Iodine-131 Thyroid Uptake Results in Travelers Returning from Europe After the Chernobyl Accident

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Thyroid screening measurements for ^{131}I were performed on 58 travelers returning from Eastern and Western Europe to Boston after the Chernobyl reactor accident on April 26, 1986. The travelers consisted of both Americans arriving home after business or vacation and European nationals visiting relatives in the Boston area. For purposes of dosimetry the population was divided into three subpopulations—adult (>18 yr old), children (≤18 yr old), and two individuals, 17 and 26 wk pregnant. Seventy-four percent of the population had detectable quantities of ^{131}I thyroid burdens, ranging from 1 nCi (37 Bq) to 900 nCi (33,300 Bq). The highest adult radiation dose equivalent was 5.18 mrem (51.8 mSv). The children, however, had considerably higher dose equivalents with one infant receiving 37 rem (370 mSv). Several other children were above 1 rem (10 mSv). The fetal dose equivalents were <14 mrem (140 μSv). The presence of rain dominated those testing positive for ^{131}I. Radioactive fallout from the Chernobyl accident contaminated a wide range of Europe and a large population subsequently ingested radioactivity. The children exhibited the highest thyroid radiation dose equivalents of the individuals monitored in the present study. The significance of this is presently unknown.

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Determination of thyroidal radioiodine is one of the most efficient methods for screening large numbers of individuals after the accidental release of fission products into the environment. Three examples where thyroid monitoring proved beneficial include: Marshallese Islanders who were exposed to fallout from a thermonuclear detonation on March 1, 1954, the inhabitants in England close to the Windscale reactor fire in October 1957, and children living in the Nevada-Utah area during the atomic testing program in the 1950s and 1960s (*1,2*). In the latter two iodine-131 (^{131}I) contributed nearly all of the collective dose to the thyroid gland (2,*19*).

Routine thyroid bioassays are performed for persons exposed occupationally to radioiodines. In medicine thyroid uptake measurements are used clinically to determine the functional state of the gland. The relatively small size and anatomic proximity of the thyroid gland, its avidity for iodine, as well as its relatively long retention of this element, allows for tracer monitoring with simple measuring equipment over an extended period of time.

Thyroid screening tests for ^{131}I were performed on travelers returning from Eastern and Western Europe to Boston after the Chernobyl reactor accident in Russia. The travelers were either American citizens who were exposed to radioactive fallout during their travels or citizens of Europe visiting relatives in the United States. The local news media informed the public via television, radio, and newspaper of the free screening for radioactivity at Massachusetts General Hospital. The phone number of the Radiation Safety Officer was provided for appointments and the latter was available for consultation via page 24 hr a day.

This report summarizes the ^{131}I screening results of 58 individuals who returned to the Boston area up to 7 wk after the Chernobyl accident.

MATERIALS AND METHODS

Thyroid Screening Procedure

Each individual who reported to the MGH Radiation Safety Office for thyroid screening encountered the following.

1. An information form was filled out prior to the thyroid

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measurement requesting:
   a. name and address;
   b. age;
   c. itinerary from time of accident until present;
   d. activity while traveling, such as climbing mountains, hiking, touring, etc.;
   e. weather patterns, especially rain;
   f. thyroid function status;
   g. potassium iodide, frequency of ingestion;
   h. any unusual occurrences associated with the Chernobyl accident.
2. The thyroid counting procedure was explained in detail to each person prior to data collection (*3*).
3. Those with thyroidal ^{131}I were informed of this in comparison to the standard quantity of ^{131}I used for thyroid function testing (5 μCi, 0.0195 MBq) or the occupational NRC action level for ^{131}I of 0.04 μCi (0.0015 MBq) (*3,4*).

