ORNL/TM-2017/442

Estimated Doses to Members of the Public from Exposure to Patients with ^{131}I Thyroid Treatment

Shaheen Dewji
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August 18, 2017

OAK RIDGE NATIONAL LABORATORY
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ORNL/TM-2017/442

Environmental Sciences Division
Human Health and Regulatory Risk Analysis Group
Center for Radiation Protection Knowledge

ESTIMATED DOSES TO MEMBERS OF THE PUBLIC FROM EXPOSURE TO PATIENTS WITH ^{131}I THYROID TREATMENT

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Date Published: August 18, 2017

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, TN 37831-6283
managed by
UT-BATTELLE, LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

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ACKNOWLEDGEMENTS

This work was funded by the United States Nuclear Regulatory Commission under Contract No. NRC-HQ-60-11-D-0024 with Oak Ridge National Laboratory. The authors thank Dr. Scott Mosher for his technical assistance on this project.

ABSTRACT

Dose rates and effective doses to members of the public potentially exposed internally and externally to the ^{131}I burden in patients recently treated with this radionuclide were estimated. Tissue attenuation and iodine biokinetics were considered in the patient in an effort to improve external dose estimates based on the point source/target method currently recommended by the Nuclear Regulatory Commission (NRC). The external dose estimates were derived using Monte Carlo methods based on a phantom called PIMAL with movable arms and legs, previously developed at Oak Ridge National Laboratory (ORNL) and the NRC. PIMAL was used to generate phantoms in seated, standing, and reclining positions. Organ-specific activities of ^{131}I in the thyroid, bladder, and combined remaining tissues were calculated as a function of time for several combinations of voiding frequency and thyroidal uptake of administered ^{131}I.

A conservative estimate of the internal committed effective dose that a housekeeper might receive in the cleaning of a hotel room in which a released ^{131}I patient is staying has been performed. The scenario that was established largely uses parameters that are maximum values to compute the dose. The committed effective dose computed includes inhalation from airborne contamination and skin absorption by contact with a contaminated commode. Conservative ^{131}I exhalation rates based on reported data for ^{131}I patients were used to compute the air concentration in a room. This air concentration was used with a light activity breathing rate and an inhalation dose coefficient to compute the committed effective dose to a member of the patient's household. The resulting CEDE is very small compared to the other external doses to members of the public presented in this report. It supports the previous guidance of Regulatory Guide 8.39 that the principal pathway of concern for dose to the members of the public is the external irradiation pathway.

1. INTRODUCTION

To protect individuals from the radiation emitted by a patient receiving ^{131}I treatment, a licensee is required to estimate the maximum likely effective dose to members of the public. As prescribed in the NRC Regulatory Guide 8.39, "Release of Patients Administered Radioactive Materials", a licensee may authorize the release of the patient if the effective dose is unlikely to exceed 5 mSv[1].

The current regulations offer three release criteria that would allow the release of the patient if any one of these criteria is met. First, the patient may be released if the administered activity is below a stipulated radionuclide-specific activity, which for ^{131}I is 2.4 GBq. Second, the patient may be released if the measured dose rate at 1 meter is less than 0.02 mSv/hr. Third, the patient may be released if defensible calculations by the licensee indicate that the maximum dose likely to be received by any exposed member of the public is less than 5 mSv. The purpose of this report is to provide dose coefficients for a variety of plausible exposure scenarios that could be used by licensees to determine whether the third criterion is met.

In the patient-specific calculations, the licensee may consider factors such as occupancy factor, effective half-life of the radionuclide in the patient's body, and tissue shielding. A conservative method of calculating the maximum likely dose to members of the public is provided in NRC Reg. Guide 8.39. This approach assumes that there is no tissue attenuation of penetrating radiations by the patient's body, there is no biological component that reduces the effective half-life of the radionuclide, and the patient's body burden is a point source. The assumption of no biological removal from the body introduces some conservatism into dose estimates for ^{131}I, as a significant portion of the administered amount generally is excreted in urine over the first few hours after administration. Also, it has been shown that the assumption of a point source with no tissue attenuation substantially overestimates the dose rate to nearby persons[2,3,4].

One consequence of such conservatism in the dose calculation is that the patient may be required to spend considerably more time than necessary in the hospital before release. Also, an overly conservative dose estimate may unnecessarily restrict family members from spending time with the patient during the course of radiation therapy. For these reasons, improved methods are needed to determine release criteria for patients administered radioactive material. The purpose of this study was to provide realistic dose estimates for exposed individuals primarily by creating physiologically accurate phantom models of the patient and members of the public, while considering the biological behavior of ^{131}I in the patient's body as a function of time.

[1]Nuclear Regulatory Commission, "Release of Patients Administered Radioactive Materials" Regulatory Guide 8.39, 1997.
[2]Han E. et al. , "Organ S Values and Effective Doses for Family Members Exposed to Adult Patients Following I-131 Treatment: A Monte Carlo Simulation Study", *Med. Phys*., 40 (8), 2013.
[3]R. Sparks, et al., "The need for better methods to determine release criteria for patients administered with radioactive material", *Health Physics*, 85, 385–388, 1998.
[4]Al-Haj, Abdalla N., Charlie S. Lagarde, and Aida M. Lobriguito. "Patient parameters and other radiation safety issues in ^{131}I therapy for thyroid cancer treatment." *Health Physics*, 93.6 (2007): 656–666.

2. BIOKINETIC MODELING

Predictions of the distribution of activity in the patient following acute administration of ^{131}I were based on a biokinetic model for systemic iodine proposed by Leggett[5]. The model structure is shown in Figure 2-1. The reader is referred to the published paper for a list of baseline (default) parameter values of the model for the adult.

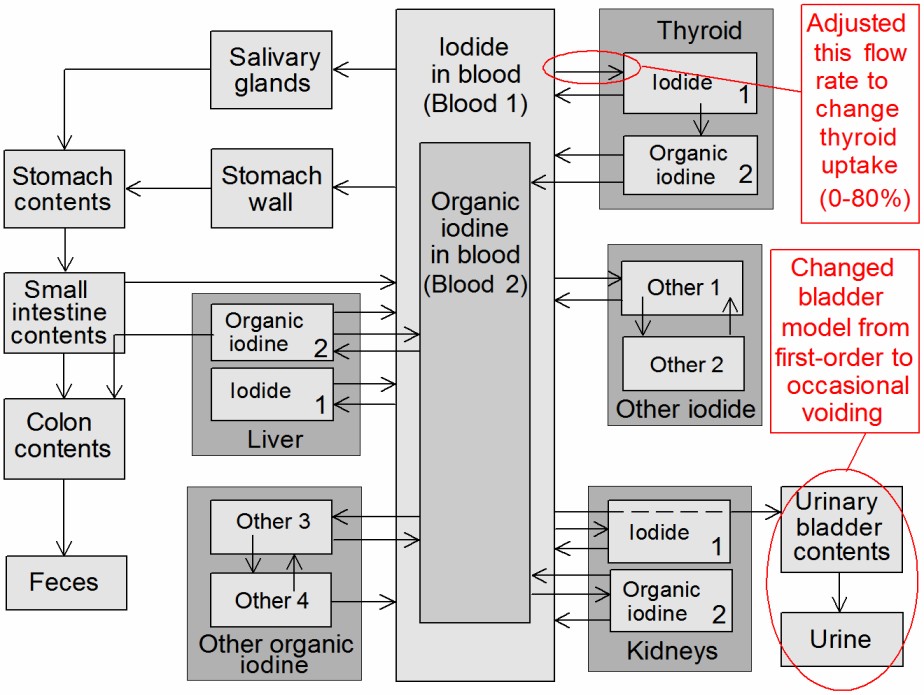


Figure 2-1. Structure of the iodine model used in the analysis and features of the model from baseline model assumptions in some exposure scenarios (Leggett, 2010).

Intravenous administration of ^{131}I was assumed. Little difference in projected dose estimates would result if oral administration were assumed instead, as the model predicts rapid and nearly complete (99%) absorption of ingested iodine to blood.

External dose estimates based on model predictions of the time-dependent distribution of ^{131}I in the body were simplified by dividing systemic iodine into three regions (pools): thyroid contents, urinary bladder contents, and all other systemic iodine combined. Iodine was assumed to be uniformly distributed within each of these three regions. The ^{131}I contents of the thyroid and urinary bladder of the patient generally represented the primary sources of external dose to members of the public.

Three different levels of thyroid uptake of ^{131}I were considered: a peak thyroid content of 5% of intravenously administered activity (representing differentiated thyroid cancer, DTC), a peak of ~27% (normal thyroid), and a peak of 80% (hyperthyroid). Normal thyroid uptake was defined by the model of Leggett (2010)[6] with baseline parameter values. That model predicts a peak thyroid content of 30% of intravenously administered stable iodine, but only ~27% peak thyroid content is reached for intravenously

[5]R. Leggett, "A physiological systems model for iodine for use in radiation protection. *Radiation Research* 174: 496–516.
[6] *Ibid.*

administered ^{131}I due to radioactive decay over the roughly 1 day period prior. Peak thyroid uptakes of 5% and 80% were implemented by adjusting the transfer coefficient from blood (Blood 1 in Figure 2-1) to thyroid (Thyroid 1, the thyroid iodide compartment) while leaving all other transfer coefficients in the model at their baseline values. The baseline transfer coefficient from Blood 1 to Thyroid 1 is 7.26 d^{-1}. Change of this coefficient to 1.04 d^{-1} yields a peak thyroid content of 5% of intravenously administered ^{131}I, and change of this coefficient to 86 d^{-1} yields a peak thyroid content of 80%.

Different patterns of voiding of activity from the urinary bladder contents were considered in conjunction with each of the three thyroid uptake scenarios:

A. Continuous Voiding (Figure 2-2) – In the published model, removal of activity from the urinary bladder contents in urine is depicted as continuous voiding at a constant rate. Specifically, it is assumed that removal of activity from the urinary bladder contents is a first-order process occurring at the rate 12 d^{-1}, as assumed for adults in reports of the International Commission on Radiological Protection (ICRP) on environmental or occupational intake of radionuclides (ex. ICRP, 1993)[7].

B. Intermittent (Periodic) Voiding (Figure 2-3) – This refers to voiding of the urinary bladder contents only at specified time intervals, e.g., every 4 (or 8 or 12) hr following administration of ^{131}I. For cases involving intermittent voiding, instantaneous and complete voiding of the urinary bladder contents was assumed.

C. Single Voiding Only (Figure 2-4) – In some exposure scenarios involving relatively short-term exposure to members of the public, it was assumed that there was a single voiding at a specified time post-administration (e.g., 2 hr) and no further voiding in urine between administration and time of exposure.

[7]International Commission on Radiological Protection. Age-dependent doses to members of the public from intake of radionuclides: Part 2. ICRP Publication 67. Oxford: Pergamon Press; 1993.

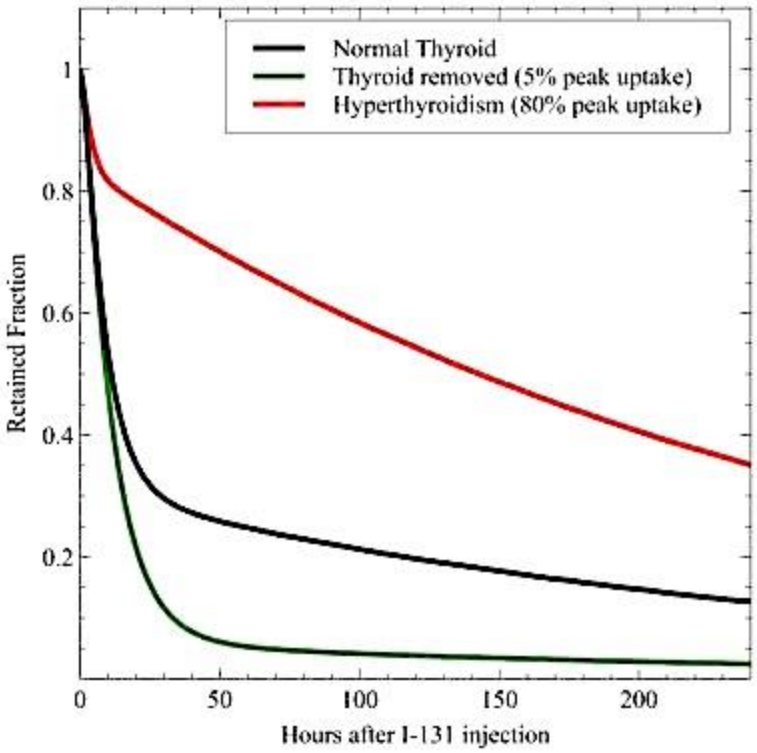


Figure 2-2. Retained fraction of ^{131}I in the body as a function of time assuming a continuous voiding pattern.

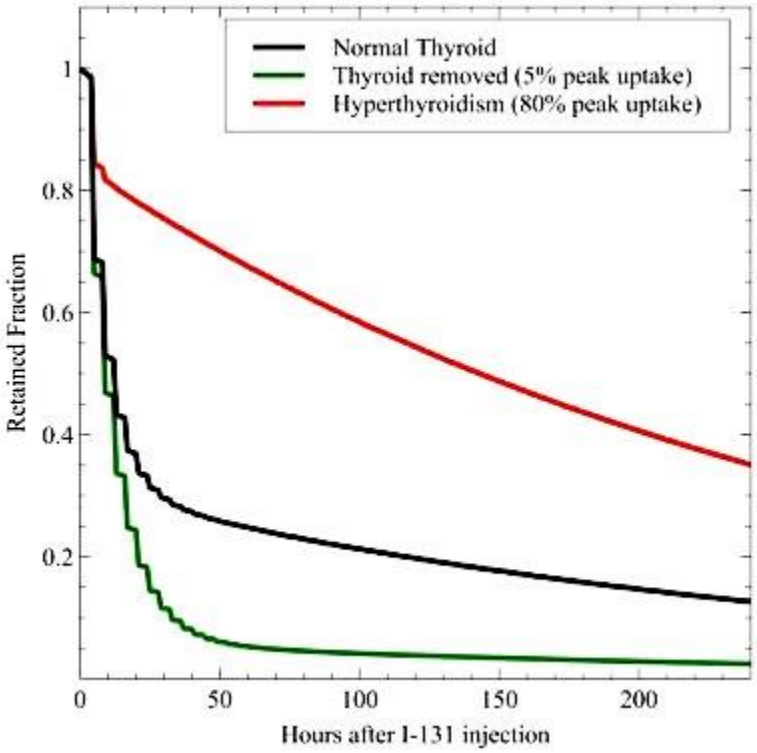


Figure 2-3. Retained fraction of ^{131}I in the body as a function of time assuming a 4 hr periodic voiding pattern.

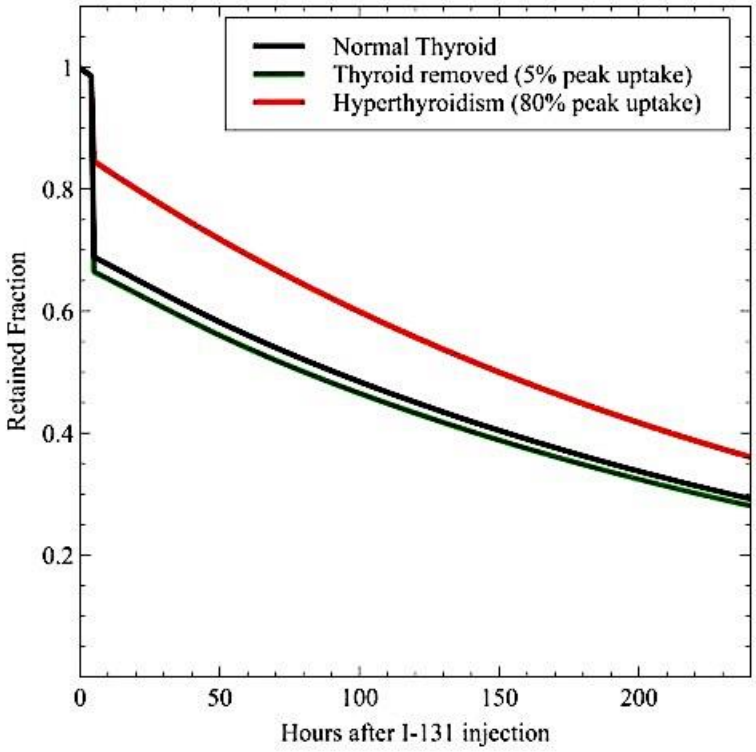


Figure 2-4. Retained fraction of ^{131}I in the body assuming single void at 4 hr after administration.

All biokinetic models employed are summarized in Appendix A.

3. COMPUTATIONAL PHANTOMS

3.1 PIMAL ANTHROPOMORPHIC PHANTOM MODEL

The **P**hantom w**i**th **M**ovable **A**rms and **L**egs (PIMAL) version 3.0 (May 2011), developed by Oak Ridge National Laboratory and the Nuclear Regulatory Commission, was with the Monte Carlo N-Particle (MCNP) radiation-transport code version 6[8] to estimate organ doses to members of the public due to external irradiation from the ^{131}I burden of the patient. PIMAL is a computational phantom that permits articulation of the arms and legs at joints to allow for a variety of postures in exposure simulations. PIMAL 3.0 includes three mathematical phantoms: a hermaphrodite model, a female model, and a male model. These mathematical phantoms are based on revisions of ORNL phantom models described by Han[9]. In the scope of this investigation, the mathematical hermaphrodite phantom was employed. The phantom incorporates tissue compositions and densities from ICRP Publication 89[10].

PIMAL permits the arms of the phantom to be bent at the elbow and shoulder and the legs to be bent at the knee and hip joints. These features were used to generate phantoms representing standing; sitting on a bus; sitting on a bed with legs extended; and sleeping on a bed.[11]

3.2 MONTE CARLO SIMULATION GEOMETRIES

Three sets totaling 10 cases of exposure scenarios were investigated in this study: public transportation cases (6), nursing home cases (2), and hotel cases (2).

For public transportation, situations in which the ^{131}I patient and the exposed individual were traveling on a bus in one of six seated or standing position permutations were investigated.

The following exposure geometries were investigated in the public transportation scenario:

(1) the patient and exposed individual standing face-to-face, separated by a distance of 10 cm (chest to chest);
(2) the patient seated in front of the exposed individual, both facing in the same direction;
(3) the patient seated behind the exposed individual, both facing in the same direction;
(4) the patient exposed individual were seated side-by-side, both facing in the same direction;
(5) the patient standing beside a seated exposed individual, both facing in the same direction; and
(6) the patient seated near a standing exposed individual, both facing in the same direction.

For the nursing home scenario, two cases were explored:

(1) a caregiver is seated 30 cm from the ^{131}I patient's beside; and
(2) the ^{131}I patient and another nursing home resident are lying in adjacent beds 250 cm apart.

---

[8] Pelowitz, D. B., A. J. Fallgren, and G. E. McMath. 2014. *MCNPT User's Manual, Code Version 6.0*. Los Alamos: Los Alamos National Laboratory.

[9] E. Han, W. E. Bolch, and K. F. Eckerman, "Revisions to the ORNL series of adult and pediatric computational phantoms for use with the MIRD schema," *Health Phys.* 90:337–356; 2006.

[10] International Commission on Radiological Protection, Basic anatomical and physiological data for use in radiological protection: Reference values, ICRP Publication 89. Oxford: Pergamon Press; 2002.

[11] Geometry errors were found for certain leg configurations. These resulted from undefined volumes when the upper legs overlapped the testes and lower abdomen. These errors were located in the generated PIMAL input decks and were corrected using a standard text editor before running the external dose simulations in this study. This has been rectified in newer version of PIMAL 4.0/4.1.0.

For the hotel room scenario, two cases were explored:

(1) the ^{131}I patient and another hotel guest were either seated back-to-back in bed separated by a wall in adjacent rooms; and
(2) the ^{131}I patient and another hotel guest were either lying flat back-to-back in bed separated by a wall in adjacent rooms.

Depictions of the MCNP geometries employed for each of these cases are summarized alongside the tabulated external dose data in Section 4.

The technique used to incorporate both the PIMAL patient phantom and the PIMAL exposed public receptor into the Monte Carlo radiation transport simulations was the "universe" capability in MCNP6. With this technique, each computational phantom is placed in its custom articulated position in a box representing a "universe". The segments of these universes containing the phantoms are then inserted into the main simulation geometry. The universe approach is useful when the torso is rotated, as PIMAL 3.0 only rotates limbs, where the phantom must be rotated and translated directly in the MCNP input deck. In essence, by employing universes in MCNP, it is even possible to model a crowd of people using customized PIMAL inputs, each in distinct positions.

3.3 MONTE CARLO SOURCE DISTRIBUTION

As indicated earlier, the external dose calculations were simplified by pooling the generally small portion of ^{131}I predicted to be contained in tissues and fluids other than the thyroid and urinary bladder into a single region. Thus, the patient's body burden of ^{131}I was divided into three pools: thyroid contents, urinary bladder contents, and all other systemic iodine combined. For each Monte Carlo calculation, a unit activity of ^{131}I was assigned to one of these three regions, and three separate Monte calculations were then combined to predict the external dose rate from a unit activity distributed among the three regions. For example, in the standing face-to-face public transportation scenario, we performed three independent simulations where the source was either in the thyroid, the bladder contents, or remainder of the body, as shown in Figure 3-1. The photon source terms were obtained from nuclear decay data for ^{131}I in ICRP Publication 107[12].

[12]International Commission on Radiological Protection, "Nuclear Data for dosimetric calculations," ICRP Publication 107, Annals of the ICRP, 2009.

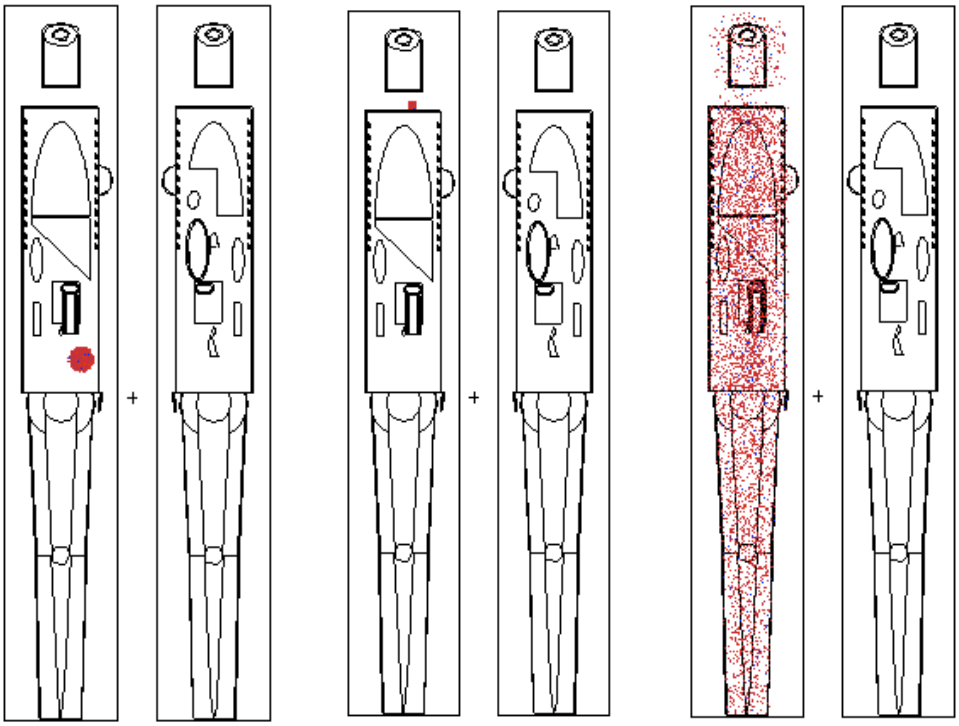


Figure 3-1. MCNP ^{131}I source particle simulation in (A) bladder, (B) thyroid, and (C) remainder/soft tissue.

