylaxis Following Nuclear Accidents: Proceedings of a Joint WHO/CEC Workshop.* Oxford, Pergamon Press, 1990; 141-150.

Souchkevitch GN, Tsyb AI., eds. *Health Consequences of the Chernobyl Accident: Scientific Report.* World Health Organization, Geneva, 1996; 248-250.

Stepanenko V, Tsyb A, Skvortsov V, Kondrashov A, Shakhtarin V, Hoshi M, Ohtaki M, Matsuura M, Takada J, Endo S. "New Results of Thyroid Retrospective Dosimetry in Russia Following the Chernobyl Accident." In: Thomas G, Karaoglou A, Williams ED., eds. *Radiation and Thyroid Cancer.* Singapore: World Scientific, 1999; 333-339.

Stsjazhko VA, Tsyb AF, Tronko ND, Souchkevitch G, Baverstock K. "Childhood Thyroid Cancer Since Accident at Chernobyl." *BMJ* 1995; 310:801.

UNSCEAR. United Nations Scientific Committee on the Effects of Atomic Radiation. *Sources, effects and risks of ionizing radiation 2000 Report to the General Assembly, with annexes,* New York, N.Y., United Nations; 2000.

Williams ED, Becker D, Dimidchik EP, Nagataki S, Pinchera A, Tronko ND. "Effects on the Thyroid in Populations Exposed to Radiation as a Result of the Chernobyl Accident." In: *One Decade After Chernobyl: Summing up the Consequence of the Accident.* Vienna, International Atomic Energy Agency, 1996; 207-230.

World Health Organization, Geneva, *Guidelines for Iodine Prophylaxis following Nuclear Accidents: Update 1999.*

"Report on the Joint WHO/CEC Workshop on Iodine Prophylaxis following Nuclear Accidents: Rationale for Stable Iodine Prophylaxis." In: Rubery E, Smales E., eds. Iodine Prophylaxis following Nuclear Accidents: Proceedings of a joint WHO/CEC Workshop.

Zvonova IA and Balonov MI. "Radioiodine Dosimetry and Prediction of Consequences of Thyroid Exposure of the Russian Population Following the Chernobyl Accident." Pages 71-125 in : The Chernobyl Papers. Doses to the Soviet Population and Early Health Effects Studies. Volume I (S.E. Mervin and M.I. Balonov, eds.). Research Enterprises Inc., Richland, Washington, 1993.

1. For the radiation emitted by  $^{131}\text{I}$  (electrons and photons), the radiation-weighting factor is equal to one, so that the absorbed dose to the thyroid gland expressed in centigrays (cGy) is numerically equal to the thyroid equivalent dose expressed in rem (1 cGy = 1 rem).
2. We have included in this guidance an extensive bibliography of the sources used in developing these revised recommendations.