Dosimetric Methodology

1. The radiation dose equivalent calculation, mrem (μSv), to the thyroid gland assumes that each individual was exposed to a "bolus" of ^{131}I on the day of the Chernobyl accident or several days later as determined by meteorological conditions.
2. Figure 1 illustrates the movement of the radiation cloud from Chernobyl as a function of time after the accident (*5*). The wind shift after Day 1 necessitated dividing the exposed populations into two distinct zones. Each traveler was placed into either Zone A or Zone B after a review of their itinerary.
3. The thyroid radiation dose equivalent was determined by utilizing standard MIRD methodology as follows (*6,7*).
   a. *General formula*:
   $\bar{D} = A \cdot S,$
   where D = mean absorbed dose in rads,
   A = A(t)dt = cumulated activity in μCi·hr with A(t) being the activity as a function of time within the source organ, and
   S = the mean absorbed dose to the target organ per unit cumulated activity in the source 4 organ, (rad/μCi·hr).
   For the present study,
   A = 1.44 (μCi in thyroid corrected to time of bolus exposure) ($T_{1/2}$ eff in hours), μCi-hr. The thyroid is the source and target organ.
   rem = dose equivalent = (rad) (quality factor of 1)
   b. The numerous assumptions used for calculating the radiation dose equivalent in the populations studied are listed in Table 1.

RESULTS

Travel data with associated ^{131}I thyroid burdens are shown in Table 2 for 58 individuals who were in Europe during the Chernobyl accident. Individuals traveled, or lived in all parts of Eastern and Western Europe and of this population, 74.1% (43 persons) had detectable quantities of ^{131}I in their thyroid gland. The range of thyroid burdens, corrected for a time after the accident (Fig. 1), ranged from 1 nCi (37 Bq) up to 900 nCi (33,300 Bq). The latter is an adult and a native of Poland; Person 49 in Table 2.

Anecdotal comments noted by the travelers included hearing an "explosion" (Person 1) while traveling near the reactor site, rain causing a "burning or itching" sensation on the skin, restriction of certain foods, and

FIGURE 1
The distribution of fallout from the Chernobyl accident as a function of time. Zone A includes the radiation belt during the first week and Zone B the radiation belt after the wind shift on Day 7. Each traveler's itinerary was reviewed prior to placement in either Zone A or Zone B.

TABLE 1
Dosimetric Assumptions for Determining ^{131}I Thyroid Dose Equivalents

Population	Assumptions*	Reference
Adult (>18 yr)	1. $T_{1/2e}$ = 7.4 d.	17
	2. Standard man thyroid mass.	6
Children (≤18 yr)	1. Thyroid mass (g) = $1.63 + 0.040\,T + 0.001\,T^2$. where: T = postpartum age in months.	8,9
	2. $T_{1/2e}$ is a function of age.	8
	3. "S" value for different thyroid masses.	10
Mothers (>18 yr)	1. % administered ^{131}I deposited in mother's thyroid is a function of gestational age; 50% at 12 wk.	8
	2. Mass of maternal thyroid = 30 g	8
Fetal	1. Thyroid mass (g) = $0.198 + 0.00192\,t^2 - 0.039t$, for t > 11 wk gestational age.	10
	2. The "% per g fetal thyroid" of maternal ingested ^{131}I is a function of gestational age in weeks (t) equals $5.43t - 0.453t^2 + 0.0203t^3 - 4.61\,E-04t^4 + 4.13E\text{-}06t^5$.	8,11
	3. $\lambda bio = 3.8E\text{-}08\,(0.441t - 4.446)$, sec^{-1} where t = gestational age in weeks.	8

* For MIRD "S" methodology (D = AS).

the taking of potassium iodide tablets to block the thyroid gland. Person 46, commented that his mother in Poland routinely filtered the town water through an activated charcoal cartridge prior to consumption because of impurities. One dominant feature of those testing positive was the presence of rain. This was true of Persons 1, 3, 9–12, 14, 16, 18, 22, 23, 25, 28, 30–32, 35, 36, 38–41, 44, 46, 49–51 and 54–56. Person 26, a student in Ireland, was exposed to rain over many days, but did not test positively for ^{131}I. The dosimetric results for the subpopulations studied are shown in Tables 3, 4, and 5. None of the adults (Table 3) received a significant thyroid dose, with the highest being 5.18 rem (51.8 mSv) for Person 49. The children, however, received significantly higher ^{131}I thyroid burdens (Table 4). The highest dose equivalent was that to a 1-yr-old Polish infant (51), whose ^{131}I thyroid burden resulted in 37.0 rem (370 mSv). His 3-yr-old sister had a dose equivalent of 1.8 rem (18 mSv). Two additional children (54 and 55) were exposed in Greece where they experienced rain and ate the local milk and foods. Their thyroid dose equivalents were 3.9 rem (39 mSv) and 9.7 rem (97 mSv), respectively.