3.4 MONTE CARLO RADIATION TRANSPORT

The Monte Carlo radiation-transport code, MCNP6, was used to estimate organ doses in this study. The PIMAL phantoms were employed in various exposure geometries for the patient and exposed individual. In each run, the source was simulated in the thyroid, bladder contents, or remaining soft tissue of the patient. The computation was performed on a Linux kernel 2.6.23 powered by Quad-Core AMD Opteron™ 2352 Processors. Cross sections and isotopic abundances were obtained from Evaluated Nuclear Data Files - ENDF/B-VI Release-8. No variance reduction techniques were employed[13].

Organ doses were estimated in the exposed individual using the kerma approximation. This approximation is known to be accurate to ~2% for ^{131}I due to the low primary photon energy of 364 keV[14]. The kerma approximation was implemented using the volume-averaged track length fluence estimator along with the kerma factors (heating numbers) from the MCNP6 nuclear data tables. Electrons were not tracked in these simulations, but bremsstrahlung photons were generated and tracked. Doses for active marrow and the bone surface were estimated using skeletal response functions published by Cristy

[13]D. B. Pelowitz, *MCNP6 User's Manual Version 1.0*, LA-CP-13-00634, Rev. 0, 2013.
[14] Han E. et al., "Organ S Values and Effective Doses for Family Members Exposed to Adult Patients Following I-131 Treatment: A Monte Carlo Simulation Study", *Med. Phys.* 40 (8), 2013.

and Eckerman[15]. The skeletal response function estimates of dose were implemented using the volume-averaged track length fluence estimator along with the published photon fluence-to-dose data[16].

3.5 EXTERNAL DOSE CALCULATION

Time-dependent effective dose rates were calculated for the exposed individual for each combination of exposure geometries, thyroid uptake, and bladder voiding assumptions. Sex-averaged effective dose rates were calculated according to ICRP Publication 103 recommendations[17]. These effective dose rates were initially calculated assuming unit activity in each of the patient's source organs and subsequently multiplied by the time-dependent ^{131}I organ activity derived from the appropriate implementation of the biokinetic model. Tissue weighting factors employed are summarized in Table 3-1 and Table 3-2.

Table 3-1. ICRP Publication 103 tissue weighting factors

Tissue	w_T	Sum (w_T)
Red bone marrow, colon, lung, stomach, breast, remainder tissues	0.12	0.72
Gonads	0.08	0.08
Bladder, esophagus, liver, thyroid	0.04	0.16
Endosteum (bone surface), brain, salivary glands, skin	0.01	0.04

Remainder: adrenals, extrathoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle oral mucosa, pancreas, prostate (male), small intestine, spleen, thymus, uterus/(cervix) (female).

Table 3-2. ICRP Publication 103 derived tissue-weighting factors used with MCNP-PIMAL simulation

MCNP Organ in PIMAL	Fractional Organ Weighting from ICRP 103
Left and Right Testes	0.04
Left and Right Ovaries	0.04
Colon, Rectum - Mucosa and Remainder Walls	0.12
Left and Right Lungs	0.12
Stomach Mucosa and Remainder Wall	0.12
Urinary Bladder Mucosa and Remainder Wall	0.04
Breast- Left and Right Glands	0.12
Liver	0.04
Esophagus Mucosa and Remainder Wall	0.04
Thyroid	0.04
Skin of Head and Neck, Female Trunk, and Male Genitalia	0.01
Active Marrow	0.12
Bone Surface	0.01
Adrenals	0.015
Table 3-2. cont'd	

[15] Cristy, M, and KF Eckerman. 1987. *Specific Absorbed Fractions of Energy at Various Ages from Internal Photon Sources. V. Fifteen-Year-Old Male and Adult Female.* ORNL/TM-8381, Oak Ridge National Laboratory, Oak Ridge, TN.
[16] *Ibid.*
[17] ICRP (2007). International Commission on Radiological Protection ICRP Publication 103.

Brain	0.01
Pharynx and Larynx Mucosa and Remainder Wall	0.01
Small Intestine	0.015
Kidneys - Left and Right	0.015
Trunk Muscle	0.015
Pancreas	0.015
Spleen	0.015
Thymus	0.015
Uterus	0.0075
Prostate	0.0075
Eyes - Left and Right	0
SUM	1.0

**Tissue-weighting factor of remainder tissues were averaged over the eight tallied organs output from the native PIMAL simulation. Sex-specific organs (uterus/prostate) were further averaged to calculate the sex-specific organ contributions to remainder.*

4. EXTERNAL DOSE RESULTS

Three sets of scenarios for external dose exposure to the public were investigated in this study. For each of these cases, the dose rates (mSv/MBq-hr administered) and cumulative doses (mSv/MBq administered) were calculated.

Time-dependent effective dose rates were determined for the exposed individual for each combination of exposure geometries, thyroid uptake, and bladder voiding assumptions. For each of the following cases, thyroid uptakes for normal, DTC, and hyperthyroid behavior were considered. **Cumulative doses (mSv/MBq) are provided in this chapter, and dose rates (mSv/MBq-hr) for each of the cases are provided in charts in Appendix B.**

4.1 PUBLIC TRANSPORTATION CASES

These cases involve the ^{131}I patient traveling on a bus with an exposed member of the public in six seated or standing position permutations. Although the simulations were modeled after a local public transit bus, the scenarios can be extended to apply to like situations (taxi, air travel, passenger vehicle, etc.).

i. Patient and exposed individual stood face-to-face, separated by a distance ranging from 10 cm to 300 cm (chest to chest) (Figure 4-1, Table 4-1);
ii. Patient was seated in front of the exposed individual, both facing in the same direction (Figure 4-2, Table 4-2);
iii. Patient was seated behind the exposed individual, both facing in the same direction (Figure 4-3, Table 4-3);
iv. Patient and exposed individual were seated side-by-side, both facing in the same direction (Figure 4-4, Table 4-4);
v. Patient was standing beside a seated exposed individual (perpendicular to each other) (Figure 4-5, Table 4-5); and
vi. Patient was sitting near a standing exposed individual (perpendicular to each other) (Figure 4-6, Table 4-6).

The biokinetic voiding cases used for public transportation assumed a single void at 2, 4, or 8 hr after ^{131}I administration, after which no further voids occurred *(Voiding Case C elaborated in previous section)*. It was assumed that the patient boarded the bus immediately after voiding.

Cumulative doses to a member of the public were calculated for the ^{131}I patient riding the bus for ride times ranging from 0.25 hr to 24 hr for each of the voiding cases. For example, this table provides an integrated dose for a public passenger for a patient boarding a bus 4 hr after ^{131}I administration, voids immediately prior to boarding, and rides the bus for 15 minutes (0.25hr).

Overall, *Case (i) - Standing Face-to-Face 10 cm Separation* - provided the most conservative dose of the six cases simulated for public exposure on public transportation. From the seated cases alone, i.e., *Cases ii–vi* (dose rates summarized in Appendix B), *Case (iii) – Patient Seated Behind Member of Public –* provided the most conservative dose for public exposure for the seated cases. Occupancy factors had not been considered in these cases since the time steps over which doses have been integrated are discretized. Occupancy factors were assumed not to be necessary in public transportation since the scenario represents a single exposure in a finite single timeframe where the placement of the patient and member of the public are unchanged relative to each other.

4.1.1 Case i) Public Transportation: Face-to-Face

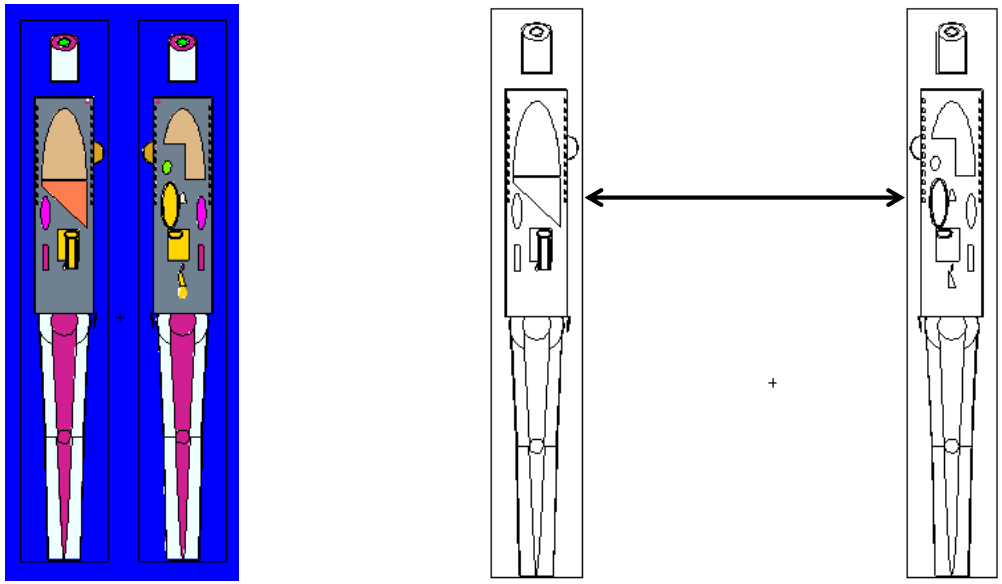


Figure 4-1. VisEd represenatation of public transporation scenario: face-to-face separation at distances ranging from 10–300 cm.

The doses for the most conservative case (10 cm separation) are provided in Table 4-1. Dose rate comparisons for various separation distances (10–300 cm) are provided in Appendix B.

Table 4-1. Cumulative dose (mSv/MBq) on public transportation – face-to-face 10 cm separation

Voiding Model: Single Initial Void at 2, 4, or 8 hr. No Void Thereafter. Exposure starts immediately after voiding. No occupancy factor employed.										
Time of Single Void After Administration (hr)	**Thyroid Uptake Model**	**Time on Transportation (hr)**								
		0.25	**0.5**	**1**	**2**	**4**	**6**	**8**	**12**	**24**
2	**Normal Thyroid**	3.71E-5	7.46E-5	1.51E-4	3.07E-4	6.35E-4	9.78E-4	1.33E-3	2.06E-3	4.28E-3
	DTC (5% Thyroid Uptake)	3.56E-5	7.15E-5	1.44E-4	2.94E-4	6.08E-4	9.36E-4	1.28E-3	1.98E-3	4.18E-3
	Hyperthyroid (80% Thyroid Uptake)	4.79E-5	9.63E-5	1.94E-4	3.93E-4	7.99E-4	1.21E-3	1.62E-3	2.43E-3	4.79E-3
4	**Normal Thyroid**	3.26E-5	6.55E-5	1.32E-4	2.69E-4	5.53E-4	8.48E-4	1.15E-3	1.77E-3	3.67E-3
	DTC (5% Thyroid Uptake)	2.98E-5	5.99E-5	1.21E-4	2.46E-4	5.08E-4	7.82E-4	1.06E-3	1.65E-3	3.48E-3
	Hyperthyroid (80% Thyroid Uptake)	4.84E-5	9.69E-5	1.94E-4	3.90E-4	7.84E-4	1.18E-3	1.57E-3	2.34E-3	4.60E-3
8	**Normal Thyroid**	2.64E-5	5.30E-5	1.07E-4	2.16E-4	4.41E-4	6.71E-4	9.06E-4	1.38E-3	2.82E-3
	DTC (5% Thyroid Uptake)	2.13E-5	4.27E-5	8.62E-5	1.75E-4	3.61E-4	5.55E-4	7.54E-4	1.17E-3	2.45E-3
	Hyperthyroid (80% Thyroid Uptake)	4.82E-5	9.63E-5	1.93E-4	3.85E-4	7.68E-4	1.15E-3	1.53E-3	2.27E-3	4.45E-3

4.1.2 Case ii) Public Transportation: Patient Seated in Front of Member of Public

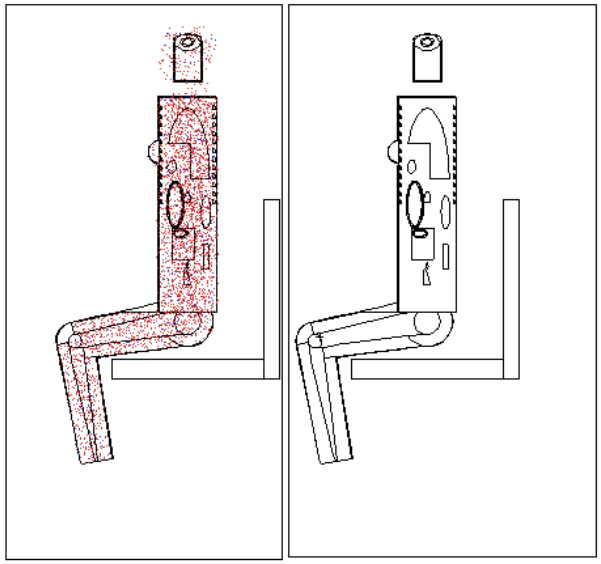


Figure 4-2. VisEd representation of public transportation scenario: Patient seated in front of member of public on bus with soft tissue source distribution.

Table 4-2. Cumulative dose (mSv/MBq) on public transportation – patient seated in front of member of public

Voiding Model: Single Initial Void at 2, 4, or 8 hr. No Void Thereafter. Exposure starts immediately after voiding. No occupancy factor employed.										
Time of Single Void After Administration (hr)	**Thyroid Uptake Model**	**Time on Transportation (hr)**								
		0.25	**0.5**	**1**	**2**	**4**	**6**	**8**	**12**	**24**
2	**Normal Thyroid**	1.08E-5	2.14E-5	4.25E-5	8.36E-5	1.62E-4	2.37E-4	3.08E-4	4.44E-4	8.17E-4
	DTC (5% Thyroid Uptake)	1.06E-5	2.12E-5	4.19E-5	8.22E-5	1.58E-4	2.30E-4	2.97E-4	4.22E-4	7.50E-4
	Hyperthyroid (80% Thyroid Uptake)	1.19E-5	2.37E-5	4.73E-5	9.41E-5	1.87E-4	2.78E-4	3.69E-4	5.49E-4	1.07E-3
4	**Normal Thyroid**	9.21E-6	1.84E-5	3.64E-5	7.17E-5	1.40E-4	2.04E-4	2.66E-4	3.85E-4	7.14E-4
	DTC (5% Thyroid Uptake)	8.87E-6	1.76E-5	3.49E-5	6.86E-5	1.32E-4	1.92E-4	2.49E-4	3.54E-4	6.29E-4
	Hyperthyroid (80% Thyroid Uptake)	1.14E-5	2.28E-5	4.56E-5	9.09E-5	1.81E-4	2.70E-4	3.59E-4	5.34E-4	1.04E-3
8	**Normal Thyroid**	7.10E-6	1.42E-5	2.81E-5	5.56E-5	1.09E-4	1.60E-4	2.09E-4	3.05E-4	5.73E-4
	DTC (5% Thyroid Uptake)	6.25E-6	1.24E-5	2.47E-5	4.84E-5	9.36E-5	1.36E-4	1.76E-4	2.51E-4	4.49E-4
	Hyperthyroid (80% Thyroid Uptake)	1.11E-5	2.21E-5	4.42E-5	8.82E-5	1.76E-4	2.63E-4	3.49E-4	5.20E-4	1.02E-3

4.1.3 Case iii) Public Transportation: Patient Seated Behind Member of Public

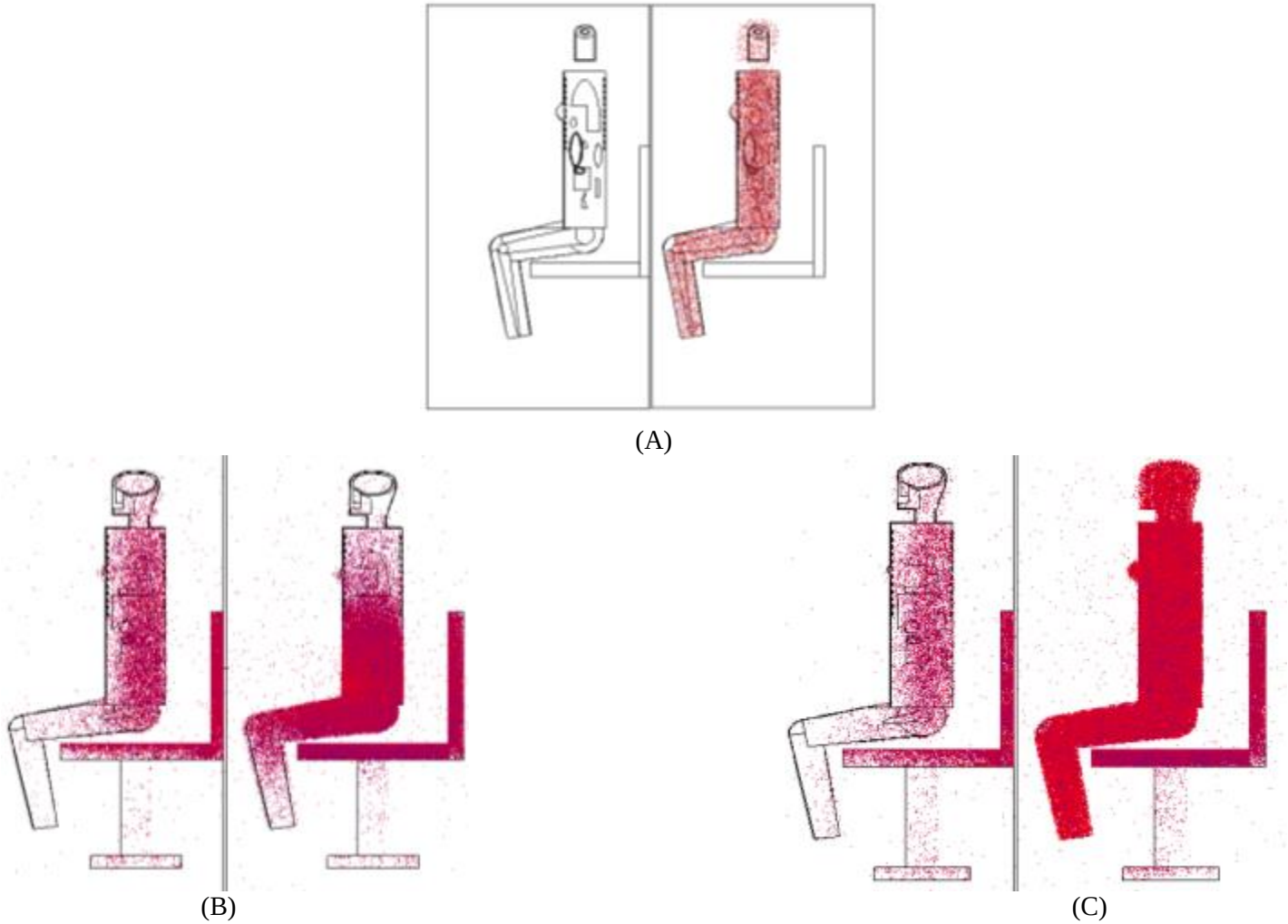
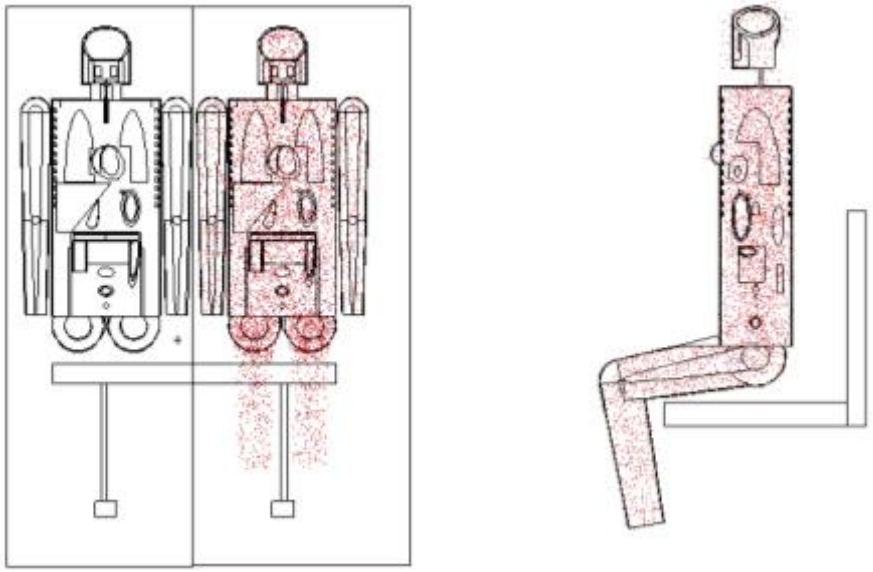


Figure 4-3. VisEd representation of public transportation scenario: Patient seated behind of member of public on bus: (A) soft tissue source distribution; (B) bladder source distribution and collision plot; and (C) soft tissue source distribution and collision plot.

Table 4-3. Cumulative dose (mSv/MBq) on public transportation – patient seated behind person on public transportation

Voiding Model: Single Initial Void at 2, 4, or 8 hr. No Void Thereafter. Exposure starts immediately after voiding. No occupancy factor employed.										
Time of Single Void After Administration (hr)	**Thyroid Uptake Model**	**Time on Transportation (hr)**								
		0.25	**0.5**	**1**	**2**	**4**	**6**	**8**	**12**	**24**
2	**Normal Thyroid**	9.97E-6	2.00E-5	4.02E-5	8.14E-5	1.66E-4	2.53E-4	3.41E-4	5.20E-4	1.06E-3
	DTC (5% Thyroid Uptake)	9.54E-6	1.91E-5	3.84E-5	7.74E-5	1.57E-4	2.38E-4	3.21E-4	4.89E-4	9.97E-4
	Hyperthyroid (80% Thyroid Uptake)	1.31E-5	2.62E-5	5.28E-5	1.07E-4	2.17E-4	3.28E-4	4.38E-4	6.57E-4	1.30E-3
4	**Normal Thyroid**	8.78E-6	1.76E-5	3.54E-5	7.14E-5	1.45E-4	2.21E-4	2.97E-4	4.52E-4	9.17E-4
	DTC (5% Thyroid Uptake)	7.99E-6	1.60E-5	3.22E-5	6.49E-5	1.32E-4	2.00E-4	2.69E-4	4.09E-4	8.33E-4
	Hyperthyroid (80% Thyroid Uptake)	1.32E-5	2.65E-5	5.31E-5	1.07E-4	2.14E-4	3.21E-4	4.28E-4	6.39E-4	1.26E-3
8	**Normal Thyroid**	7.15E-6	1.43E-5	2.88E-5	5.79E-5	1.17E-4	1.77E-4	2.38E-4	3.59E-4	7.22E-4
	DTC (5% Thyroid Uptake)	5.71E-6	1.14E-5	2.30E-5	4.63E-5	9.38E-5	1.42E-4	1.91E-4	2.91E-4	5.90E-4
	Hyperthyroid (80% Thyroid Uptake)	1.32E-5	2.64E-5	5.27E-5	1.05E-4	2.10E-4	3.14E-4	4.18E-4	6.23E-4	1.22E-3

4.1.4 Case iv) Public Transportation: Patient Seated Beside a Member of Public



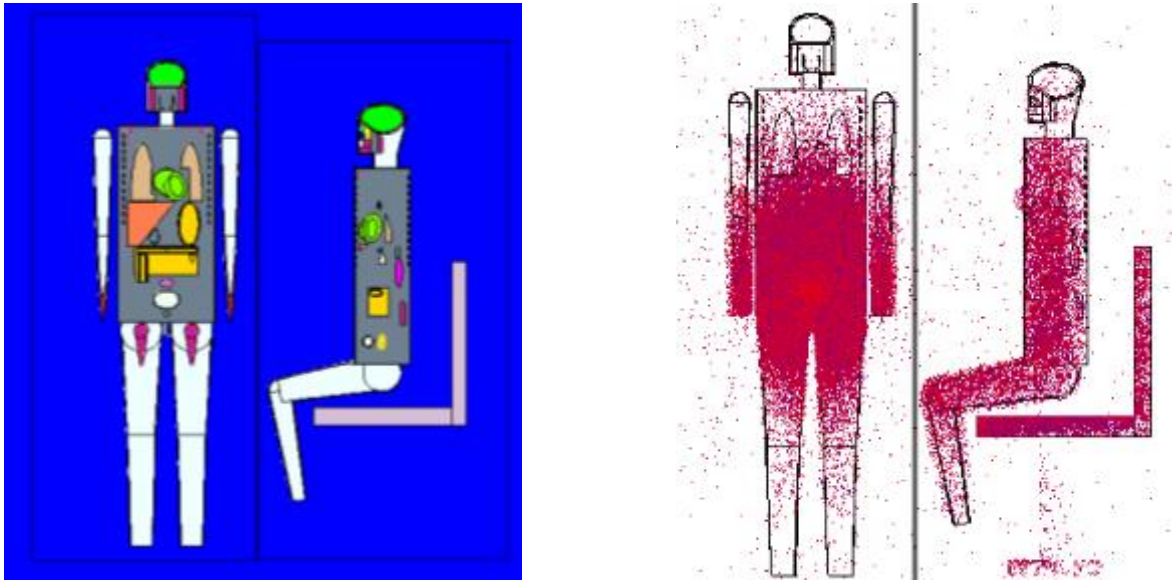
(A) (B)

Figure 4-4. VisEd representation of public transportation scenario: Patient seated beside member of public on bus: (A) soft tissue source distribution and (B) profile view.

Table 4-4. Cumulative dose (mSv/MBq) on public transportation – patient seated beside member of public

Voiding Model: Single Initial Void at 2, 4, or 8 hr. No Void Thereafter. Exposure starts immediately after voiding. No occupancy factor employed.										
Time of Single Void After Administration (hr)	**Thyroid Uptake Model**	**Time on Transportation (hr)**								
		0.25	**0.5**	**1**	**2**	**4**	**6**	**8**	**12**	**24**
2	**Normal Thyroid**	7.39E-6	1.47E-5	2.92E-5	5.76E-5	1.12E-4	1.64E-4	2.14E-4	3.10E-4	5.76E-4
	DTC (5% Thyroid Uptake)	7.23E-6	1.44E-5	2.85E-5	5.59E-5	1.08E-4	1.57E-4	2.03E-4	2.88E-4	5.13E-4
	Hyperthyroid (80% Thyroid Uptake)	8.63E-6	1.73E-5	3.45E-5	6.90E-5	1.38E-4	2.06E-4	2.74E-4	4.08E-4	8.00E-4
4	**Normal Thyroid**	6.38E-6	1.27E-5	2.53E-5	4.98E-5	9.73E-5	1.43E-4	1.87E-4	2.71E-4	5.07E-4
	DTC (5% Thyroid Uptake)	6.04E-6	1.20E-5	2.38E-5	4.67E-5	9.02E-5	1.31E-4	1.70E-4	2.42E-4	4.31E-4
	Hyperthyroid (80% Thyroid Uptake)	8.46E-6	1.69E-5	3.38E-5	6.76E-5	1.35E-4	2.01E-4	2.68E-4	3.99E-4	7.81E-4
8	**Normal Thyroid**	5.01E-6	9.99E-6	1.99E-5	3.93E-5	7.71E-5	1.14E-4	1.49E-4	2.18E-4	4.13E-4
	DTC (5% Thyroid Uptake)	4.27E-6	8.51E-6	1.69E-5	3.31E-5	6.41E-5	9.32E-5	1.21E-4	1.73E-4	3.09E-4
	Hyperthyroid (80% Thyroid Uptake)	8.28E-6	1.66E-5	3.31E-5	6.61E-5	1.32E-4	1.97E-4	2.62E-4	3.89E-4	7.62E-4

4.1.5 Case v) Public Transportation: Patient Standing Beside Seated Member of Public



(A) (B)

Figure 4-5. VisEd representation of public transportation scenario: (A) patient standing beside seated member of public on bus and (B) bladder source distribution and collision plot.

Table 4-5. Cumulative dose (mSv/MBq) on public transportation – patient standing beside seated member of public

Voiding Model: Single Initial Void at 2, 4, or 8 hr. No Void Thereafter. Exposure starts immediately after voiding. No occupancy factor employed.										
Time of Single Void After Administration (hr)	**Thyroid Uptake Model**	**Time on Transportation (hr)**								
		0.25	**0.5**	**1**	**2**	**4**	**6**	**8**	**12**	**24**
2	**Normal Thyroid**	7.68E-6	1.53E-5	3.03E-5	5.94E-5	1.15E-4	1.67E-4	2.16E-4	3.09E-4	5.63E-4
	DTC (5% Thyroid Uptake)	7.94E-6	1.58E-5	3.14E-5	6.20E-5	1.21E-4	1.77E-4	2.31E-4	3.34E-4	6.15E-4
	Hyperthyroid (80% Thyroid Uptake)	5.99E-6	1.19E-5	2.32E-5	4.48E-5	8.51E-5	1.24E-4	1.61E-4	2.35E-4	4.48E-4
4	**Normal Thyroid**	6.27E-6	1.25E-5	2.47E-5	4.86E-5	9.40E-5	1.37E-4	1.78E-4	2.55E-4	4.66E-4
	DTC (5% Thyroid Uptake)	6.57E-6	1.31E-5	2.60E-5	5.13E-5	1.00E-4	1.47E-4	1.92E-4	2.77E-4	5.10E-4
	Hyperthyroid (80% Thyroid Uptake)	4.99E-6	9.94E-6	1.97E-5	3.86E-5	7.54E-5	1.11E-4	1.46E-4	2.16E-4	4.18E-4
8	**Normal Thyroid**	4.37E-6	8.69E-6	1.72E-5	3.40E-5	6.60E-5	9.65E-5	1.26E-4	1.82E-4	3.36E-4
	DTC (5% Thyroid Uptake)	4.55E-6	9.06E-6	1.80E-5	3.55E-5	6.94E-5	1.02E-4	1.33E-4	1.92E-4	3.54E-4
	Hyperthyroid (80% Thyroid Uptake)	4.39E-6	8.77E-6	1.75E-5	3.48E-5	6.91E-5	1.03E-4	1.37E-4	2.03E-4	3.98E-4

4.1.6 Case vi) Public Transportation: Patient Seated Beside Standing Member of Public

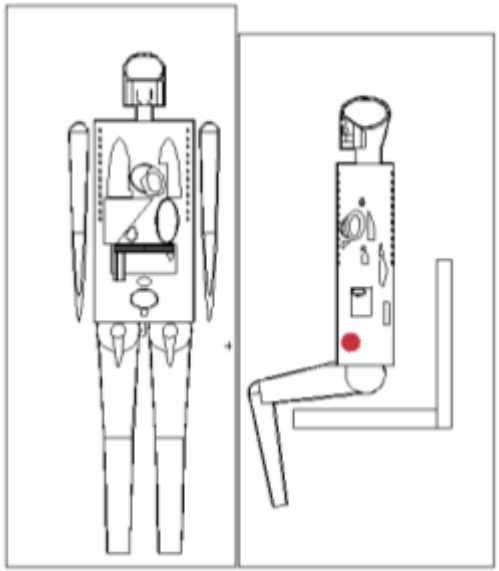


Figure 4-6. VisEd representation of public transportation scenario: Patient seated beside standing member of public on bus for bladder source distribution.

Table 4-6. Cumulative dose (mSv/MBq) on public transportation – patient seated beside standing member of public

Voiding Model: Single Initial Void at 2, 4, or 8 hr. No Void Thereafter. Exposure starts immediately after voiding. No occupancy factor employed.										
Time of Single Void After Administration (hr)	**Thyroid Uptake Model**	**Time on Transportation (hr)**								
		0.25	**0.5**	**1**	**2**	**4**	**6**	**8**	**12**	**24**
2	**Normal Thyroid**	3.71E-5	7.46E-5	1.51E-4	3.07E-4	6.35E-4	9.78E-4	1.33E-3	2.06E-3	4.28E-3
	DTC (5% Thyroid Uptake)	3.56E-5	7.15E-5	1.44E-4	2.94E-4	6.08E-4	9.36E-4	1.28E-3	1.98E-3	4.18E-3
	Hyperthyroid (80% Thyroid Uptake)	4.79E-5	9.63E-5	1.94E-4	3.93E-4	7.99E-4	1.21E-3	1.62E-3	2.43E-3	4.79E-3
4	**Normal Thyroid**	5.94E-6	1.19E-5	2.39E-5	4.80E-5	9.67E-5	1.46E-4	1.96E-4	2.95E-4	5.91E-4
	DTC (5% Thyroid Uptake)	5.21E-6	1.04E-5	2.08E-5	4.16E-5	8.30E-5	1.24E-4	1.65E-4	2.46E-4	4.82E-4
	Hyperthyroid (80% Thyroid Uptake)	9.99E-6	2.00E-5	4.01E-5	8.07E-5	1.62E-4	2.44E-4	3.25E-4	4.86E-4	9.55E-4
8	**Normal Thyroid**	4.07E-6	8.14E-6	1.63E-5	3.24E-5	6.45E-5	9.64E-5	1.28E-4	1.90E-4	3.71E-4
	DTC (5% Thyroid Uptake)	3.60E-6	7.20E-6	1.44E-5	2.87E-5	5.70E-5	8.51E-5	1.13E-4	1.68E-4	3.26E-4
	Hyperthyroid (80% Thyroid Uptake)	6.29E-6	1.26E-5	2.51E-5	5.02E-5	1.00E-4	1.49E-4	1.98E-4	2.96E-4	5.78E-4

4.2 NURSING HOME/HOME CASES

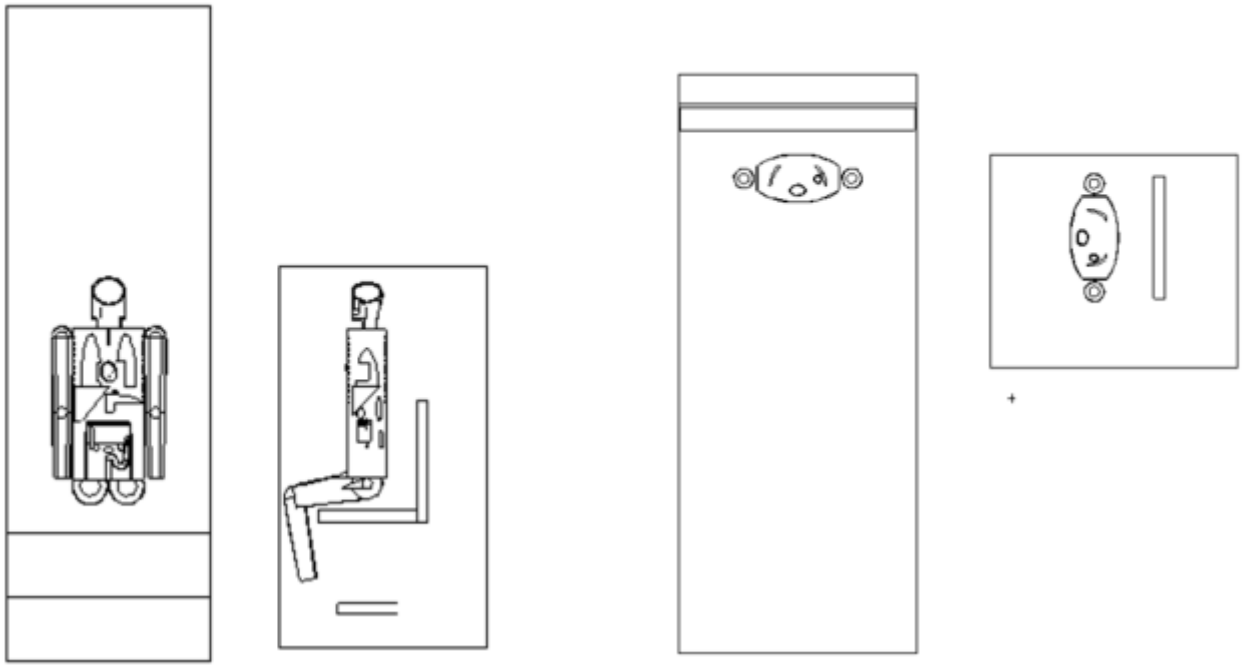
The home/nursing home scenario involves the ^{131}I patient in two cases relative to an exposed member of the public.

i. Caregiver seated 30 cm from the ^{131}I patient seated in bed (Figure 4-7, Table 4-7); and
ii. Nursing home resident seated in adjacent bed 250 cm from ^{131}I patient seated in separate bed (Figure 4-8, Table 4-8).

The biokinetic voiding cases used for the home/nursing home employ continuous voiding *(Voiding Case A elaborated in the previous section)*. Since continuous voiding is employed, an occupancy factor can be multiplied to this tabulated data (none have been applied in this tabulation) at the discretion of the NRC.

Cumulative doses (sans occupancy factors) are calculated for a member of the public exposed following 2, 4, 8, 24, and 72 hr after ^{131}I administration integrated over a 90-day period following initial administration. For example, a cumulative dose is calculated 2 hr following ^{131}I administration up to 90 days following administration to provide an "infinite" dose. If the patient returned home 72 hr following administration, the infinite dose is lower than if returned home within a shorter period, as the ^{131}I has further temporally and biokinetically decayed before being exposed to a member of public (caregiver or nursing home roommate). In summary, the infinite dose (to 90 days) for public exposure is higher for 2 hr following administration, whereas the infinite dose 72 hr following administration is lowest. Application of occupancy factors at the discretion of the NRC further reduces the dose to the caregiver/roommate by providing a more realistic temporal exposure scenario.

4.2.1 Caregiver Seated 30 cm from Patient in Bed



(A) (B)

Figure 4-7. VisEd representation of home/nursing home scenario: Caregiver seated 30 cm from patient in bed: (A) from side view and (B) aerial view.

Table 4-7. Infinite cumulative dose (mSv/MBq) to caregiver seated 30 cm from patient seated in bed

Voiding Model: Continuous. No occupancy factor applied.			
Exposure Period Post Administration (Integrated to 90 days)	**Thyroid Uptake Model**		
	Normal Thyroid	**DTC (5%)**	**Hyperthyroid (80%)**
2 hr →90 d	1.96E-3	5.71E-4	5.15E-3
4 hr →90 d	1.92E-3	5.32E-4	5.11E-3
8 hr →90 d	1.86E-3	4.70E-4	5.03E-3
24 hr → 90 d	1.70E-3	3.55E-4	4.74E-3
72 hr →90 d	1.42E-3	2.73E-4	3.98E-3

4.2.2 Patient in Adjacent Beds in Nursing Home

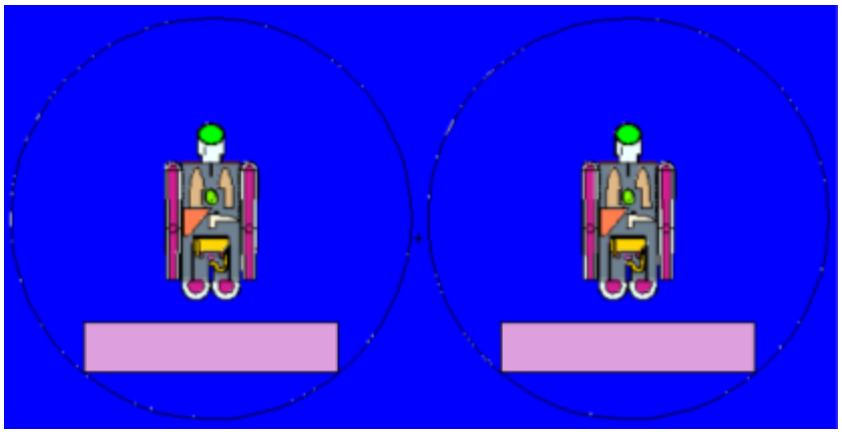


Figure 4-8. VisEd representation of nursing home scenario where a patient is in an adjacent bed.

Table 4-8. Infinite cumulative dose (mSv/MBq) to seated person in adjacent nursing home bed 250 cm from patient seated in bed

Voiding Model: Continuous. No occupancy factor applied.			
Exposure Period Post Administration (Integrated to 90 days)	**Thyroid Uptake Model**		
	Normal Thyroid	**DTC (5%)**	**Hyperthyroid (80%)**
2 hr →90 d	3.04E-4	8.45E-5	8.06E-4
4 hr →90 d	2.99E-4	7.92E-5	8.00E-4
8 hr →90 d	2.90E-4	7.09E-5	7.87E-4
24 hr → 90 d	2.67E-4	5.50E-5	7.42E-4
72 hr →90 d	2.21E-4	4.26E-5	6.19E-4

4.3 HOTEL CASES

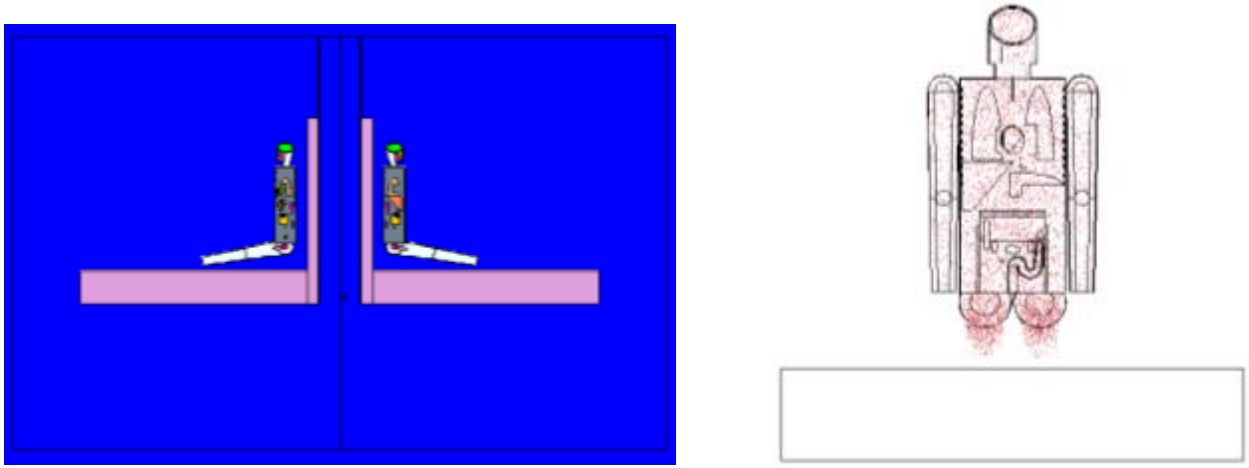
Two cases were investigated for the hotel scenario in which the ^{131}I patient and hotel guest are in adjacent rooms, back-to-back in bed.

i. ^{131}I patient is seated in bed, back-to-back with the hotel guest seated in bed in the adjacent room (Figure 4-9, Tables 4-9 to 4-11); and
ii. ^{131}I patient is lying down in bed, back-to-back with the hotel guest lying down in bed in the adjacent room (Figure 4-10, Tables 4-12 to 4-14).

The biokinetic voiding cases used for the hotel employ periodic voiding *(Voiding Case B elaborated in the previous section)* where the patient voids every 4, 8, or 12 hr. Since periodic voiding is employed and it is assumed that the patient and guest are not always seated in bed over the integrated time frame, an occupancy factor can be multiplied to this tabulated data (none have been applied in this tabulated) at the discretion of the NRC.

Cumulative doses (sans occupancy factors) are calculated for the adjacent guest. The tabulated data has exposure starting (i.e., when the patient is in the room) at 2, 4, 8, 12, 24, or 48 hr after the ^{131}I administration and exposure lasting for any of 2, 4, 8, 12, or 24 hr. For example, the tabulated data can provide the dose to the adjacent guest by the patient having checked in 48 hr after treatment, where the guest is exposed in bed for 8 hr immediately thereafter.

4.3.1 Patient Seated in Bed Back-to-Back with Adjacent Room Guest



(A) (B)

Figure 4-9. VisEd representation of hotel scenario: (A) patient seated in bed adjacent to guest in adjoining hotel room and (B) front view of patient seated in bed showing soft tissue source distribution.

Table 4-9. Cumulative dose (mSv/MBq) to seated person in adjacent hotel room bed to seated patient (4 hr void)

Voiding Model: Periodic Void (4 hr). No occupancy factor applied.