The pregnant travelers (9 and 16) received <8 mrem (80 μSv) to their thyroids (Table 5). Their fetuses, who were at a gestational age of thyroid activity, received ~10 to 14 mrem (100–140 μSv).

DISCUSSION

On April 26, 1986, very early in the morning, a reactor unit of 1,000 mol wt in the Chernobyl Power Station ignited following an explosion. Soviet authorities officially announced on May 5th that the reactor fire had ended and had ceased operating (*12*). During this episode substantial quantities of radioactive material (fission products) were released into the atmosphere and, subsequently, areas of Eastern and Western Europe were contaminated. According to a NRC report the radionuclides detected in the air in Europe included: iodine-131, cesium-137, cesium-134, tellurium-132, ruthenium-103, molybdenum-99, neptunium-239, and niobium-95 (*13,14*).

Of the released radionuclides ^{131}I is the tracer of choice to screen for in large populations of exposed individuals. Subsequently, the first traveler was screened at the MGH on May 2, 1986, and the last on June 18, 1986. The individuals tested came from all over Europe as noted in Table 2, and 74.1% of those screened (N = 58) had a positive ^{131}I thyroid burden. Many brought back anecdotal stories of confusion as to the actual severity of the accident. This, of course, caused considerable anxiety and psychological trauma. Several of the participants were in tears during their screening. This was especially true of mothers whose children were being measured. In Poland, where the administration of potassium iodide tablets was common, some individuals witnessed children being "painted" with tincture of iodine. While this is not an accepted procedure for blocking the thyroid gland against ^{131}I uptake, it nevertheless has had success in animals (*15*). Its use in humans, however, has not been documented. The local practice of filtering tap water in one Polish town may have reduced ^{131}I thyroid burdens; Person 46.

A summary of the dosimetry associated with the three subpopulations studied is contained in Tables 3, 4, and 5. The majority of adults (>18 yr old) had minimal uptake of ^{131}I, which agrees with the results from Brookhaven National Laboratory (BNL) with groups returning from the Soviet Union (*16*). Individuals 49 and 56 however, had thyroid dose equivalents approximate to that obtained from a ^{131}I diagnostic uptake study (*3*). Those individuals ≤18 yr of age (children) proved to be the group of greatest risk relative to their thyroid ^{131}I dose equivalent (Table 4). The highest ^{131}I thyroid burden was to a 1-yr-old Polish infant who received 37 rem (370 mSv). Three other children received 1.8, 3.9, and 9.7 rem (180, 390, 970 mSv). The remaining children were below 275 mrem (2.75 mSv).