Starting Time of Exposure Post Administration (hr)	Thyroid Uptake Model	Length of Stay in Bed (hr)													
		2	4	8	12	24	48	72	96	120	144	168	192	216	240
2	Normal Thyroid	1.67E-5	2.92E-5	5.05E-5	6.74E-5	1.05E-4	1.64E-4	2.16E-4	2.64E-4	3.07E-4	3.47E-4	3.83E-4	4.16E-4	4.47E-4	4.74E-4
	DTC (5%)	1.67E-5	2.88E-5	4.87E-5	6.28E-5	8.64E-5	1.05E-4	1.16E-4	1.26E-4	1.26E-4	1.42E-4	1.49E-4	1.49E-4	1.61E-4	1.67E-4
	Hyperthyroid (80%)	1.69E-5	3.18E-5	6.09E-5	8.93E-5	1.72E-4	3.27E-4	4.68E-4	5.99E-4	7.18E-4	8.27E-4	9.27E-4	1.02E-3	1.10E-3	1.18E-3
4	Normal Thyroid	1.25E-5	2.43E-5	4.29E-5	5.81E-5	9.40E-5	1.52E-4	2.04E-4	2.51E-4	2.94E-4	3.33E-4	3.69E-4	4.02E-4	4.32E-4	4.60E-4
	DTC (5%)	1.21E-5	2.34E-5	3.99E-5	5.18E-5	7.21E-5	8.96E-5	1.00E-4	1.10E-4	1.10E-4	1.26E-4	1.33E-4	1.33E-4	1.45E-4	1.50E-4
	Hyperthyroid (80%)	1.49E-5	2.97E-5	5.83E-5	8.65E-5	1.68E-4	3.22E-4	4.63E-4	5.92E-4	7.10E-4	8.19E-4	9.18E-4	1.01E-3	1.09E-3	1.17E-3
8	Normal Thyroid	9.52E-6	1.86E-5	3.38E-5	4.70E-5	8.02E-5	1.37E-4	1.88E-4	2.34E-4	2.76E-4	3.15E-4	3.51E-4	3.83E-4	4.13E-4	4.40E-4
	DTC (5%)	8.52E-6	1.65E-5	2.84E-5	3.71E-5	5.28E-5	6.82E-5	7.86E-5	8.77E-5	8.77E-5	1.04E-4	1.10E-4	1.10E-4	1.22E-4	1.28E-4
	Hyperthyroid (80%)	1.44E-5	2.87E-5	5.68E-5	8.45E-5	1.65E-4	3.17E-4	4.56E-4	5.83E-4	6.99E-4	8.06E-4	9.04E-4	9.94E-4	1.08E-3	1.15E-3
12	Normal Thyroid	7.74E-6	1.52E-5	2.83E-5	4.02E-5	7.16E-5	1.27E-4	1.77E-4	2.23E-4	2.64E-4	3.03E-4	3.38E-4	3.70E-4	3.99E-4	4.26E-4
	DTC (5%)	6.11E-6	1.19E-5	2.06E-5	2.71E-5	3.97E-5	5.36E-5	6.37E-5	7.27E-5	7.27E-5	8.82E-5	9.50E-5	9.50E-5	1.07E-4	1.12E-4
	Hyperthyroid (80%)	1.41E-5	2.81E-5	5.59E-5	8.32E-5	1.63E-4	3.12E-4	4.49E-4	5.74E-4	6.89E-4	7.95E-4	8.91E-4	9.80E-4	1.06E-3	1.14E-3
24	Normal Thyroid	5.54E-6	1.10E-5	2.14E-5	3.14E-5	5.99E-5	1.12E-4	1.60E-4	2.04E-4	2.44E-4	2.80E-4	3.14E-4	3.44E-4	3.72E-4	3.98E-4
	DTC (5%)	2.61E-6	5.09E-6	9.19E-6	1.26E-5	2.04E-5	3.17E-5	4.12E-5	4.97E-5	4.97E-5	6.45E-5	7.10E-5	7.10E-5	8.24E-5	8.73E-5
	Hyperthyroid (80%)	1.35E-5	2.69E-5	5.35E-5	7.96E-5	1.56E-4	2.99E-4	4.30E-4	5.50E-4	6.60E-4	7.61E-4	8.53E-4	9.38E-4	1.02E-3	1.09E-3
48	Normal Thyroid	4.57E-6	9.11E-6	1.81E-5	2.68E-5	5.24E-5	1.00E-4	1.44E-4	1.84E-4	2.20E-4	2.54E-4	2.84E-4	3.12E-4	3.38E-4	3.62E-4
	DTC (5%)	1.08E-6	2.14E-6	4.15E-6	6.06E-6	1.14E-5	2.08E-5	2.93E-5	3.71E-5	3.71E-5	5.06E-5	5.66E-5	5.66E-5	6.69E-5	7.15E-5
	Hyperthyroid (80%)	1.24E-5	2.47E-5	4.90E-5	7.30E-5	1.43E-4	2.74E-4	3.94E-4	5.04E-4	6.05E-4	6.97E-4	7.82E-4	8.60E-4	9.31E-4	9.96E-4

Table 4-10. Cumulative dose (mSv/MBq) to seated person in adjacent hotel room bed to seated patient (8 hr void)

Voiding Model: Periodic Void (8 hr). No occupancy factor applied.

Starting Time of Exposure Post Administration (hr)	Thyroid Uptake Model	Length of Stay in Bed (hr)													
		2	4	8	12	24	48	72	96	120	144	168	192	216	240
2	Normal Thyroid	1.67E-5	3.26E-5	5.73E-5	7.51E-5	1.15E-4	1.74E-4	2.26E-4	2.74E-4	3.17E-4	3.57E-4	3.93E-4	4.26E-4	4.57E-4	4.84E-4
	DTC (5%)	1.67E-5	3.25E-5	5.60E-5	7.15E-5	9.79E-5	1.18E-4	1.29E-4	1.38E-4	1.38E-4	1.54E-4	1.61E-4	1.61E-4	1.74E-4	1.79E-4
	Hyperthyroid (80%)	1.69E-5	3.34E-5	6.41E-5	9.25E-5	1.75E-4	3.30E-4	4.72E-4	6.02E-4	7.21E-4	8.30E-4	9.31E-4	1.02E-3	1.11E-3	1.18E-3
4	Normal Thyroid	1.59E-5	3.10E-5	4.96E-5	6.69E-5	1.04E-4	1.62E-4	2.14E-4	2.61E-4	3.04E-4	3.43E-4	3.79E-4	4.12E-4	4.42E-4	4.70E-4
	DTC (5%)	1.58E-5	3.07E-5	4.72E-5	6.20E-5	8.36E-5	1.02E-4	1.13E-4	1.22E-4	1.22E-4	1.38E-4	1.45E-4	1.45E-4	1.58E-4	1.63E-4
	Hyperthyroid (80%)	1.65E-5	3.28E-5	6.15E-5	8.97E-5	1.72E-4	3.25E-4	4.66E-4	5.95E-4	7.14E-4	8.22E-4	9.22E-4	1.01E-3	1.10E-3	1.17E-3
8	Normal Thyroid	9.52E-6	1.86E-5	3.59E-5	4.90E-5	8.32E-5	1.40E-4	1.91E-4	2.37E-4	2.79E-4	3.18E-4	3.54E-4	3.86E-4	4.16E-4	4.43E-4
	DTC (5%)	8.52E-6	1.65E-5	3.13E-5	4.00E-5	5.76E-5	7.34E-5	8.39E-5	9.30E-5	9.30E-5	1.09E-4	1.16E-4	1.16E-4	1.28E-4	1.33E-4
	Hyperthyroid (80%)	1.44E-5	2.87E-5	5.69E-5	8.46E-5	1.65E-4	3.17E-4	4.56E-4	5.83E-4	7.00E-4	8.06E-4	9.05E-4	9.94E-4	1.08E-3	1.15E-3
12	Normal Thyroid	8.77E-6	1.73E-5	3.04E-5	4.29E-5	7.46E-5	1.30E-4	1.80E-4	2.26E-4	2.67E-4	3.06E-4	3.41E-4	3.73E-4	4.02E-4	4.29E-4
	DTC (5%)	7.56E-6	1.47E-5	2.34E-5	3.13E-5	4.45E-5	5.88E-5	6.90E-5	7.79E-5	7.79E-5	9.35E-5	1.00E-4	1.00E-4	1.12E-4	1.17E-4
	Hyperthyroid (80%)	1.42E-5	2.82E-5	5.59E-5	8.33E-5	1.63E-4	3.12E-4	4.49E-4	5.74E-4	6.89E-4	7.95E-4	8.91E-4	9.80E-4	1.06E-3	1.14E-3
24	Normal Thyroid	5.54E-6	1.10E-5	2.17E-5	3.17E-5	6.03E-5	1.13E-4	1.60E-4	2.04E-4	2.44E-4	2.81E-4	3.14E-4	3.45E-4	3.73E-4	3.98E-4
	DTC (5%)	2.61E-6	5.09E-6	9.78E-6	1.32E-5	2.14E-5	3.28E-5	4.23E-5	5.08E-5	5.08E-5	6.56E-5	7.21E-5	7.21E-5	8.35E-5	8.84E-5
	Hyperthyroid (80%)	1.35E-5	2.69E-5	5.35E-5	7.96E-5	1.56E-4	2.99E-4	4.30E-4	5.50E-4	6.60E-4	7.61E-4	8.53E-4	9.38E-4	1.02E-3	1.09E-3
48	Normal Thyroid	4.57E-6	9.11E-6	1.81E-5	2.69E-5	5.24E-5	1.00E-4	1.44E-4	1.84E-4	2.20E-4	2.54E-4	2.85E-4	3.13E-4	3.38E-4	3.62E-4
	DTC (5%)	1.08E-6	2.14E-6	4.21E-6	6.11E-6	1.14E-5	2.09E-5	2.94E-5	3.72E-5	3.72E-5	5.07E-5	5.67E-5	5.67E-5	6.70E-5	7.16E-5
	Hyperthyroid (80%)	1.24E-5	2.47E-5	4.90E-5	7.30E-5	1.43E-4	2.74E-4	3.94E-4	5.04E-4	6.05E-4	6.98E-4	7.82E-4	8.60E-4	9.31E-4	9.96E-4

Table 4-11. Cumulative dose (mSv/MBq) to seated person in adjacent hotel room bed to seated patient (12 hr void)

Voiding Model: Periodic Void (12 hr). No occupancy factor applied.

Starting Time of Exposure Post Administration (hr)	Thyroid Uptake Model	Length of Stay in Bed (hr)													
		2	4	8	12	24	48	72	96	120	144	168	192	216	240
2	Normal Thyroid	1.67E-5	3.26E-5	6.23E-5	8.42E-5	1.25E-4	1.85E-4	2.37E-4	2.84E-4	3.28E-4	3.67E-4	4.04E-4	4.37E-4	4.67E-4	4.95E-4
	DTC (5%)	1.67E-5	3.25E-5	6.18E-5	8.16E-5	1.10E-4	1.31E-4	1.43E-4	1.52E-4	1.52E-4	1.68E-4	1.75E-4	1.75E-4	1.87E-4	1.93E-4
	Hyperthyroid (80%)	1.69E-5	3.34E-5	6.58E-5	9.60E-5	1.79E-4	3.33E-4	4.75E-4	6.05E-4	7.24E-4	8.34E-4	9.34E-4	1.03E-3	1.11E-3	1.19E-3
4	Normal Thyroid	1.59E-5	3.10E-5	5.97E-5	7.49E-5	1.14E-4	1.73E-4	2.24E-4	2.71E-4	3.14E-4	3.54E-4	3.90E-4	4.23E-4	4.53E-4	4.81E-4
	DTC (5%)	1.58E-5	3.07E-5	5.87E-5	7.06E-5	9.61E-5	1.16E-4	1.27E-4	1.36E-4	1.36E-4	1.52E-4	1.59E-4	1.59E-4	1.71E-4	1.77E-4
	Hyperthyroid (80%)	1.65E-5	3.28E-5	6.49E-5	9.31E-5	1.75E-4	3.29E-4	4.70E-4	5.99E-4	7.17E-4	8.26E-4	9.25E-4	1.02E-3	1.10E-3	1.18E-3
8	Normal Thyroid	1.46E-5	2.87E-5	4.39E-5	5.83E-5	9.37E-5	1.51E-4	2.02E-4	2.48E-4	2.90E-4	3.29E-4	3.65E-4	3.97E-4	4.27E-4	4.54E-4
	DTC (5%)	1.43E-5	2.80E-5	3.99E-5	5.05E-5	7.01E-5	8.69E-5	9.76E-5	1.07E-4	1.07E-4	1.22E-4	1.29E-4	1.29E-4	1.41E-4	1.47E-4
	Hyperthyroid (80%)	1.61E-5	3.21E-5	6.03E-5	8.80E-5	1.69E-4	3.20E-4	4.59E-4	5.86E-4	7.03E-4	8.10E-4	9.08E-4	9.98E-4	1.08E-3	1.16E-3
12	Normal Thyroid	7.74E-6	1.52E-5	2.96E-5	4.33E-5	7.54E-5	1.31E-4	1.81E-4	2.27E-4	2.68E-4	3.07E-4	3.42E-4	3.74E-4	4.03E-4	4.30E-4
	DTC (5%)	6.11E-6	1.19E-5	2.25E-5	3.23E-5	4.64E-5	6.09E-5	7.11E-5	8.01E-5	8.01E-5	9.56E-5	1.02E-4	1.02E-4	1.14E-4	1.19E-4
	Hyperthyroid (80%)	1.41E-5	2.81E-5	5.59E-5	8.32E-5	1.63E-4	3.12E-4	4.49E-4	5.74E-4	6.89E-4	7.95E-4	8.91E-4	9.80E-4	1.06E-3	1.14E-3
24	Normal Thyroid	5.54E-6	1.10E-5	2.17E-5	3.21E-5	6.07E-5	1.13E-4	1.61E-4	2.05E-4	2.45E-4	2.81E-4	3.15E-4	3.45E-4	3.73E-4	3.99E-4
	DTC (5%)	2.61E-6	5.09E-6	9.78E-6	1.42E-5	2.24E-5	3.40E-5	4.35E-5	5.20E-5	5.20E-5	6.68E-5	7.33E-5	7.33E-5	8.47E-5	8.96E-5
	Hyperthyroid (80%)	1.35E-5	2.69E-5	5.35E-5	7.96E-5	1.56E-4	2.99E-4	4.30E-4	5.50E-4	6.60E-4	7.61E-4	8.53E-4	9.38E-4	1.02E-3	1.09E-3
48	Normal Thyroid	4.57E-6	9.11E-6	1.81E-5	2.69E-5	5.24E-5	1.00E-4	1.44E-4	1.84E-4	2.20E-4	2.54E-4	2.85E-4	3.13E-4	3.38E-4	3.62E-4
	DTC (5%)	1.08E-6	2.14E-6	4.21E-6	6.20E-6	1.15E-5	2.10E-5	2.95E-5	3.73E-5	3.73E-5	5.09E-5	5.68E-5	5.68E-5	6.72E-5	7.17E-5
	Hyperthyroid (80%)	1.24E-5	2.47E-5	4.90E-5	7.30E-5	1.43E-4	2.74E-4	3.94E-4	5.04E-4	6.05E-4	6.98E-4	7.82E-4	8.60E-4	9.31E-4	9.96E-4

4.3.2 Patient Lying Down in Bed Back-to-Back with Adjacent Room Guest

(A) (B)

Figure 4-10. VisEd representation of hotel scenario: (A) patient laying flat in bed adjacent to guest in adjoining room and (B) bird's eye view showing soft tissue source distribution.

Table 4-12. Cumulative dose (mSv/MBq) to person lying down in adjacent hotel room bed to patient lying down (4 hr void)

Voiding Model: Periodic Void (4 hr). No occupancy factor applied.

Starting Time of Exposure Post Administration (hr)	Thyroid Uptake Model	Length of Stay in Bed (hr)													
		2	4	8	12	24	48	72	96	120	144	168	192	216	240
2	Normal Thyroid	4.57E-6	8.63E-6	1.62E-5	2.32E-5	4.22E-5	7.62E-5	1.07E-4	1.35E-4	1.60E-4	1.84E-4	2.05E-4	2.24E-4	2.42E-4	2.58E-4
	DTC (5%)	3.99E-6	7.18E-6	1.24E-5	1.63E-5	2.38E-5	3.21E-5	3.83E-5	4.38E-5	4.38E-5	5.33E-5	5.74E-5	5.74E-5	6.46E-5	6.77E-5
	Hyperthyroid (80%)	8.13E-6	1.65E-5	3.35E-5	5.04E-5	9.97E-5	1.92E-4	2.76E-4	3.53E-4	4.23E-4	4.87E-4	5.46E-4	6.00E-4	6.49E-4	6.94E-4
4	Normal Thyroid	4.06E-6	8.00E-6	1.52E-5	2.20E-5	4.07E-5	7.43E-5	1.05E-4	1.33E-4	1.58E-4	1.81E-4	2.02E-4	2.21E-4	2.39E-4	2.55E-4
	DTC (5%)	3.19E-6	6.04E-6	1.05E-5	1.39E-5	2.07E-5	2.87E-5	3.48E-5	4.02E-5	4.02E-5	4.97E-5	5.37E-5	5.37E-5	6.09E-5	6.40E-5
	Hyperthyroid (80%)	8.38E-6	1.69E-5	3.39E-5	5.07E-5	9.96E-5	1.91E-4	2.74E-4	3.51E-4	4.21E-4	4.84E-4	5.43E-4	5.96E-4	6.45E-4	6.89E-4
8	Normal Thyroid	3.66E-6	7.25E-6	1.40E-5	2.04E-5	3.85E-5	7.16E-5	1.02E-4	1.29E-4	1.54E-4	1.77E-4	1.98E-4	2.17E-4	2.34E-4	2.50E-4
	DTC (5%)	2.35E-6	4.48E-6	7.90E-6	1.06E-5	1.63E-5	2.37E-5	2.97E-5	3.51E-5	3.51E-5	4.43E-5	4.83E-5	4.83E-5	5.54E-5	5.84E-5
	Hyperthyroid (80%)	8.51E-6	1.70E-5	3.38E-5	5.03E-5	9.85E-5	1.89E-4	2.71E-4	3.46E-4	4.15E-4	4.77E-4	5.35E-4	5.87E-4	6.35E-4	6.79E-4
12	Normal Thyroid	3.41E-6	6.76E-6	1.32E-5	1.94E-5	3.70E-5	6.96E-5	9.91E-5	1.26E-4	1.51E-4	1.73E-4	1.94E-4	2.12E-4	2.29E-4	2.45E-4
	DTC (5%)	1.79E-6	3.42E-6	6.12E-6	8.32E-6	1.33E-5	2.03E-5	2.62E-5	3.14E-5	3.14E-5	4.05E-5	4.45E-5	4.45E-5	5.14E-5	5.44E-5
	Hyperthyroid (80%)	8.43E-6	1.68E-5	3.33E-5	4.96E-5	9.71E-5	1.86E-4	2.67E-4	3.41E-4	4.09E-4	4.70E-4	5.27E-4	5.79E-4	6.26E-4	6.69E-4
24	Normal Thyroid	3.03E-6	6.02E-6	1.19E-5	1.77E-5	3.43E-5	6.53E-5	9.35E-5	1.19E-4	1.43E-4	1.64E-4	1.84E-4	2.02E-4	2.18E-4	2.33E-4
	DTC (5%)	9.57E-7	1.86E-6	3.49E-6	4.95E-6	8.72E-6	1.50E-5	2.05E-5	2.55E-5	2.55E-5	3.42E-5	3.80E-5	3.80E-5	4.46E-5	4.75E-5
	Hyperthyroid (80%)	8.06E-6	1.61E-5	3.19E-5	4.75E-5	9.28E-5	1.78E-4	2.55E-4	3.26E-4	3.91E-4	4.50E-4	5.04E-4	5.53E-4	5.98E-4	6.40E-4
48	Normal Thyroid	2.69E-6	5.37E-6	1.06E-5	1.58E-5	3.10E-5	5.92E-5	8.49E-5	1.08E-4	1.30E-4	1.49E-4	1.67E-4	1.84E-4	1.98E-4	2.12E-4
	DTC (5%)	5.70E-7	1.13E-6	2.22E-6	3.28E-6	6.29E-6	1.18E-5	1.68E-5	2.14E-5	2.14E-5	2.93E-5	3.28E-5	3.28E-5	3.88E-5	4.14E-5
	Hyperthyroid (80%)	7.36E-6	1.47E-5	2.91E-5	4.33E-5	8.48E-5	1.62E-4	2.33E-4	2.98E-4	3.57E-4	4.11E-4	4.60E-4	5.06E-4	5.47E-4	5.85E-4

Table 4-13. Cumulative dose (mSv/MBq) to person lying down in adjacent hotel room bed to patient lying down (8 hr void)

Voiding Model: Periodic Void (8 hr). No occupancy factor applied.

Starting Time of Exposure Post Administration (hr)	Thyroid Uptake Model	Length of Stay in Bed (hr)													
		2	4	8	12	24	48	72	96	120	144	168	192	216	240
2	Normal Thyroid	4.57E-6	9.00E-6	1.70E-5	2.41E-5	4.33E-5	7.73E-5	1.08E-4	1.36E-4	1.62E-4	1.85E-4	2.06E-4	2.26E-4	2.43E-4	2.59E-4
	DTC (5%)	3.99E-6	7.57E-6	1.32E-5	1.72E-5	2.50E-5	3.35E-5	3.97E-5	4.52E-5	4.52E-5	5.47E-5	5.88E-5	5.88E-5	6.60E-5	6.91E-5
	Hyperthyroid (80%)	8.13E-6	1.67E-5	3.39E-5	5.08E-5	1.00E-4	1.92E-4	2.76E-4	3.53E-4	4.23E-4	4.88E-4	5.46E-4	6.00E-4	6.49E-4	6.94E-4
4	Normal Thyroid	4.43E-6	8.74E-6	1.60E-5	2.30E-5	4.17E-5	7.54E-5	1.06E-4	1.34E-4	1.59E-4	1.82E-4	2.03E-4	2.23E-4	2.40E-4	2.56E-4
	DTC (5%)	3.59E-6	6.84E-6	1.13E-5	1.50E-5	2.20E-5	3.00E-5	3.62E-5	4.16E-5	4.16E-5	5.10E-5	5.51E-5	5.51E-5	6.23E-5	6.54E-5
	Hyperthyroid (80%)	8.55E-6	1.72E-5	3.42E-5	5.10E-5	9.99E-5	1.91E-4	2.75E-4	3.51E-4	4.21E-4	4.85E-4	5.43E-4	5.96E-4	6.45E-4	6.89E-4
8	Normal Thyroid	3.66E-6	7.25E-6	1.42E-5	2.07E-5	3.89E-5	7.19E-5	1.02E-4	1.29E-4	1.54E-4	1.77E-4	1.98E-4	2.17E-4	2.34E-4	2.50E-4
	DTC (5%)	2.35E-6	4.48E-6	8.21E-6	1.09E-5	1.68E-5	2.43E-5	3.03E-5	3.56E-5	3.56E-5	4.49E-5	4.89E-5	4.89E-5	5.60E-5	5.90E-5
	Hyperthyroid (80%)	8.51E-6	1.70E-5	3.38E-5	5.03E-5	9.85E-5	1.89E-4	2.71E-4	3.46E-4	4.15E-4	4.77E-4	5.35E-4	5.87E-4	6.35E-4	6.79E-4
12	Normal Thyroid	3.52E-6	6.98E-6	1.34E-5	1.97E-5	3.74E-5	6.99E-5	9.94E-5	1.26E-4	1.51E-4	1.73E-4	1.94E-4	2.13E-4	2.30E-4	2.45E-4
	DTC (5%)	1.94E-6	3.73E-6	6.43E-6	8.78E-6	1.38E-5	2.09E-5	2.67E-5	3.20E-5	3.20E-5	4.11E-5	4.51E-5	4.51E-5	5.20E-5	5.50E-5
	Hyperthyroid (80%)	8.43E-6	1.68E-5	3.33E-5	4.97E-5	9.71E-5	1.86E-4	2.67E-4	3.41E-4	4.09E-4	4.70E-4	5.27E-4	5.79E-4	6.26E-4	6.69E-4
24	Normal Thyroid	3.03E-6	6.02E-6	1.19E-5	1.77E-5	3.44E-5	6.53E-5	9.35E-5	1.19E-4	1.43E-4	1.64E-4	1.84E-4	2.02E-4	2.18E-4	2.33E-4
	DTC (5%)	9.57E-7	1.86E-6	3.55E-6	5.01E-6	8.83E-6	1.51E-5	2.07E-5	2.57E-5	2.57E-5	3.44E-5	3.82E-5	3.82E-5	4.48E-5	4.76E-5
	Hyperthyroid (80%)	8.06E-6	1.61E-5	3.19E-5	4.75E-5	9.28E-5	1.78E-4	2.55E-4	3.26E-4	3.91E-4	4.50E-4	5.04E-4	5.53E-4	5.98E-4	6.40E-4
48	Normal Thyroid	2.69E-6	5.37E-6	1.07E-5	1.58E-5	3.10E-5	5.92E-5	8.49E-5	1.08E-4	1.30E-4	1.49E-4	1.67E-4	1.84E-4	1.98E-4	2.12E-4
	DTC (5%)	5.70E-7	1.13E-6	2.23E-6	3.28E-6	6.30E-6	1.18E-5	1.68E-5	2.14E-5	2.14E-5	2.93E-5	3.28E-5	3.28E-5	3.88E-5	4.14E-5
	Hyperthyroid (80%)	7.36E-6	1.47E-5	2.91E-5	4.33E-5	8.48E-5	1.62E-4	2.33E-4	2.98E-4	3.57E-4	4.11E-4	4.60E-4	5.06E-4	5.47E-4	5.85E-4

Table 4-14. Cumulative dose (mSv/MBq) to person lying down in adjacent hotel room bed to patient lying down (12 hr void)

Voiding Model: Periodic Void (12 hr). No occupancy factor applied.

Starting Time of Exposure Post Administration (hr)	Thyroid Uptake Model	Length of Stay in Bed (hr)													
		2	4	8	12	24	48	72	96	120	144	168	192	216	240
2	Normal Thyroid	4.57E-6	9.00E-6	1.75E-5	2.51E-5	4.44E-5	7.85E-5	1.09E-4	1.37E-4	1.63E-4	1.86E-4	2.07E-4	2.27E-4	2.44E-4	2.61E-4
	DTC (5%)	3.99E-6	7.57E-6	1.38E-5	1.83E-5	2.64E-5	3.49E-5	4.12E-5	4.67E-5	4.67E-5	5.61E-5	6.03E-5	6.03E-5	6.75E-5	7.06E-5
	Hyperthyroid (80%)	8.13E-6	1.67E-5	3.41E-5	5.12E-5	1.00E-4	1.93E-4	2.77E-4	3.54E-4	4.24E-4	4.88E-4	5.47E-4	6.00E-4	6.49E-4	6.94E-4
4	Normal Thyroid	4.43E-6	8.74E-6	1.71E-5	2.38E-5	4.28E-5	7.66E-5	1.07E-4	1.35E-4	1.60E-4	1.83E-4	2.04E-4	2.24E-4	2.41E-4	2.57E-4
	DTC (5%)	3.59E-6	6.84E-6	1.26E-5	1.60E-5	2.33E-5	3.15E-5	3.77E-5	4.31E-5	4.31E-5	5.25E-5	5.66E-5	5.66E-5	6.37E-5	6.68E-5
	Hyperthyroid (80%)	8.55E-6	1.72E-5	3.46E-5	5.14E-5	1.00E-4	1.92E-4	2.75E-4	3.52E-4	4.21E-4	4.85E-4	5.43E-4	5.97E-4	6.45E-4	6.90E-4
8	Normal Thyroid	4.21E-6	8.34E-6	1.51E-5	2.17E-5	4.00E-5	7.31E-5	1.03E-4	1.30E-4	1.55E-4	1.78E-4	1.99E-4	2.18E-4	2.35E-4	2.51E-4
	DTC (5%)	2.98E-6	5.73E-6	9.15E-6	1.21E-5	1.82E-5	2.58E-5	3.18E-5	3.71E-5	3.71E-5	4.64E-5	5.04E-5	5.04E-5	5.74E-5	6.05E-5
	Hyperthyroid (80%)	8.70E-6	1.74E-5	3.42E-5	5.07E-5	9.89E-5	1.89E-4	2.71E-4	3.46E-4	4.15E-4	4.78E-4	5.35E-4	5.88E-4	6.36E-4	6.80E-4
12	Normal Thyroid	3.41E-6	6.76E-6	1.33E-5	1.97E-5	3.75E-5	7.00E-5	9.95E-5	1.26E-4	1.51E-4	1.74E-4	1.94E-4	2.13E-4	2.30E-4	2.45E-4
	DTC (5%)	1.79E-6	3.42E-6	6.33E-6	8.88E-6	1.40E-5	2.11E-5	2.70E-5	3.22E-5	3.22E-5	4.13E-5	4.53E-5	4.53E-5	5.22E-5	5.52E-5
	Hyperthyroid (80%)	8.43E-6	1.68E-5	3.33E-5	4.96E-5	9.71E-5	1.86E-4	2.67E-4	3.41E-4	4.09E-4	4.70E-4	5.27E-4	5.79E-4	6.26E-4	6.69E-4
24	Normal Thyroid	3.03E-6	6.02E-6	1.19E-5	1.77E-5	3.44E-5	6.54E-5	9.36E-5	1.19E-4	1.43E-4	1.64E-4	1.84E-4	2.02E-4	2.18E-4	2.33E-4
	DTC (5%)	9.57E-7	1.86E-6	3.55E-6	5.12E-6	8.94E-6	1.53E-5	2.08E-5	2.58E-5	2.58E-5	3.45E-5	3.83E-5	3.83E-5	4.49E-5	4.78E-5
	Hyperthyroid (80%)	8.06E-6	1.61E-5	3.19E-5	4.75E-5	9.28E-5	1.78E-4	2.55E-4	3.26E-4	3.91E-4	4.50E-4	5.04E-4	5.53E-4	5.98E-4	6.40E-4
48	Normal Thyroid	2.69E-6	5.37E-6	1.07E-5	1.59E-5	3.10E-5	5.92E-5	8.49E-5	1.08E-4	1.30E-4	1.49E-4	1.67E-4	1.84E-4	1.98E-4	2.12E-4
	DTC (5%)	5.70E-7	1.13E-6	2.23E-6	3.29E-6	6.31E-6	1.18E-5	1.68E-5	2.14E-5	2.14E-5	2.93E-5	3.28E-5	3.28E-5	3.88E-5	4.14E-5
	Hyperthyroid (80%)	7.36E-6	1.47E-5	2.91E-5	4.33E-5	8.48E-5	1.62E-4	2.33E-4	2.98E-4	3.57E-4	4.11E-4	4.60E-4	5.06E-4	5.47E-4	5.85E-4

5. INTERNAL DOSE ESTIMATE

The discharge of patients after the administration of ^{131}I is determined by regulatory limits on radiation dose to family members and the general public.[18] The guidelines for release are based only on consideration of external exposure rates to others and do not specifically include ^{131}I uptake by inhalation, ingestion, or absorption through the skin by contact with contaminated items. Of particular concern in this work was the internal absorbed dose to a hotel housekeeper as many of the released patients spent a day or two in a hotel to avoid contact with their family members.

Regulatory Guide 8.39[19] provides the following equation to estimate the maximum internal effective dose to an individual from a contact with a released patient:

$$D_i = 10^{-5} Q_{adm} DCF \ , \tag{5-1}$$

where

Q_{max} = the dose in activity (mCi) administered to the patient, and

DCF = dose conversion factor to convert an intake in mCi to an internal committed effective dose equivalent (FGR11).

Thus, the guidelines have assumed an internal uptake by a family member or person in the public is no more than 10^{-5} of the administered activity is ingested by the patient. The regulatory guide asserts that it is a common rule of thumb to assume that no more than 10^{-6} of the activity handled will become intake to an individual working with the material. The rule of thumb value of 10^{-6} as formally developed in the work of Brodsky[20] was multiplied by 10 to account for the intake of the most highly exposed individual and to add a degree of conservatism.

Recently, North[21] reported a study of uptake by persons and dogs living in the same dwellings as patients administered ^{131}I after their release. In that study group, the patients were kept at the hospital for one night. The thyroids of the exposed people and dogs were counted for ^{131}I uptake. Households of 22 cancer patients, representing 43 people and 7 dogs, were used in the study. Three people and four dogs had positive assays. The activity burden in the household members as a fraction of the administered activity was found to range from $6(10^{-6})$ to $2(10^{-5})$ in the three people who had positive results. The higher end uptake fraction for the household members was a male who admitted to kissing his girlfriend frequently. A higher transfer fraction was found in one of the dogs, but the owner admitted that he allowed the dog to lick him. North concluded that the transfer of measurable activities of ^{131}I from the patient to members of the households was rare, and when there was a positive result, the transfer fraction of administered activity of 10^{-5} in general seemed to be conservative.

Earlier results of Jacobson, Plato, and Toeroek[22] looked at the contamination of home environment for released patients. They followed the households of seven patients with 17 household members. The internal thyroid dose equivalent of all the household members was computed based on thyroid activity in

[18] U.S. Nuclear Regulatory Commission, *Consolidated Guidance About Material Licenses: Program-Specific Guidance About Medical Use Licenses*, Washington, DC: U.S. Nuclear Regulatory Commission; NUREG-1556; Volume 9 (Revision 2); 2008.
[19] Nuclear Regulatory Commission, "Release of Patients Administered Radioactive Materials", Regulatory Guide 8.39, 1997.
[20] A. Brodsky, "Resuspension Factors and Probabilities of Intake of Material in Process (or 'Is 10-6 a Magic Number in Health Physics?'), *HP* 39, 991–1000 (1980).
[21] D. North, "Uptake Of ^{131}I In Households Of Thyroid Cancer Patients," *Health Physics*, 104, 434–436 (2013).
[22] A. P. Jacobson, P. A. Plato, and D. Toeroek, "Contamination of the Home Environment by Patients Treated with Iodine-131: Initial Results," *American Journal of Public Health* 68, 225–230 (1978).

the individuals. A back calculation of the resulting iodine intakes for the household members using the most conservative dose coefficients for thyroid dose from water ingestion yielded no household members with an activity intake greater than 10^{-5} of the patient administered activity. They also reported that in the majority of cases, the external exposures to individuals exceeded the internal thyroid dose equivalents significantly.

Grundel, Kopka, and Schulz[23] performed measurements of the exhaled breath of patients who were administered ^{131}I to treat thyroid autonomy, hyperthyroidism, and thyroid cancer (ablation) out to 22 days. The administered activities of the patients in the study ranged from 200–10,000 MBq of ^{131}I. They made a conservative estimate of the dose based on the concentration of ^{131}I in a 30 m^3 room volume with a ventilation rate of 0.3 air changes per hour and chose the product of their measured exhalation and effective half-life to obtain their dose estimates. They reported committed effective doses of 765 μSv and <100 μSv for a child and adult relatives, respectively.

5.1 INTERNAL DOSE TO HOTEL HOUSEKEEPER

To avoid exposing household members, often patients check into hotels after ^{131}I administration and stay for a period of time. It is assumed that the maximally exposed employee at a hotel would be the housekeeper who cleans the room. The following internal intake pathways were considered in the conservative estimate of internal dose to the housekeeper in this report:

- Inhalation of contaminated air resulting from exhalation and other means of ^{131}I release from the patient and bedsheets in the room volume. Two options were included in this scenario:
- The patient leaves the room while the housekeeper is cleaning.
- The patient remains in the room while the housekeeper is cleaning. This is an unlikely but would produce the maximum air concentration.
- The housekeeper inhales a puff release of ^{131}I that occurs when the bedding is removed.
- The housekeeper has an internal ^{131}I uptake due to dermal intake as a result of contacting the toilet seat with a portion of the forearm.

5.1.1 Housekeeper/Hotel Model Parameters

There would be an air concentration in the room, which follows the model presented for the household member with some different parameter values. In the hotel room proper, the air concentration would be driven by the same ^{131}I release avenues that were used in the household member inhalation scenario. In addition, there could be inhalation of contaminated air in the bathroom portion of the room.

A typical hotel room consists of 300–400 square feet of floor space[24], and a typical hotel bathroom would be on the order of 80–90 square feet. To maximize the air concentrations in this analysis, the smaller square footages will be used. As previously mentioned, the model for the household member's inhalation dose applies for inhalation by the hotel cleaning person, after adjustment for room size and exposure time. The room and the bathroom will be assumed to have 8 ft ceilings.

[23] M. Grundel, B. Kopka and R. Schulz, "^{131}I Exhalation by Patients Undergoing Therapy of Thyroid Diseases," *Radiation Protection Dosimetry* 129, 435–438 (2008).
[24] Dimensions Info, Hotel Room Size, http://www.dimensionsinfo.com/hotel-room-size/

It is assumed that the hotel room is cleaned 24 hr after the administration of the ^{131}I treatment. A reasonable cleaning time per room is 30 minutes[25]. It seems reasonable that 10 minutes of that time is spent cleaning the bathroom. The time spent in the room by the cleaning person will be partitioned to be 20 minutes for cleaning the room and 10 minutes for cleaning the bathroom.

Air changeover rate should in general be a minimum of 4 per hr based on The Engineering Toolbox[26]. That Toolbox further states that for night home cooling, the air changeover rate ranges from 10 to 18. Larger values of the air change rate in a room would lead to lower concentrations of ^{131}I in the room, so to be conservative, the general minimum of 4 hr^{-1} was selected. Ibis et al.[27] reported mean air concentrations of 0.23 mBq/ml of air in the room for a treatment dose of 11.1 GBq. The air concentrations in that paper would have been useful in this study except for the omission of the room air volume; the air exchanges per day were 190, which are much higher than the rates used in this study and would have resulted in a much lower air concentration.

In the dermal absorption dose computation, a toilet seat that is roughly elliptical with inner major and minor axes 14.25 and 8.25 in., respectively, and outer major and minor axes of 16 and 9.825 in., respectively, was used. The toilet seat area is then 237 cm^2. The toilet seat used is shown in Figure 5-1.

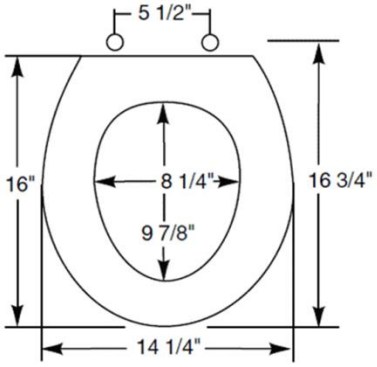


Figure 5-1. Schematic of toilet seat employed in dermal absorption dose computation.

The breathing rates for both the patient and exposed individual are assumed to be the light activity value from ICRP Publication 89, namely, 1.5 m^3/hr. The physical decay constant of ^{131}I is 3.60(10^{-3})/hr. From Federal Guidance Report 11[28], the committed effective dose coefficients are 8.89(10^{-9}) Sv/Bq and 1.44(10^{-8}) Sv/Bq for inhalation and ingestion, respectively, of ^{131}I.

5.1.2 Hotel Room Air Concentration Scenario

A very limited number of papers in the literature address the emission of ^{131}I into a room by a patient, and the ones that do tend not provide all the data that would be needed to perform sophisticated model computations. One of the most complete studies performed of the emissions of ^{131}I by patients, although

[25] Personal Communication: Ryan Hertel, Director of Finance, Midtown Atlanta W Hotel, 2014.
[26] The Engineering Toolbox, "Air Change Rates for typical Rooms and Buildings," http://www.engineeringtoolbox.com/air-change-rate-room-d_867.html, 2013.
[27] E. Ibis, C. R. Wilson, B. D. Collier, G. Akansel, A. T. Isitman, and R. G. Yoss, "Iodine-131 Contamination From Thyroid Cancer Patients, " *Journal Of Nuclear Medicine*, 33, 2110–2115 (1992).
[28] FGR11 (values taken from http://web.ornl.gov/cgi-bin/cgiwrap?user=wlj&script=fgrx.pl)

with a very small set of patients, is that of Nishizawa et al.[29] From this study, the ^{131}I air concentration can be based upon the emissions in the exhaled breath of the patient and the perspiration and evaporation from patient and materials contaminated by contact with the patient. Nishizawa et al. further reported that the maximum air release rate varied from $1.4(10^{-5})$ to $1.2(10^{-7})$ hr^{-1} of the administered activity and declined exponentially with an effective decay constant. In the present analysis, the maximum value (release fraction) was selected. They also arrived at a maximum value of 1.8% evaporation from the skin surface of the patient, which they applied to other items in the patient's room as well.

The air concentration of ^{131}I at any time after administration in the hotel room is

$$C_{air}(t) = \frac{Q_{adm}(RF)}{V_{room}\left(\lambda_{I\text{-}131} + f_r - \lambda_{eff}\right)}\left[e^{-\lambda_{eff}t} - e^{-(\lambda_{I\text{-}131}+f_r)t}\right], \tag{5-2}$$

where

f_r = air change rate, 4 hr^{-1},
λ_{131} = physical decay constant of ^{131}I, 0.0036 hr^{-1},
λ_{eff} = effective decay constant of ^{131}I (physical + biological), 0.55 day^{-1},
Q_{adm} = administered activity (Bq),
RF = maximum release fraction per hour of administered activity, $1.4(10^{-5})$ $Bq/(Bq_{adm}\text{-}hr)$, and
V_{room} = hotel room volume, 68 m^3.

The effective decay constant of ^{131}I varies widely in value in the available literature. Several were investigated, but the value of 0.55 days was selected and is the average value for two patients treated after removal of their thyroid for thyroid cancer in Grundel et al.[30] This leads to the largest room concentrations of the justifiable values available in Grundel et al. and Nishizawa et al.

If the patient leaves the room during cleaning, committed effective dose to the housekeeper from inhaling contaminated air in the room for 30 minutes, 24 hr after the patient has undergone the ^{131}I administration, is

$$CED_{exit} = \frac{C_{air}(24)\times DC\times BR_{Housekeeper}}{\left(\lambda_{I\text{-}131} + f_r\right)}\times \left[1 - e^{-(\lambda_{I\text{-}131}+f_r)0.5}\right] \quad . \tag{5-3}$$

In this case, the concentration is assumed to merely decay and be removed by the ventilation system during the cleaning.

In the case where the patient remains in the room while it is being cleaned, the committed effective dose becomes

[29] K. Nishizawa, K.Ohara, M.Ohshima, H. Maekoshi, T. Orito and T. Watanabe, "Monitoring of I Excretions and Used Materials Of Patients Treated with ^{131}I," *Health Physics,* 38, 467–481 (1980).
[30] M. Grundel, B. Kopka, and R. Schulz, "^{131}I Exhalation by Patients Undergoing Therapy of Thyroid Diseases," *Radiation Protection Dosimetry*, 129, 435–438 (2008).

$$CED = \frac{Q_{adm}\left(RF\right)BR_{Housekeeper}DC}{V_{room}\left(\lambda_{I\text{-}131} + f_r - \lambda_{eff}\right)} \times \left[\frac{e^{-\lambda_{eff}(24)} - e^{-\lambda_{eff}(24.5)}}{\lambda_{eff}} + \frac{e^{-(\lambda_{I\text{-}131}+f_r)24.5} - e^{-(\lambda_{I\text{-}131}+f_r)24}}{\lambda_{I\text{-}131} + f_r}\right] . \quad (5\text{-}4)$$

This case would be rather unusual but was used to maximize the air concentration by leaving the patient in the room.

In both of these equations, $BR_{housekeeper}$ is the breathing rate of the housekeeper, and DC is the dose coefficient for inhalation previously given.

5.1.3 Hotel Room Air Puff Scenario

In this computation, which again occurs 24 hr after administration of the ^{131}I to the patient, the housekeeper changes the sheets and a puff of ^{131}I from the movement of the sheets is inhaled. Nishizawa et al.[31] reported contamination levels of sheets and coverlet as a function of time in their paper. Their study observed a maximum value 3.5(10^{-4}) of the administered activity was on a sheet 24 hr after administration. They further observed a maximum value of 1.3(10^{-4}) of the administered activity after 24 hr on the coverlet.

Assuming two sheets and one coverlet per bed, a maximum value of 8.3(10^{-4}) of the administered activity is available for the puff. The most conservative method is to assume that 10^{-5} fraction of this activity is inhaled by the housekeeper. When multiplied by the dose coefficient for inhalation, the committed effective dose for the puff scenario is obtained:

$$CED_{puff} = 10^{-5}\left[8.3(10^{-4})Q_{adm}\right]DC . \quad (5\text{-}5)$$

5.1.3.1 Dermal Intake Scenario

Achey et al.[32] reported a high ^{131}I contamination level on the toilet seat as have other papers reporting room contamination (Figure 5-2). It is not unreasonable to assume contact will be made with the toilet seat by the housekeeper, resulting in a dermal uptake. For this scenario, it is assumed that the housekeeper is wearing gloves and that the bare forearm makes contact with the seat when the toilet is being cleaned. The following parameters and assumptions are used, most of them conservative overestimates:

- The contamination is 100% removable and adheres to the skin of the housekeeper.
- The absorption of ^{131}I at a rate of 0.008% per cm^2 of contact area per hour is taken in through the skin.[33]
- The forearm area that contacts the toilet seat is based on the concentric elliptical model of the seat previously presented and the width of the arm of one of the authors (Hertel) at mid-forearm,

[31] K. Nishizawa, K.Ohara, M.Ohshima, H. Maekoshi, T. Orito and T. Watanabe, "Monitoring Of I Excretions And Used Materials Of Patients Treated With ^{131}I," *Health Physics*, 38, 467–481 (1980).
[32] B. Achey, K. Miller, M. Erdman, and S. King, "Some Experiences with Treating Thyroid Cancer Patients," *Operational Radiation Safety*, 80 Supp. 2: S62–S66 (2001).
[33] J. Harrison, "The Fate of Radioiodine Applied to Human Skin," *Health Physics* 9, 993–1000 (1963).

10.16 cm. Furthermore, it is assumed that a single contact is made. The resulting arm contact area is then 77 cm^2.

- The housekeeper is assumed to wash off any remaining activity 4 hr after the contact was made.