TABLE 2
THe Chernobyl Accident: Travelers Data

Person no.	Sex	Age	Dates in Europe	Date of count	nCi (Bq) in thyroid	Comments
1	F	55	4/21/86 to 4/30/86	5/2/86	75.9 nCi (2,808 Bq)	Kiev, Leningrad, Helsinki; heard "explosion", atmospheric warmth increase, lip blisters, skin rash, rain
2	M	25	4/26/86 to 4/30/86	5/4/86	1.24 nCi (45.9 Bq)	Moscow, Leningrad, Helsinki
3	M	30	4/28/86 to 5/2/86	5/5/86	5.89 nCi (217.9 Bq)	Switzerland; hiking in mountains, rain
4	M	35	4/20/86 to 5/1/86	5/5/85	2.94 nCi (108.8 Bq)	Leningrad, Moscow, Helsinki
5	F	32			1.21 nCi (44.8 Bq)	
6	F	60	4/23/86 to 4/30/86	5/5/85	20.51 nCi (758.9 Bq)	Leningrad, Moscow, Helsinki
7	F	16	4/25/86 to 5/2/86	5/5/85	Background	Moscow, Leningrad, Helsinki; student
8	F	17			Background	tour
9	F (26 wk preg.)	28	4/29/86 to 5/1/86	5/5/85	1.88 nCi (69.6 Bq)	Southern Czechoslovakia, Bavaria; mountain hiking, rain
10	M	31			Background	
11	F	72	4/15/85 to 5/3/86	5/5/85	14.6 nCi (540.2 Bq)	Warsaw, Krosno, Zakopane, Krakow,
12	F	74			6.21 nCi (229.8 Bq)	Czestochowa (Poland), Zurich. Visiting relatives, rain
13	M	36	4/23/86 to 5/1/86	5/6/86	2.06 nCi (76.2 Bq)	Moscow, Helsinki
14	F	64	4/25/85 to 5/3/86	5/6/86	75.3 nCi (278.6 Bq)	Kuyszyu (Belostok, Poland) Rain for several days
15	M	63	4/28/86 to 5/5/86	5/6/86	Background	Moscow, Leningrad
16	F (17 wk preg.)	28	4/27/86 to 5/3/86	5/6/86	1.6 nCi (59.2 Bq)	North and South Germany; rain, hiking
17	M	22	4/18/86–4/30/86	5/6/86	4.1 nCi (151.7 Bq)	Moscow, Leningrad, Helsinki
18	M	27	3/10/86–5/1/86	5/7/86	9.1 nCi (336.7 Bq)	Tampere (Finland), hiking, rain
19	M	45	Lives in Poland, left May 3	5/7/86	19 nCi (703 Bq)	Poland; stayed indoors
20	F	16	4/2/86 to 5/7/86	5/8/86	2.4 nCi (88.8 Bq)	West Germany; tour
21	F	17			1.0 nCi (37 Bq)	
22	F	17	4/9/86 to 5/7/86	5/8/86	Background	West Germany; tour
23	F	28	4/29/86–5/7/86	5/9/86	1.62 nCi (59.9 Bq)	Oslo, Copenhagen; rain
24	M	1.4			background	
25	F	16	4/16/86 to 5/7/86	5/9/86	6.7 nCi (247.9 Bq)	East and West Germany, lots of rain
26	M	38	4/22/86 to 5/7/86	5/9/86	11.4 nCi (421.8 Bq)	West Germany; hiking, rain
27	M	20	Student in Ireland	5/12/86	Background	Dublin, rain
28	F	33	4/30/86–5/1/86	5/13/86	4.9 nCi (181.3 Bq)	Budapest (Hungary), rain, burning skin
29	F	34	4/18/86 to 5/1/86	5/13/86	Background	West Germany
30	F	27	Lives in Poland, to	5/22/86	35.2 nCi (1,302 Bq)	Lives in Poland. 4 days of
31	M	29	USA, 4/29/86		49.9 nCi (1,846 Bq)	rain, took KI during active fallout,
32	F	28			79.0 nCi (2,923 Bq)	until present
33	M	32			66.7 nCi (2,468 Bq)	
34	M	24	4/28/86 to 5/14/86	5/19/86	48.2 nCi (1,783 Bq)	travel by railroad via Budapest, Bucarest, Brason, (Transylvania), Yugoslavia, E. & W. Germany
35	F	20	Student in Italy, to USA, 5/18/86	5/19/86	10.8 nCi (398 Bq)	Rome
36	F	39	5/1/86 to 5/12/86	5/15/86	Background	Greece, rain, burn skin
37	M	10			30.8 nCi (1,139 Bq)	
38	F	4	Prior to accident to	5/15/86	6.6 nCi (244 Bq)	Lived with husband near E. German
39	F	8	USA, 5/6/86		6.7 nCi (247.9 Bq)	border in W. Germany. Rain
40	M	2			7.1 nCi (263 Bq)	
41	F	36			6.1 nCi (227 Bq)	
42	M	34	4/25/86 to 5/10/86	5/15/86	3.7 nCi (136.9 Bq)	Berlin, rain
43	M	29			2.6 nCi (96.2 Bq)	
44	F	25	5/1/86 to 5/22/86	5/23/86	83 nCi (3,074 Bq)	Poland, stay inside, stop fresh food, KI, rain
45	F	27	5/11/86 to 5/27/86	5/30/86	Background	Moscow, Yepeuan, Baker
46	M	28	4/23/86 to 6/2/86	6/6/86	151.8 nCi (5,617 Bq)	Poland, Stayed in mother's home, rain, KI to population, filter water