To complete this computation, a contamination level for the toilet seat is required. Some data exist in the literature that helps quantify the ^{131}I contamination in the bathroom. These data are based on hospital room experiences, but they will be used in assessing the amount of contamination that the cleaning person may encounter in the hotel room bathroom. Based on the data from three male patients, Ibis et al.[34] reported a mean removable contamination of 1880 Bq/cm^2 from the toilet seat.

Achey et al.[35] further reported on the contamination levels of 50 hospitalized thyroid cancer treatment patients. Room contamination levels were reported in this paper post-discharge. The levels were reported in dpm of activity on various items. Of interest is that the contamination level has no correlation with administered activity, and there is no obvious correlation with sex. It is apparent from this study that personal habits influence contamination levels much more than administered dose or the sex of the patient.

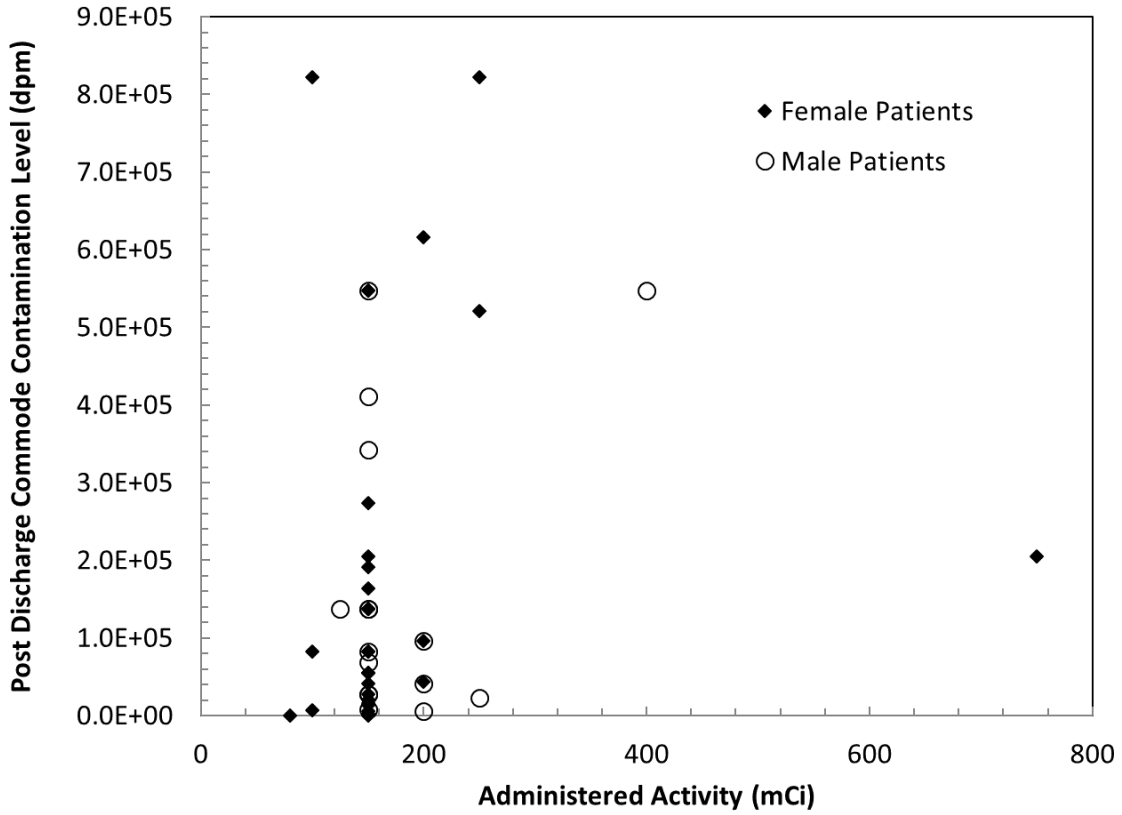


Figure 5-2. Commode contamination levels as a function of administered activity from Achey et al.

[34] E. Ibis, C. R. Wilson, B. D. Collier, G. Akansel, A. T. Isitman and R. G. Yoss, "Iodine-131 Contamination From Thyroid Cancer Patients, *" Journal Of Nuclear Medicine* 33, 2110–2115 (1992).
[35] B. Achey, K. Miller, M. Erdman, and S. King, "Some Experiences with Treating Thyroid Cancer Patients," *Operational Radiation Safety* 80 Supp. 2: S62–S66 (2001).

Although the Achey et al. paper does not refer to the levels as removable contamination, it is assumed that they were "contact" measurements of the contaminated surfaces with a pancake probe. Based on a review of data for the Ludlum Model 44-9 pancake probe and the GSM-115-HP pancake probe, the sensitive area for a pancake probe is approximately 15 cm^2. The measured contamination is assumed to be measured over an area of 15 cm^2, the field of view of the instrument in contact with a surface. It is reasonable to assume that the probe is approximately 1 cm above the surface being measured, which makes this assumption conservative as an area greater than 15 cm^2 would be seen by the probe. The maximum dpm reported by Achey et al. is converted into 911 Bq/cm^2 of ^{131}I activity, and the mean value is converted to 193 Bq/cm^2. The maximum value will be used in the following computation.

Since these values cover a wide range of possible activities, the internal committed effective dose was computed using all three values. In keeping with the methodology outlined by Harrison[36], the committed effective dose for the dermal pathway is computed by

$$E = \left[A_{contact} \times C_{I-131} \times UF \times 4hrs \right] DC_{ingestion} \ , \qquad (5\text{-}6)$$

where

$A_{contact}$ = skin contact area, 77 cm^2,
$C_{I\text{-}131}$ = skin concentration of ^{131}I (Bq/cm^2), and
UF = skin uptake factor, 0.008% cm^{-2} hr^{-1}.

Using the maximum value in the Hershey study, 23 Bq would be absorbed through the skin on of the housekeeper.

5.2 RESULTS AND CONCLUSIONS

Using a 7 GBq administration activity for cancer patients and 1.1 GBq for hyperthyroidism patients, the resultant doses to a housekeeper in a hotel are shown in Table 5-1. Based on conservative estimates for estimating the internal committed effective dose to housekeepers in hotels from released patient, the housekeeper would

- have to clean approximately 670 contaminated rooms to have a committed effective dose that exceeded 100 mrem and
- have to clean more than 3300 contaminated rooms to exceed 500 mrem.

The dose to housekeepers is extremely low even when conservative estimates of contamination levels are considered. Furthermore, one of the authors of the Achey et al. study[37,38] indicated that most of this activity in the rooms at Hershey Medical Center comes from hair shed by the patient. He further stated that they had not observed ^{131}I contamination in the people working in the medical center. This seems to confirm the low dose estimate for the hotel housekeeper scenario.

[36] J. Harrison, "The Fate of Radioiodine Applied to Human Skin," *Health Physics* 9: 993–1000 (1963).
[37] Personal Communication: Steven King, Director of Health Physics, Hershey Medical Center, 2014.
[38] B. Achey, K. Miller, M. Erdman, and S. King, "Some Experiences with Treating Thyroid Cancer Patients," *Operational Radiation Safety* 80 Supp. 2: S62–S66 (2001).

Table 5-1. Dose to hotel housekeeper (maximum toilet contamination level)

Pathway	Patient	Committed Effective Dose (mrem)
Breathing Contaminated Air	Cancer patient Hyperthyroidism	0.07 0.03
Bedding Puff Release	Cancer patient Hyperthyroidism	0.05 0.01
Skin Absorption	Either	0.03
Total Estimate	Cancer patient Hyperthyroidism	0.15 0.07

6. SUMMARY AND CONCLUSIONS

To protect individuals from the radiation emitted by a patient receiving ^{131}I treatment, a licensee must estimate the maximum likely effective dose to members of the public. Under current NRC guidance, a licensee may authorize the release of the patient if the effective dose is unlikely to exceed 5 mSv[39].

Current NRC guidance provides three numerical release criteria that would allow the release of the patient if any one of these criteria is met. First, the patient may be released if the administered activity is below a radionuclide-specific activity estimated to correspond to a maximum effective dose of 5 mSv to exposed persons, which for ^{131}I is 2.4 GBq. Second, the patient may be released if the measured dose rate at 1 meter is less than 0.02 mSv/hr. Third, the patient may be released if defensible calculations by the licensee indicate that the maximum dose likely to be received by any exposed member of the public is less than 5 mSv.

If the third criterion is used, the licensee may consider an occupancy factor, effective half-life of the radionuclide in the patient's body, tissue shielding, and other dose-modifying factors. A conservative method of calculating the maximum likely dose to members of the public is provided in NRC Regulatory Guide 8.39. This approach assumes that there is no tissue attenuation of penetrating radiations by the patient's body, there is no biological component that reduces the effective half-life of the radionuclide, and the patient's body burden is a point source.

The present report provides dose coefficients for a variety of plausible exposure scenarios that could be used by licensees to determine whether the third criterion is met. The scenarios address three general situations in which exposures to the public may occur: public transportation, nursing homes, and hotels. Different relative positions of the ^{131}I patient and exposed individual were considered for each general type of scenario. The distribution of ^{131}I in the patient was predicted using a recently published biokinetic model for iodine[40]. To simplify external dose calculations, activity in the body was divided into the two primary repositories for iodine, i.e., the thyroid and urinary bladder contents, plus a third pool representing the remainder of iodine in the body. For each physical exposure scenario, different thyroid conditions were considered (DTC, normal, and hyperthyroid) in conjunction with different urine voiding patterns (first-order, voiding at specified time intervals such as every 4 hr, and a single voiding at a specified time after administration and no further voiding). External dose rates and cumulative (effective) dose estimates were derived for each physical scenario, thyroid condition, and voiding pattern using the ORNL/NRC phantom PIMAL, together with the Monte Carlo radiation-transport code MCNP6.

The results of the analysis[41,42] indicate that the method of dose calculation prescribed in NRC Reg. Guide 8.39 typically overestimates the external dose rate to the exposed person by a factor of 2 and often much more. For example, in the public transportation scenario in which the patient and exposed person are standing face-to-face at a distance of 1 m, our methods indicate a dose rate to the exposed person of $2.5(10^{-5})$ mSv/MBq-hr. In comparison, the NRC method predicts a dose rate of $5.22(10^{-5})$ mSv/MBq-hr, or slightly greater than twice our estimated value. Our conclusions regarding the degree of conservatism of the NRC method is reasonably consistent with findings of several other investigators.

[39]Nuclear Regulatory Commission, "Release of Patients Administered Radioactive Materials," Regulatory Guide 8.39, 1997.
[40]R. Leggett, "A physiological systems model for iodine for use in radiation protection," *Radiation Research,* 174: 496–516.
[41] Dewji, Shaheen Azim, Michael Bellamy, Nolan Hertel, Richard Leggett, Sami Sherbini, Mohammad Saba, and Keith Eckerman. 2015. "Assessment of the Point-Source Method for Estimating Dose Rates to Members of the Public from Exposure to Patients with ^{131}I Thyroid Treatment." *Health Physics* 109 (3):233–241.
[42] Dewji, S., Bellamy, M., Hertel, N., Leggett, R., Sherbini, S., Saba, M., & Eckerman, K. (2015). "Estimated dose rates to members of the public from external exposure to patients with ^{131}I thyroid treatment," *Medical Physics*, *42*(4), 1851–1857.

For example, recent work carried out at King Faisal Hospital and Research Center[43] compared measured dose rates at 1 m from patients with the computed dose rate using the dose rate constants for ^{131}I. The patients were grouped into age groups and sexes. The ratios of the measured dose rates to those computed with the point source model when averaged over all cases yielded an average body shielding factor of 0.46 ± 0.13 for the 311 patients considered. There was no obvious trend by age, and the average for all females and males were 0.45 ± 0.13 and 0.50 ± 0.12, respectively.

Similarly, Siegel et al.[44] reported a comparison between theoretical dose rates at 1 m calculated by using the dose equivalent constant for ^{131}I and the infused activity and compared the values to measured dose rates for 139 patients. The mean observed dose rate was on average 60% of the theoretical dose rate and ranged from 37% to 90% of the theoretical value.

Finally, Yi et al.[45] reported a comparison of measured and theoretical dose rates computed with point source and line source representations of administered ^{131}I. For thyroid cancer patients, they reported a mean ratio calculated to measured exposure rate at 1 m of 1.79 ± 0.54 using a point source representation. This corresponds to a shielding factor of 0.56 for the measured dose rates compared to the point source calculation. The range of values observed for the calculated-to-measured rates ranged from 0.82 to 4.13, corresponding to shielding factors of 1.18 and 0.24, respectively.

A conservative estimate of the internal committed effective dose that a housekeeper might receive in the cleaning of a hotel room in which a released ^{131}I patient is staying has been performed. The scenario that was established largely uses parameters that are maximum values to compute the dose. The committed effective dose computed includes inhalation from airborne contamination and skin absorption by contact with a contaminated commode. The resulting CEDE is very small compared to the other external doses to members of the public presented in this report. It supports the previous guidance of Regulatory Guide 8.39 that the principal pathway of concern for dose to the members of the public is the external irradiation pathway.

[43]Al-Haj, Abdalla N., Charlie S. Lagarde, and Aida M. Lobriguito, "Patient parameters and other radiation safety issues in ^{131}I therapy for thyroid cancer treatment," *Health Physics* 93.6 (2007): 656–666.

[44]J. Siegel, S. Knoll, D. Regan, M. Kaminski, and R. Wahl, "A Practical Methodology for Patient Release after Tositumomab and 131I-Tositumomab Therapy," *Journal of Nuclear Medicine* 43, 354–363 (2002).

[45]Y. Yi, M. Stabin, M. McKaskle, M. Shone and A. Johnson, "Comparison of Measured and Calculated Dose Rates Near Nuclear Medicine Patients," *Health Physics* DOI: 10.1097/HP.0b013e318290cc0e (posted in advance of publication on www.health-physics.com), 2013.

APPENDIX A. SUMMARY OF ALL BIOKINETIC MODELS

APPENDIX A: SUMMARY OF ALL BIOKINETIC MODELS

A.1 PUBLIC TRANSPORTATION

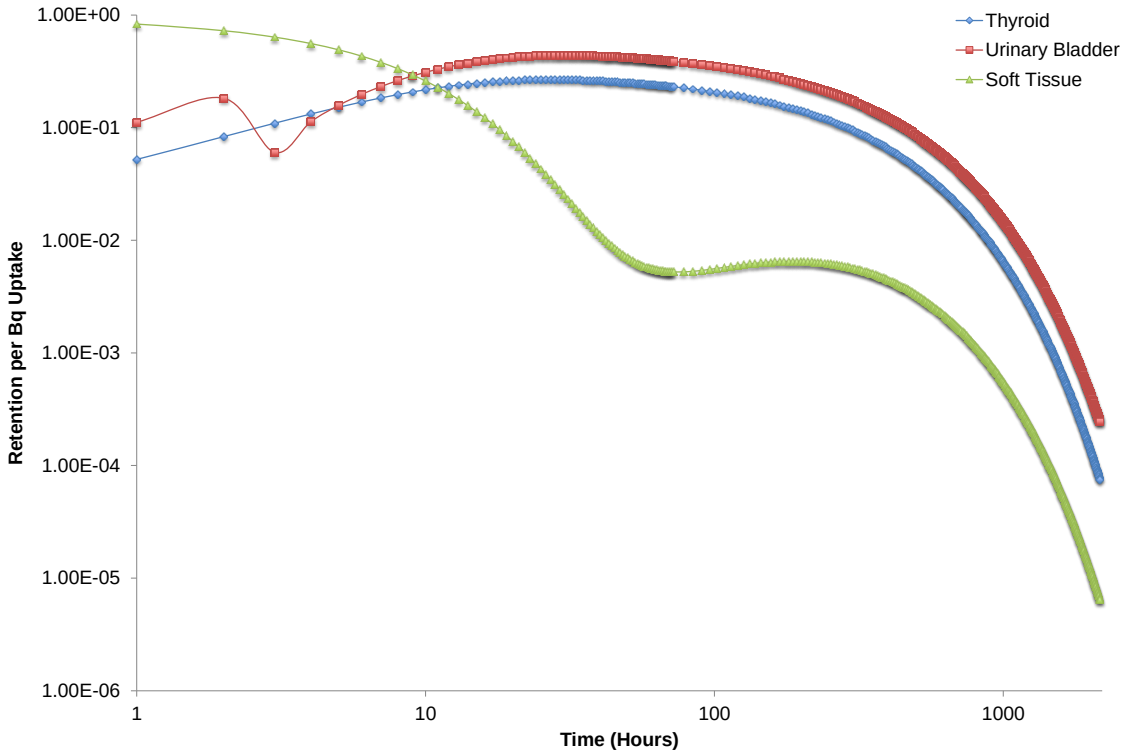


Figure A-1. Retained fraction of ^{131}I in the body assuming single void at 2 hr after administration (Normal Thyroid Uptake).

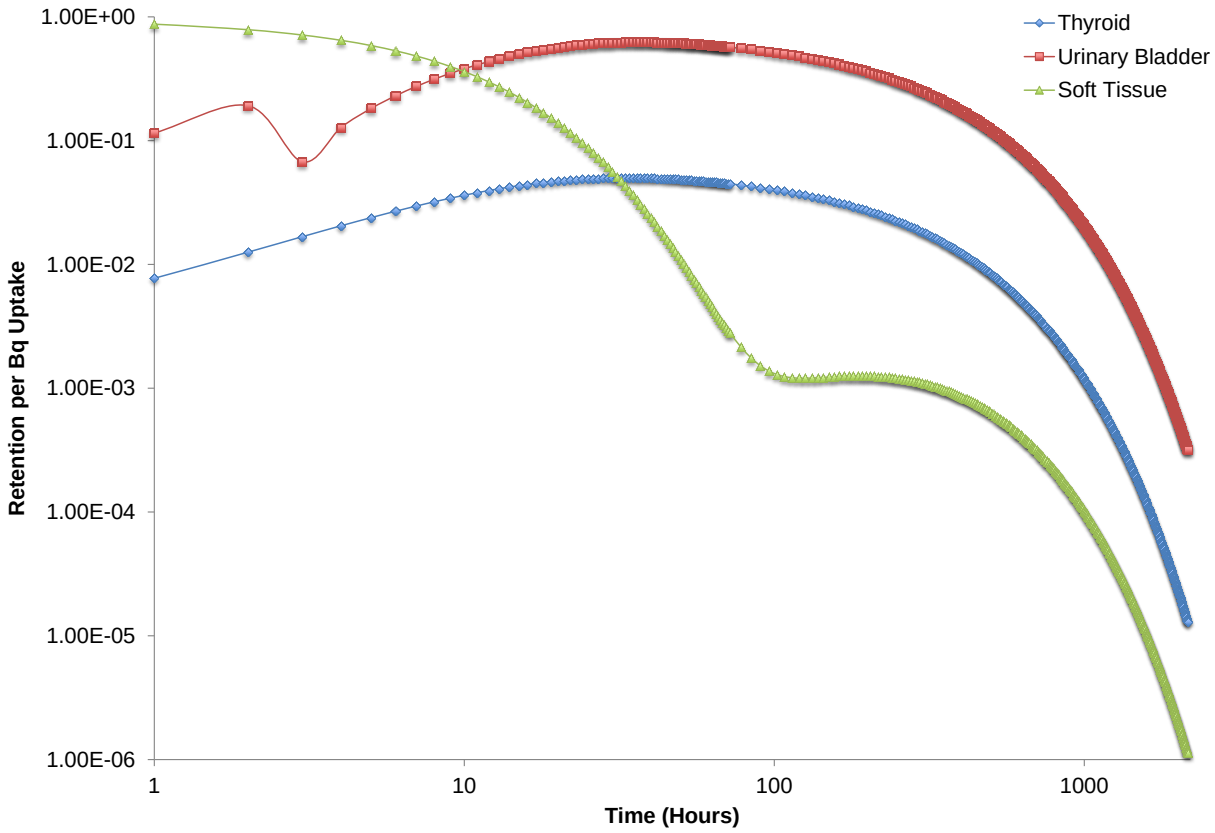


Figure A-2. Retained fraction of ^{131}I in the body assuming single void at 4 hr after administration (DTC-5% Thyroid Uptake).

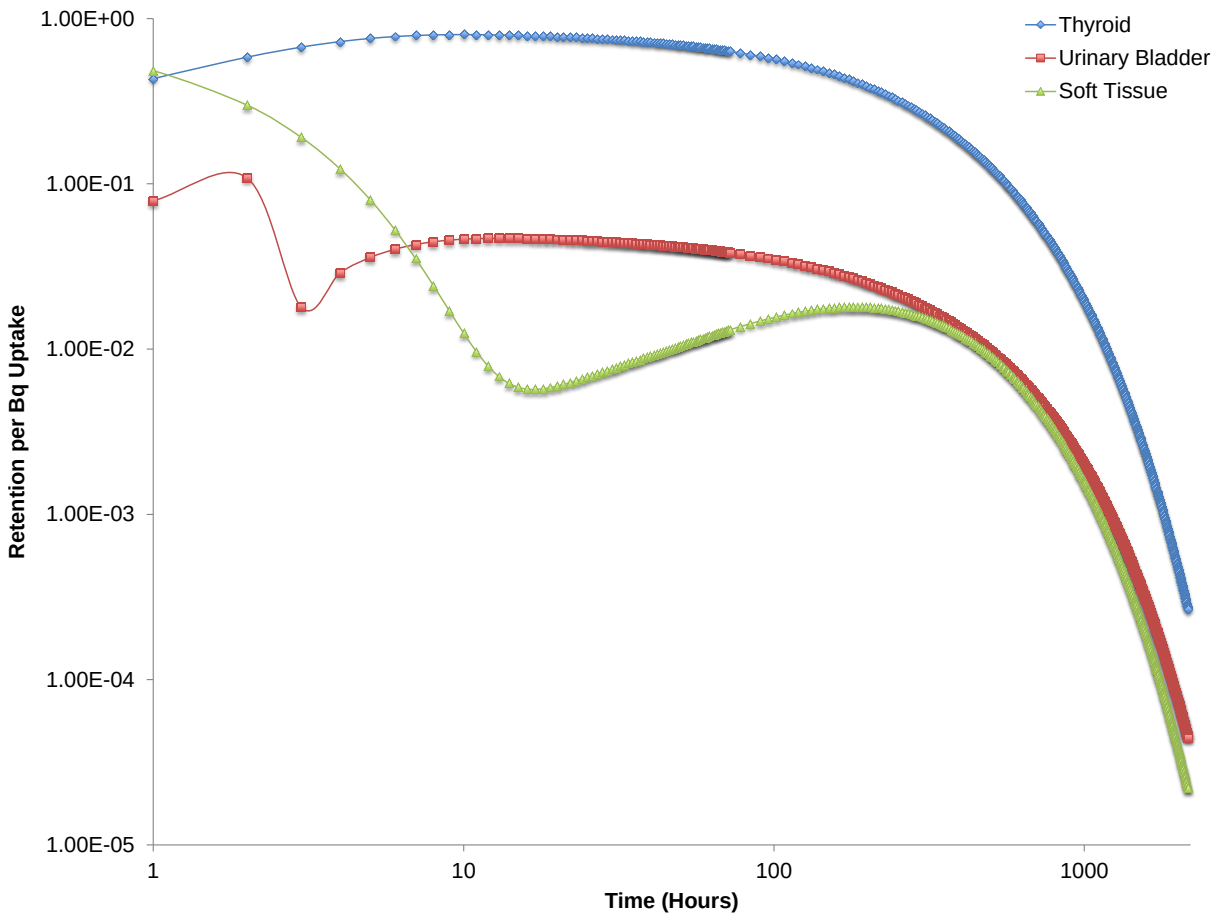


Figure A-3. Retained fraction of ^{131}I in the body assuming single void at 4 hr after administration (Hyperthyroid- 80% Thyroid Uptake).

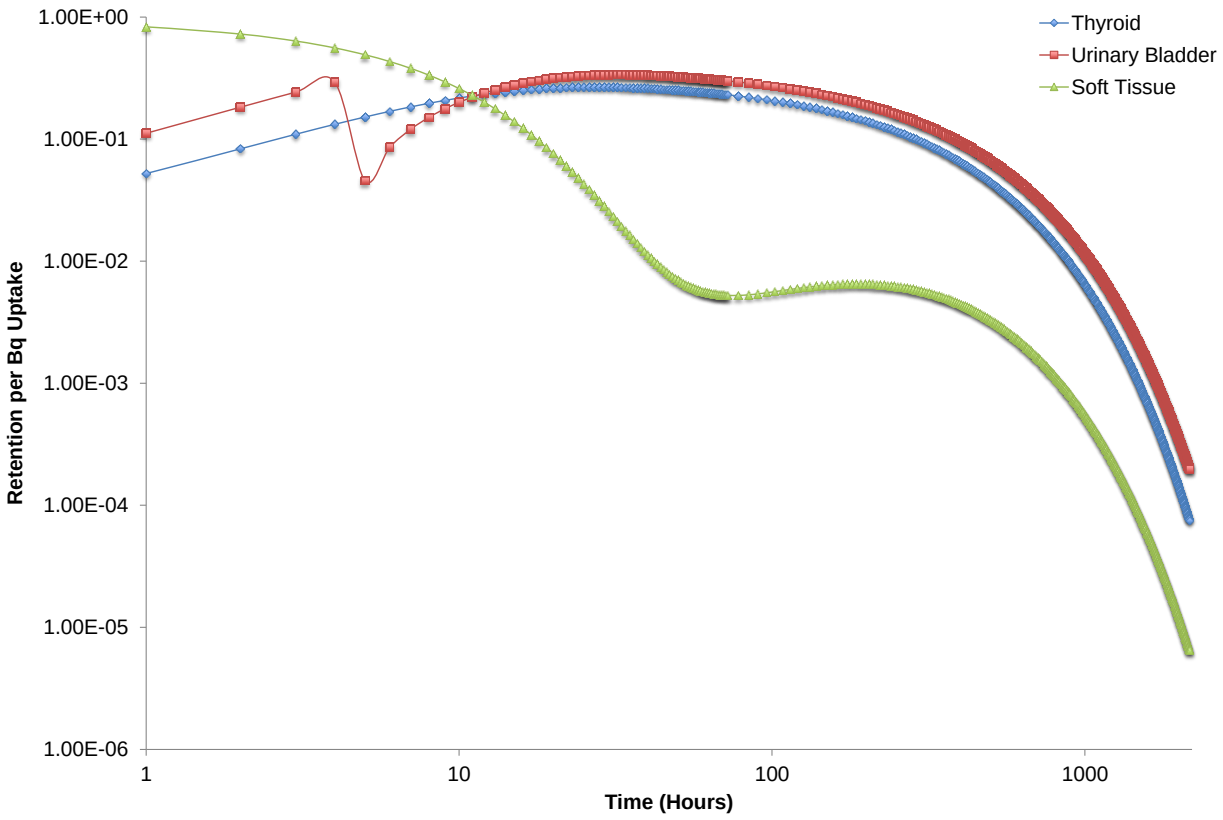


Figure A-4. Retained fraction of ^{131}I in the body assuming single void at 4 hr after administration (Normal Thyroid Uptake).

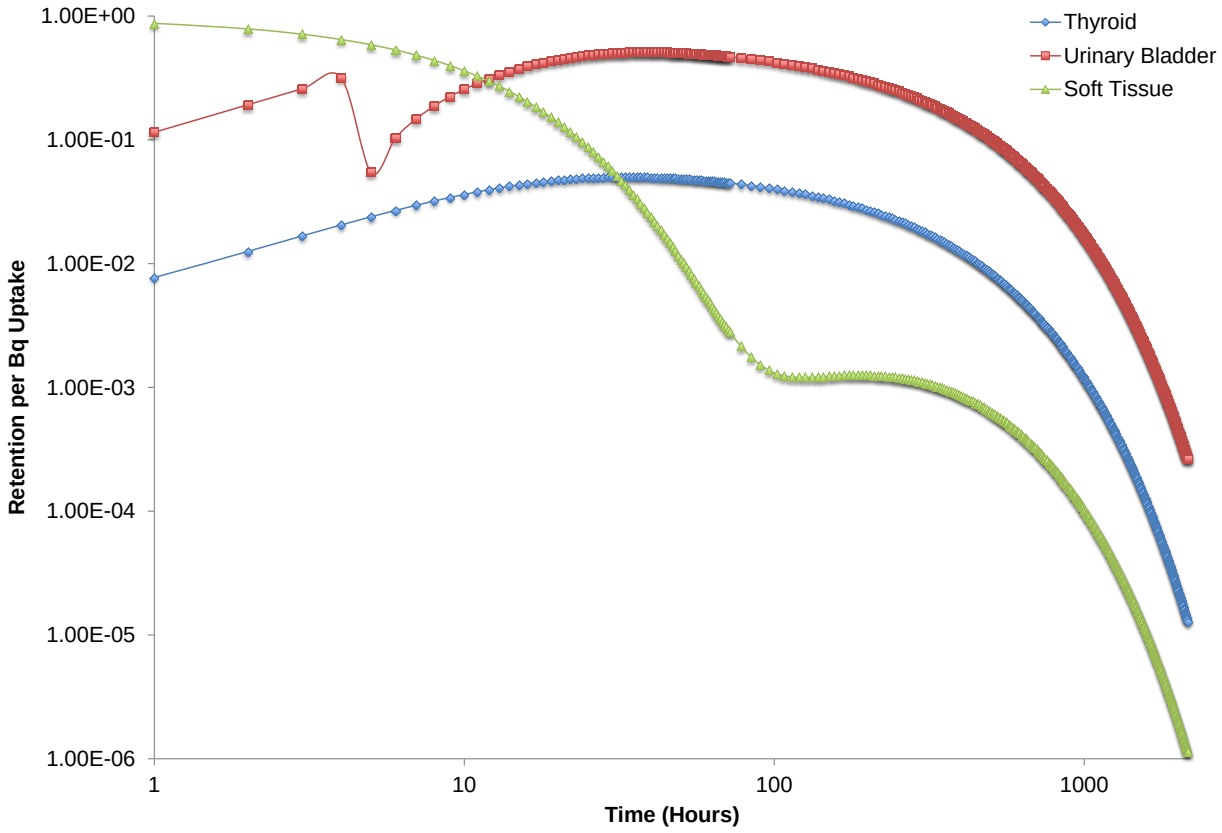


Figure A-5. Retained fraction of ^{131}I in the body assuming single void at 4 hr after administration (DTC-5% Thyroid Uptake).

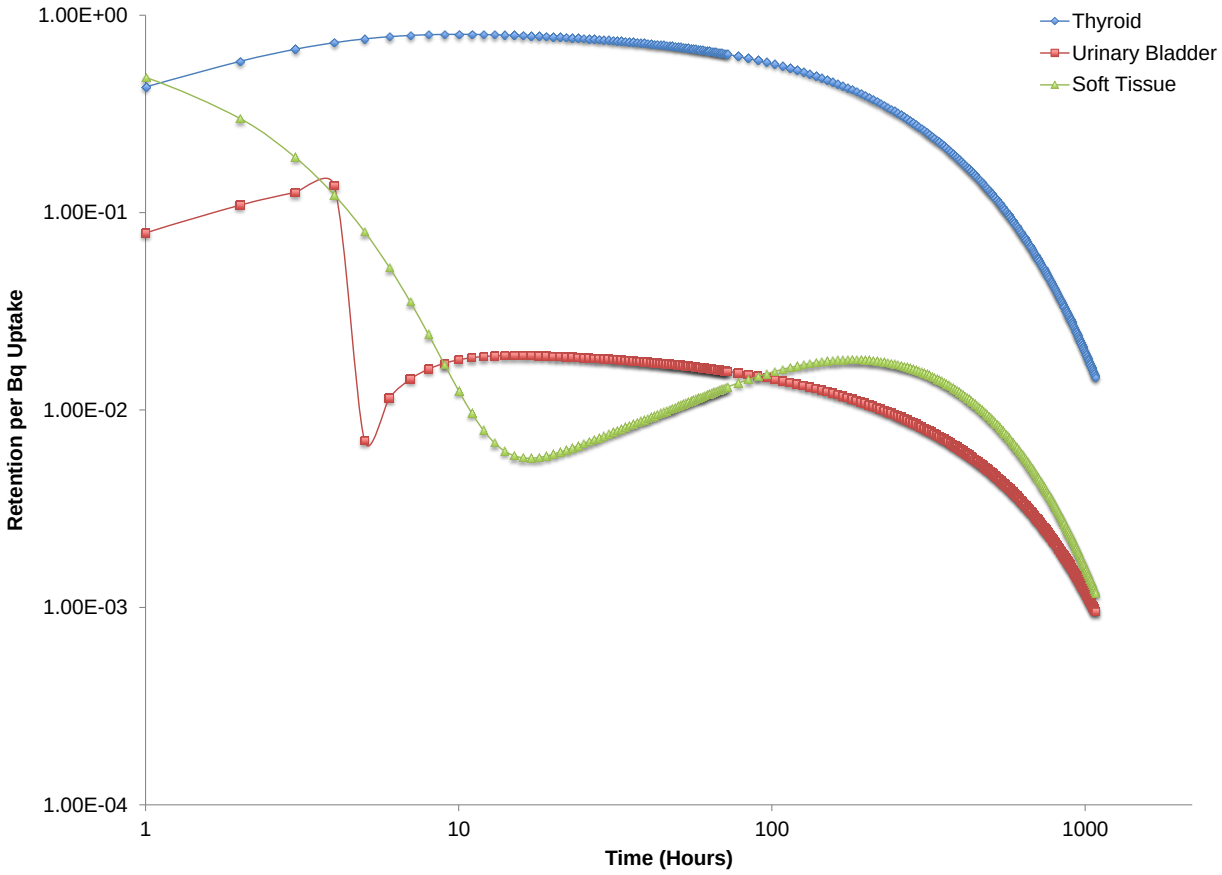


Figure A-6. Retained fraction of ^{131}I in the body assuming single void at 4 hr after administration (Hyperthyroid – 80% Thyroid Uptake).

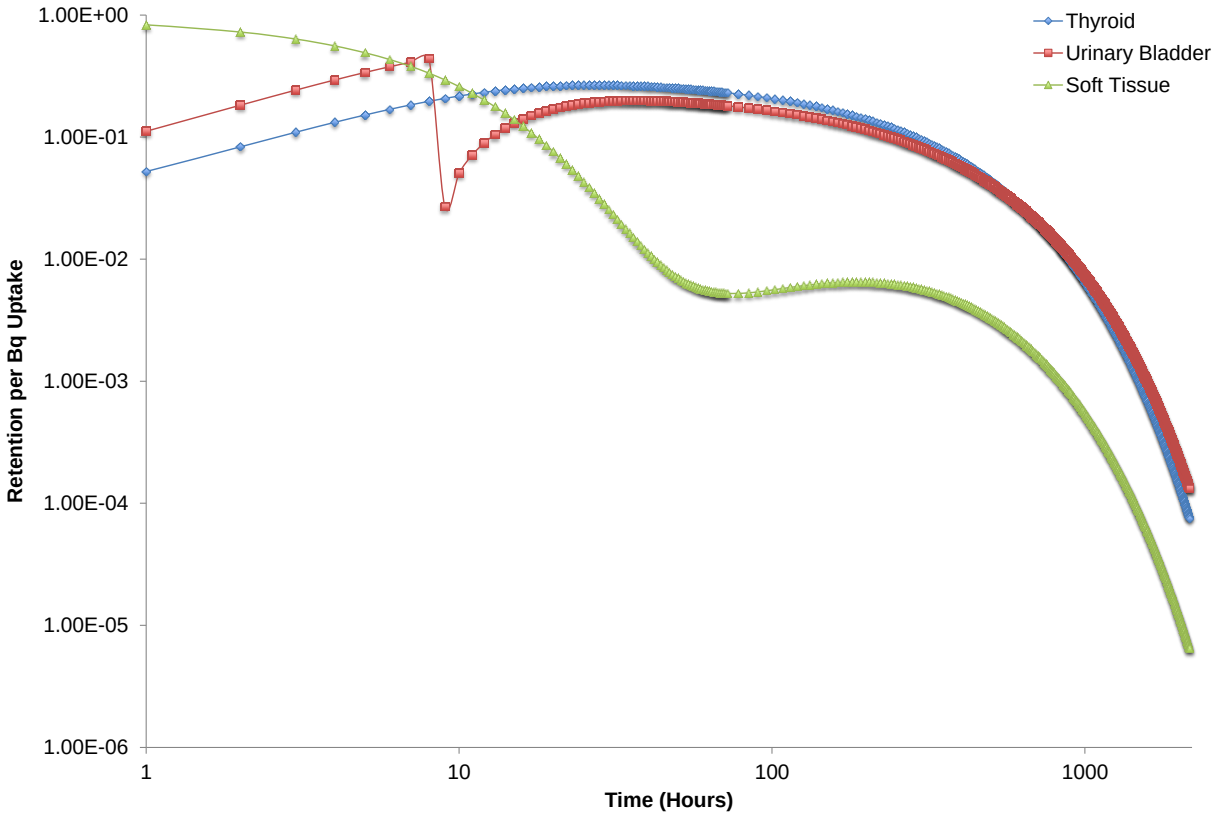


Figure A-7. Retained fraction of ^{131}I in the body assuming single void at 8 hr after administration (Normal Thyroid Uptake).

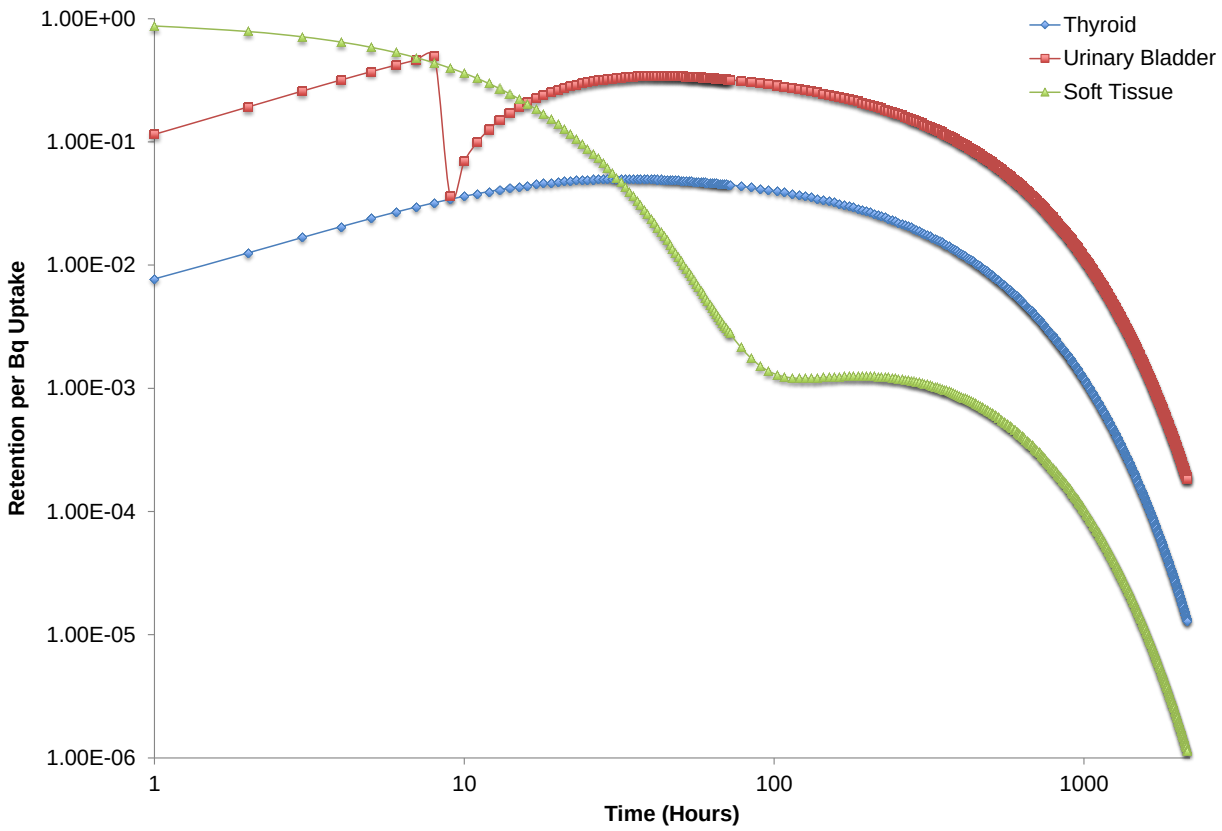


Figure A-8. Retained fraction of ^{131}I in the body assuming single void at 8 hr after administration (DTC-5% Thyroid Uptake).

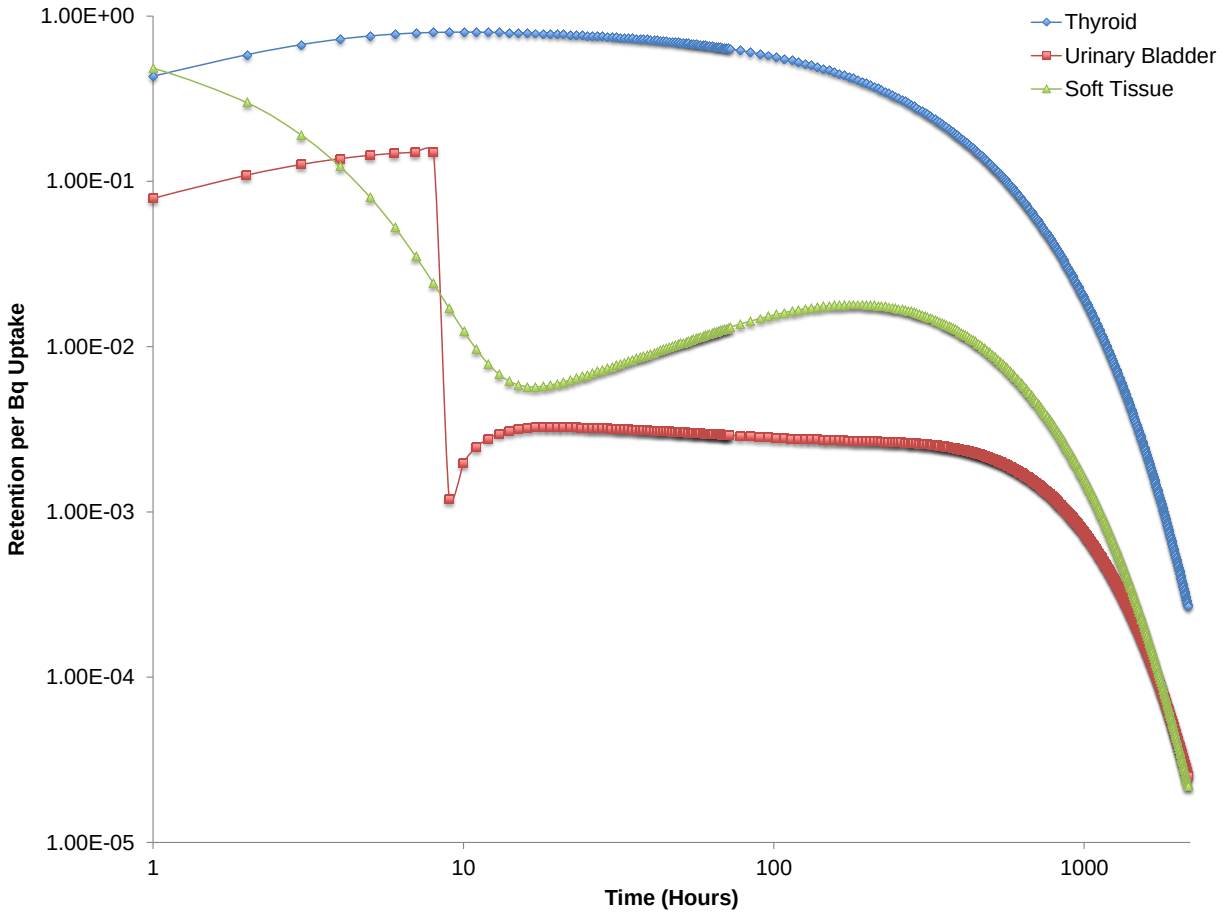


Figure A-9. Retained fraction of ^{131}I in the body assuming single void at 8 hr after administration (Hyperthyroid – 80% Thyroid Uptake).