TABLE 2—*continued*

Person no.	Sex	Age	Dates in Europe	Date of count	nCi (Bq) in Thyroid	Comments
47	F	24	5/17/86 to 6/7/86	6/13/86	Background	Moscow, Leningrad, Stockholm, Lon-
48	M	28			Background	don
49	F	32	Live in Poland, to	6/13/86	900 nCi (33,300 Bq)	Lives in Poland, Drink KI,
50	F	3	USA 6/11/86		724 nCi (26,788 Bq)	5/1 to Present, rain, burning skin
51	M	1			820 nCi (30,340 Bq)	
52	M	31	4/14/86 to 5/30/86	6/7/86	Background	Moscow, Kiev, Helsinki
53	M	33	5/26/86 to 6/2/86	6/18/86	1.8 nCi (68.2 Bq)	Leningrad, Moscow
54	M	7	In Greece since ac-	6/18/86	213 nCi (7,881 Bq)	In Greece
55	F	2	cident. To USA		247 nCi (9,139 Bq)	
56	F	28	June 16.		250 nCi (9,250 Bq)	
57	F	31	Since accident, to	6/18/86	Background	N. Bulgaria
58	M	1	USA 6/15/86		Background	

The previous reporting of similar accidents has provided insight into the potential consequences of a Chernobyl type disaster (*1*, *2*). On October 10–11, 1957 a fire in the #1 pile at the Windscale reactor in Cambria, England led to an uncontrolled release of fission products into the atmosphere (*2*). In time, radioactivity was detected over England, Wales, and parts of Northern Europe. The ingestion of ^{131}I contaminated milk proved to be the pathway which contributed most to the radiation dose. Subsequently, the banning of milk in the immediate Windscale region significantly reduced the collective ^{131}I thyroid radiation dose to the population at risk (*2*). In the latter group, young children, the highest measured thyroid dose equivalent was 16 rem (0.16 Sv) (*2*).

In the case of the Marshallese Islanders, the mean total thyroid dose equivalent was 1,130 rem (11.3 Sv) for children and 470 rem (4.7 Sv) for adults (*17*). The most definite and widespread latent thyroid effects resulting from this exposure have been the occurrence of benign and malignant thyroid modularity (*18*). In the exposed group five excess thyroid cancers have been predicted, however, six to seven have thus far been found (*17*). In addition, growth retardation and hypothyroidism have been observed in two individuals exposed in utero (*18*). These results are thought to be due to additional radiation exposure from iodine radioisotopes other than ^{131}I; ^{132}I, ^{133}I, and ^{135}I with physical half-lives of 2.26 hr, 20.3 hr, and 6.7 hr, respectively. These shorter lived isotopes of iodine are more destructive to the thyroid because of greater penetration of their beta particles and faster dose rates (*17*). Thus, the most important source of radiation exposure to the thyroid gland in the Marshallese was the internal absorption of radioiodines at an early time prior to evacuation (*18*).

TABLE 3
Adults (>18 yr): ^{131}I Thyroid Dosimetry

Person no.*	rem (mSv)*	Person no.*	rem (mSv)†
1	0.436 (4.36)	26	0.0655 (0.655)
2	0.00712 (0.0712)	28	0.0281 (0.281)
3	0.0339 (0.339)	30	0.202 (2.02)
4	0.0171 (0.171)	31	0.288 (2.88)
5	0.00696 (0.0696)	32	0.454 (4.54)
6	0.118 (1.18)	33	0.384 (3.84)
11	0.084 (0.84)	34	0.276 (2.76)
12	0.0358 (0.358)	35	0.0609 (0.609)
13	0.0118 (0.118)	41	0.035 (0.35)
14	0.432 (4.32)	42	0.0213 (0.213)
17	0.236 (2.36)	43	0.015 (0.15)
18	0.0523 (0.523)	44	0.478 (4.78)
19	0.109 (1.09)	46	0.874 (8.74)
20	0.0138 (0.138)	49	5.18 (51.8)
21	0.00576 (0.05767)	53	0.0103 (0.103)
23	0.00931 (0.0931)	56	1.43 (14.3)

* Data from Table 1.
† rem = 10 mSv; dose equivalent corrected for time of exposure (bolus) and $T_{1/2eff}$ = 7.4 days.

Children living in the Nevada-Utah area during the Nevada testing program were exposed to radioiodine in a manner similar to the Marshallese. Their average thyroid dose was estimated to be 18 rem (0.18 Sv) with a maximum of 120 rem (1.2 Sv) (*19*). Compared with unexposed children in Arizona no increase in the incidence of thyroid abnormalities was detected in these children (*19*). The presence of short-lived radioiodine isotopes in this study was not documented.

In the Chernobyl population it is not known to what extent short-lived iodine isotopes contributed to the total thyroid burden. It seems reasonable to assume that a major portion of Europe was exposed to the fallout at a time to allow for sufficient decay of short-lived radionuclides (Fig. 1). In a separate investigation of Chernobyl travelers, the BNL group identified lanthanum-140, tellurium-132, ruthenium-103, rubidium/rhodium-106, and cesium-137 with their whole-body counter (*16*). The body burdens of these radionuclides were not measured in the present study.

The dominance of rain in those testing positive was

TABLE 4
Children (≤18 yr): ^{131}I Thyroid Dosimetry

Person no.*	Age (yr)	Thyroid mass (g)†	$T_{½eff}$‡	S(rad/μCi-hr)§	mrem (μSv)¶
20	16	13.00	7.09 d	3.23E-02	19 (190)
21	17	13.95	7.09	3.23E-02	8 (80)
25	16	13.00	7.09	3.23E-02	53 (530)
37	10	7.35	7.09	6.0E-02	97 (970)
38	4	3.78	6.22	1.5E-01	213 (2,130)
39	8	6.39	6.22	7.0E-02	216 (2,160)
40	2	2.65	6.22	1.8E-01	275 (2,750)
50	3	3.20	6.22	1.55E-01	1,800 (18,000)
51	1	2.12	6.22	2.10E-01	37,000 (370,000)
54	5	4.39	6.22	8.5E-02	3,890 (38,900)
55	2	2.65	6.22	1.8E-01	9,670 (96,700)

* Data from Table 1.
† Thyroid mass (g) = 1.63 + 0.04 (age in mo) + {(0.0001) (age in mo)^2}, (Ref. 10).
‡ Calculation from bio decay constant as a function of age, (Ref. 8).
§ Ref. 9.
¶ Corrected for time of exposure (bolus).

quite evident during the initial screening procedure (Table 2). This supports the view that "wet deposition" of soil, water and vegetation increases the probability for human consumption of contaminated material. According to a recent publication, Austria was among the countries with the highest amounts of radioactive material deposited after the Chernobyl accident (*20*). The concentration of ^{131}I, ^{134}Cs was determined in dairy and human breast milk. During the first 2 weeks ^{131}I concentrations in cow's milk ranged between 0 and 3,550 Bq per 100 ml. The pooled breast milk was 1/10 of the latter concentrations. Concentrations of ^{134}Cs and ^{137}Cs increases in cows milk during the first few weeks after the accident and were highest during June (0 to 610 Bq per 100 ml). Since cows would winter feed on silage and hay contaminated in May, radioactive cesium levels of 40Bq per 100 ml were detected during the winter months. Levels in pooled breast milk during this period was below this concentration. These data prompted a precaution which recommended that pregnant women and breast feeding mothers reduce dairy milk intake during May and June 1987 (*2*).

The present study provides an estimation of the radiation dose equivalent to the thyroid gland from ^{131}I for a population of travelers who were exposed to the fallout from the Chernobyl accident. The children received the greatest thyroidal dose equivalent because of their small thyroid masses relative to adults and their apparent intake of radionuclide through the food (milk) chain. The latter was true of the Windscale children who drank milk contaminated with ^{131}I (*2*).

The possible latent effects of the radiation dose equivalents reported above are highly speculative. What can be concluded with a high degree of certainty is that the radioactive fallout from the Chernobyl accident did contaminate a wide range of Europe and a large population subsequently ingested radioactive fallout products. The present study reports on one fallout product, ^{131}I.

TABLE 5
Mother and Fetal ^{131}I Thyroid Dosimetry

Mother no.	nCi (Bq)	mrem (μSv)*	Oral uptake nCi (Bq)†
9	1.88 (69.6)	7.37 (73.7)	3.76 (139.2)
16	1.60 (59.2)	6.27 (62.7)	3.20 (118.4)

Fetus no.	Total age (wk)	% Fetus‡	Thyroid mass (g)	nCi (Bq)	mrem (μSv)
9	26	29.81	0.482	1.12 (41.5)	9.6 (96)
16	17	28.56	0.09	0.913 (35.3)	14.1 (141)

* 30-g thyroid; S = 1.5E-02 rad/μCi-hr (Ref 8).
† Assume 50% uptake by mother (Ref 8).
‡ Percentage of maternal ingested activity which is deposited in fetal thyroid per g of fetal thyroid, (Ref 8).

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