A.2 HOME/NURSING HOME

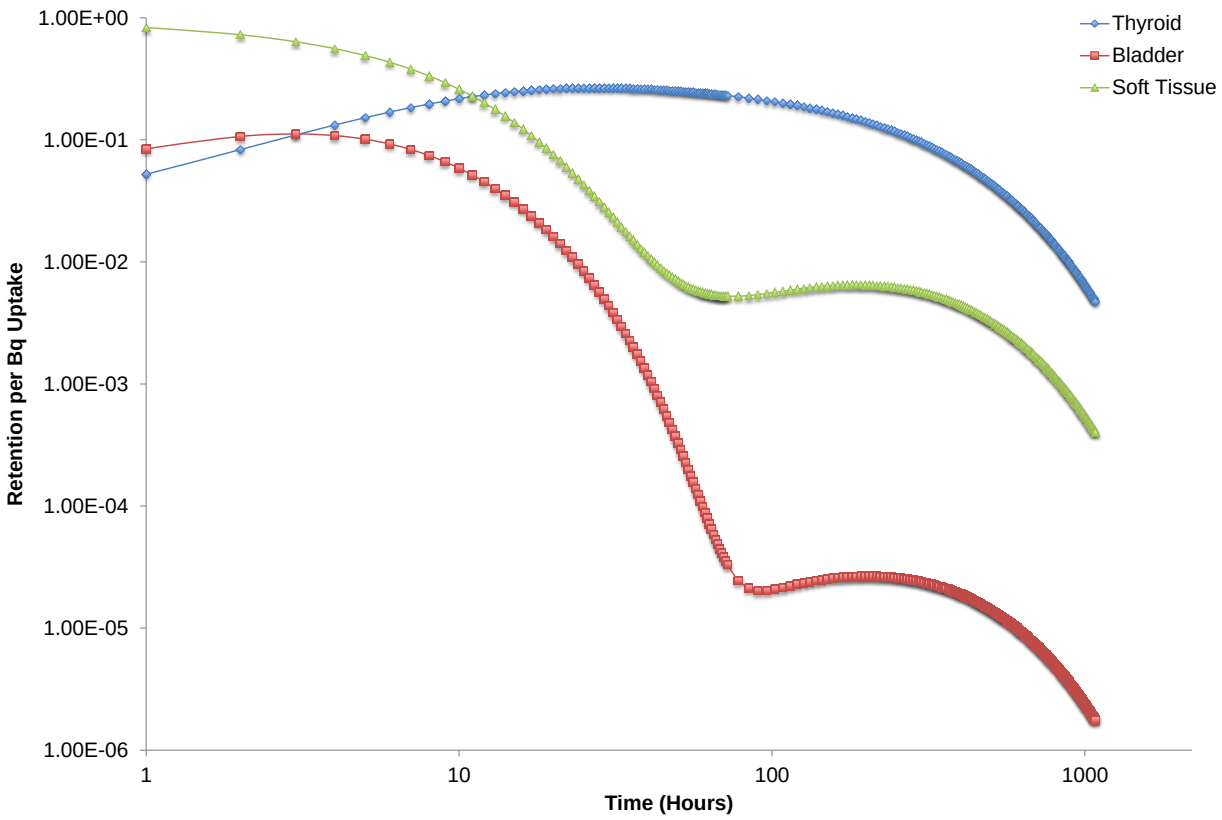


Figure A-10. Retained fraction of ^{131}I in the body as a function of time assuming a continuous voiding pattern (Normal Thyroid Uptake).

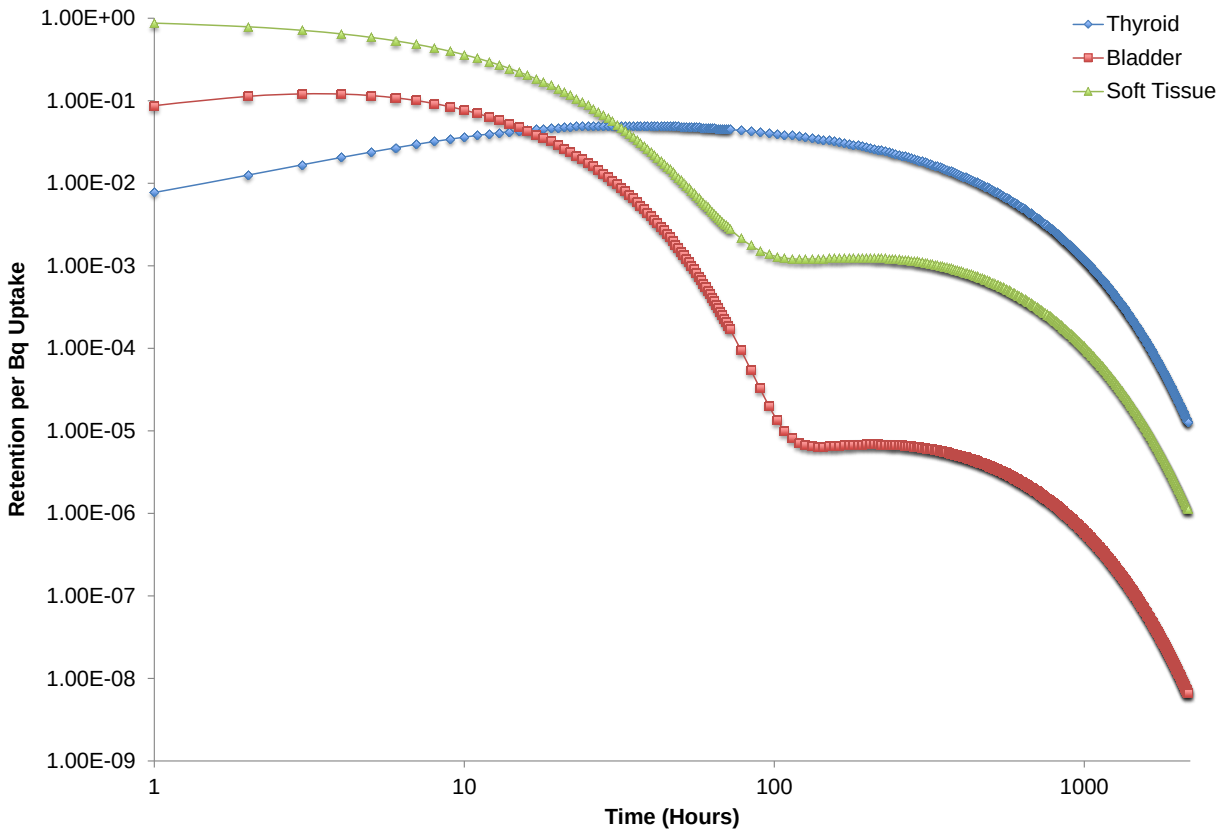


Figure A-11. Retained fraction of ^{131}I in the body as a function of time assuming a continuous voiding pattern (DTC – 5% Thyroid Uptake).

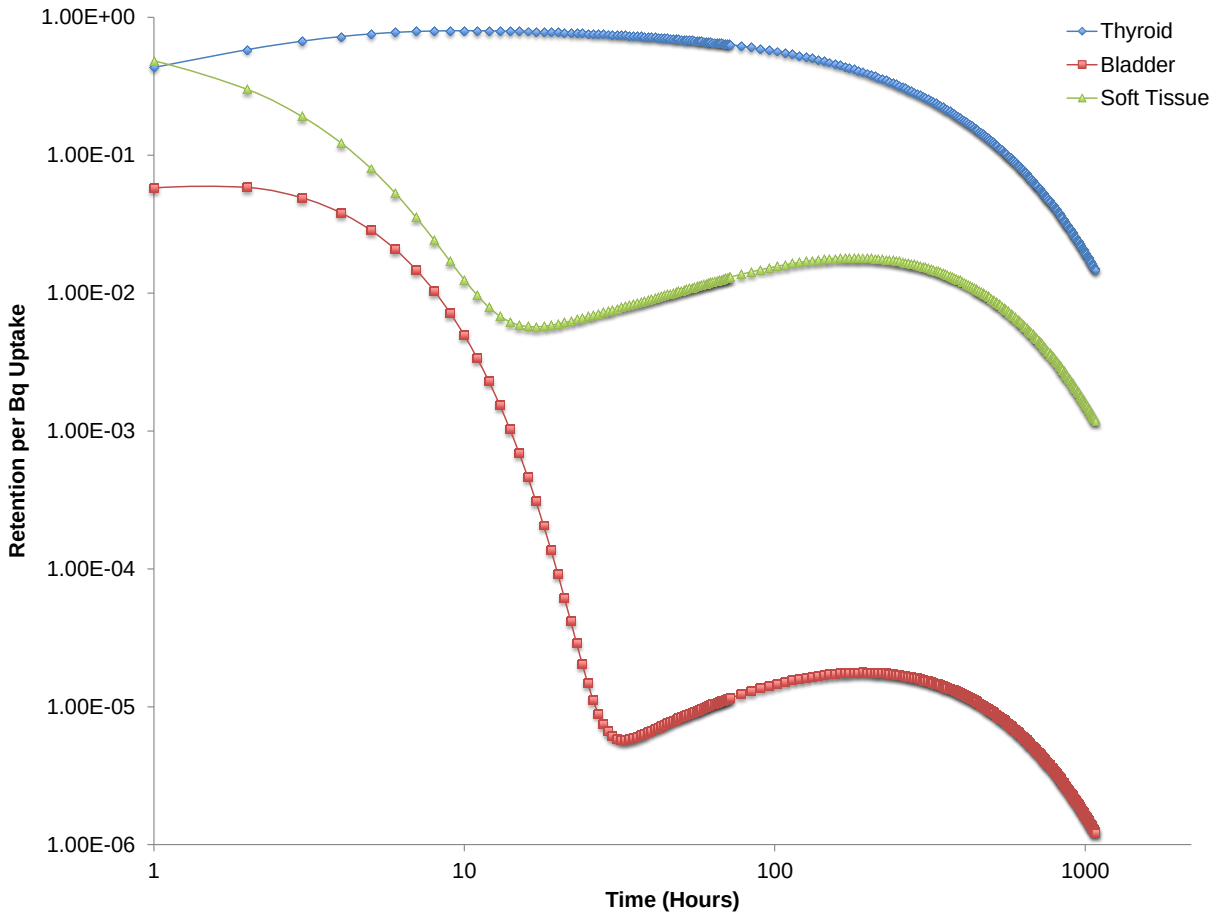


Figure A-12. Retained fraction of ^{131}I in the body as a function of time assuming a continuous voiding pattern (Hyperthyroid – 80% Thyroid Uptake).

A.3 HOTEL ROOM

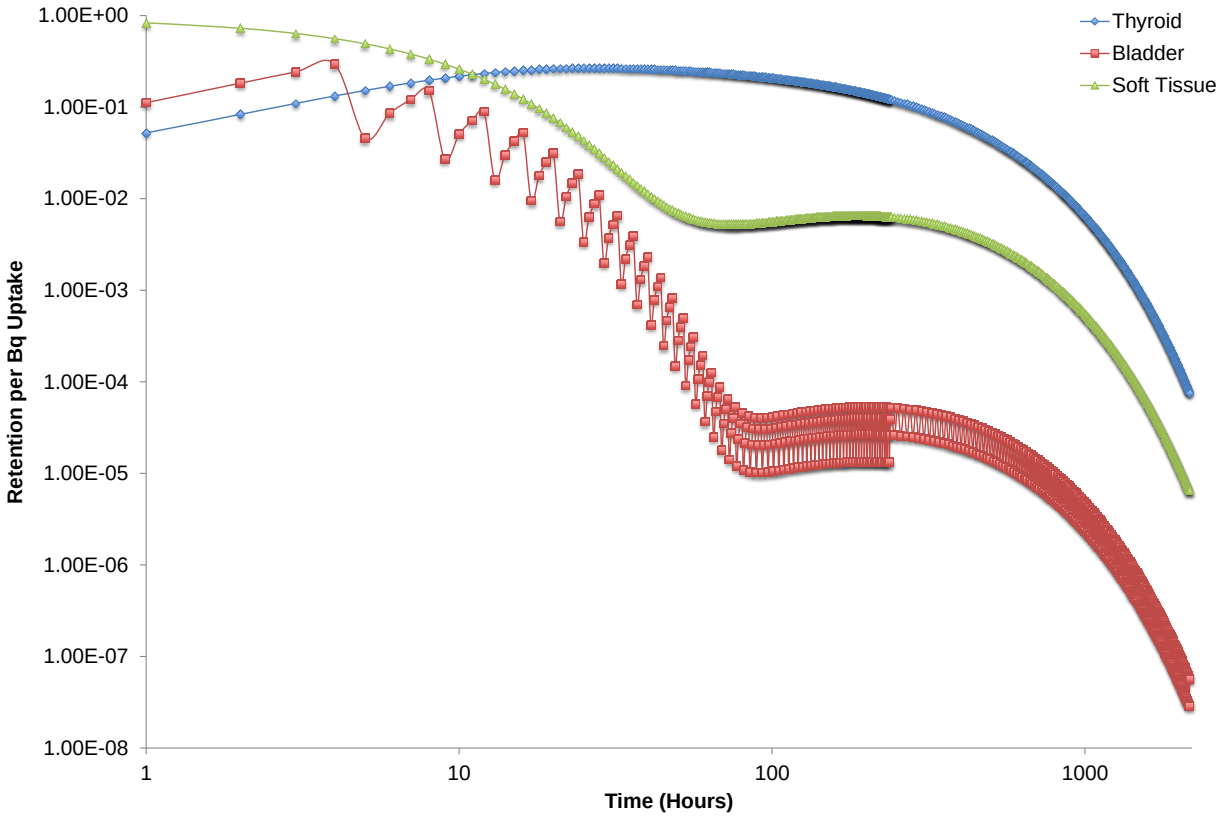


Figure A-13. Retained fraction of ^{131}I in the body as a function of time assuming a 4 hr periodic voiding pattern (Normal Thyroid Uptake).

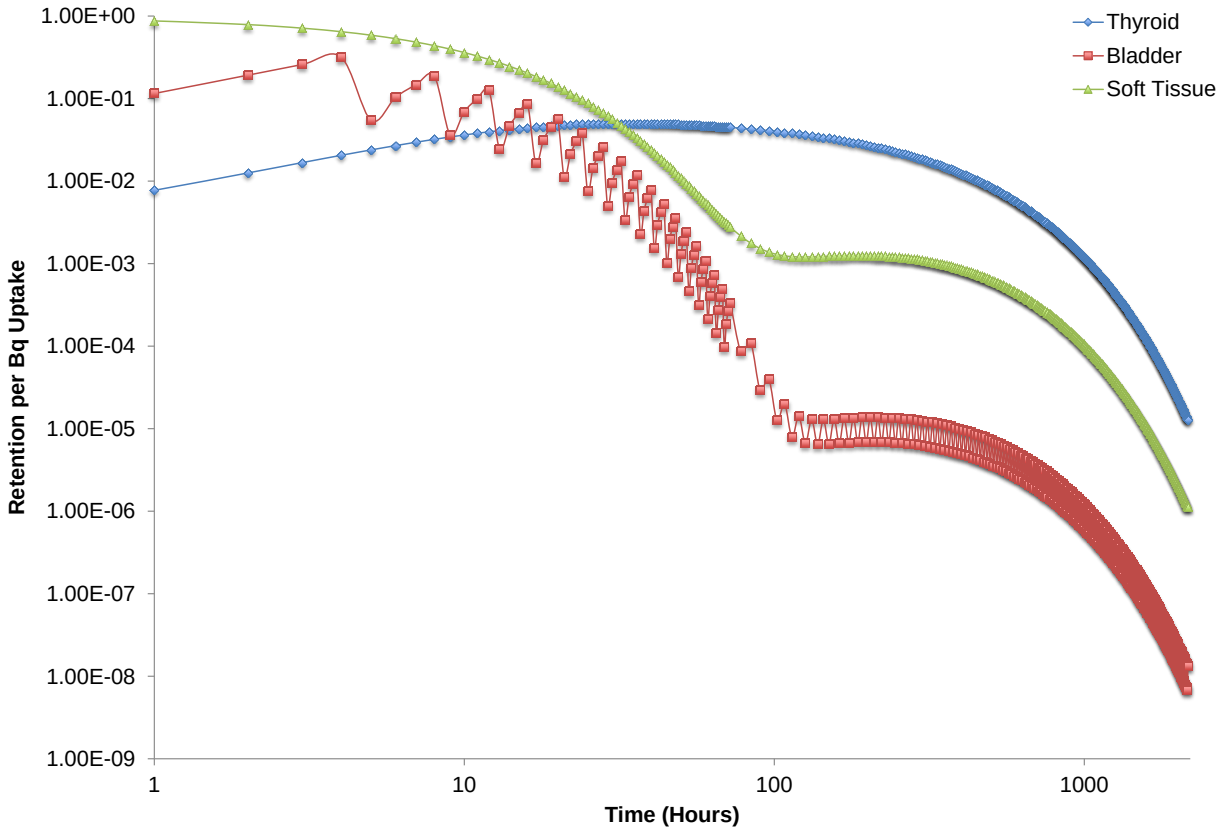


Figure A-14. Retained fraction of ^{131}I in the body as a function of time assuming a 4 hr periodic voiding pattern (DTC – 5% Thyroid Uptake).

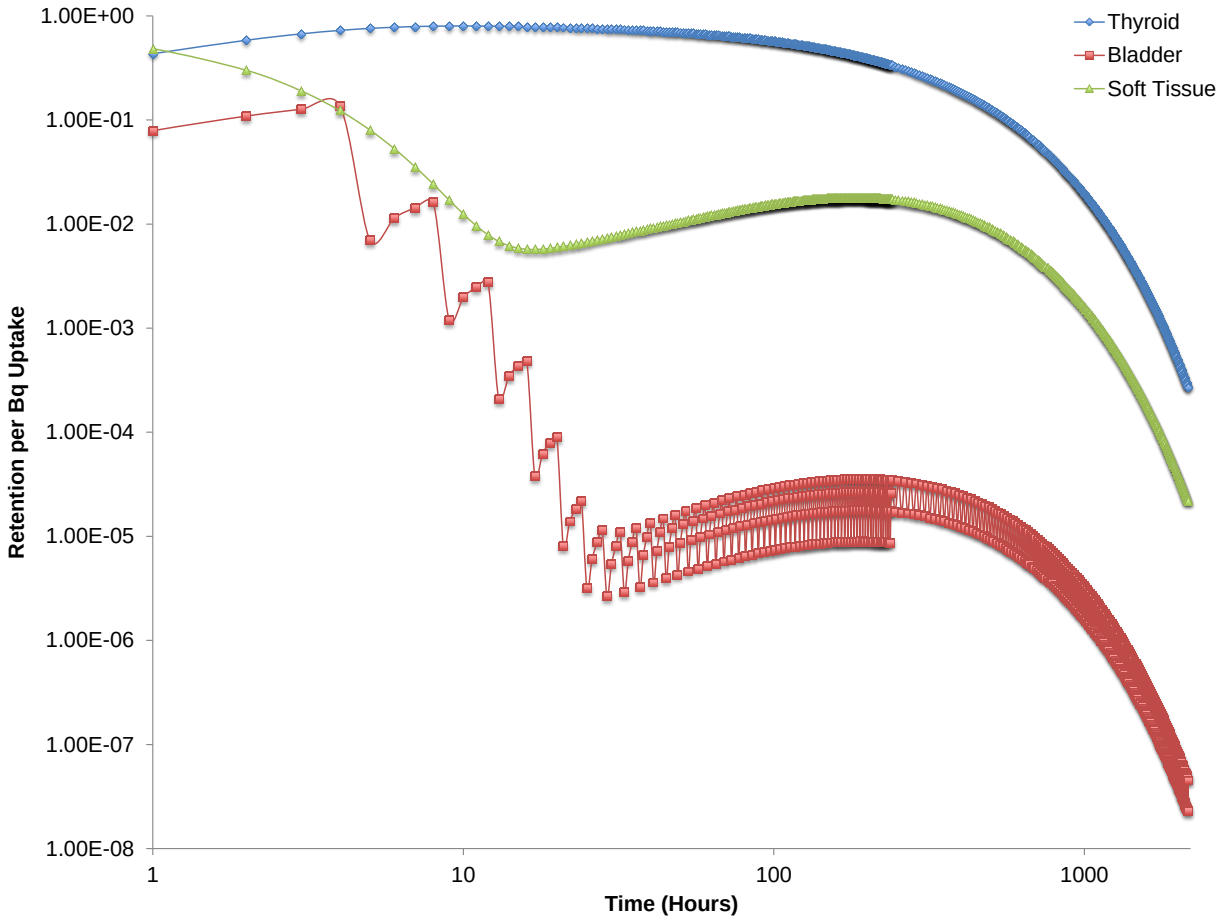


Figure A-15. Retained fraction of ^{131}I in the body as a function of time assuming a 4 hr periodic voiding pattern (Hyperthyroid – 80% Thyroid Uptake).

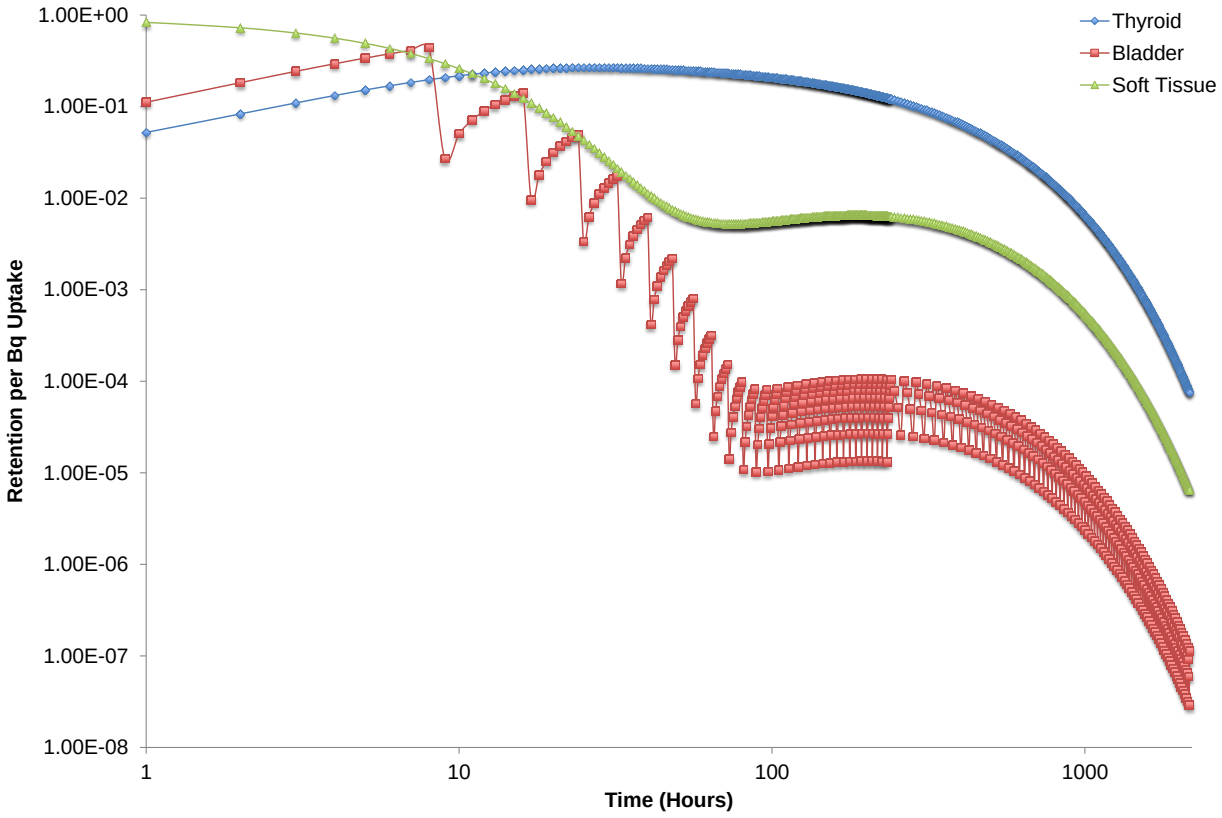


Figure A-16. Retained fraction of ^{131}I in the body as a function of time assuming a 8 hr periodic voiding pattern (Normal Thyroid Uptake).

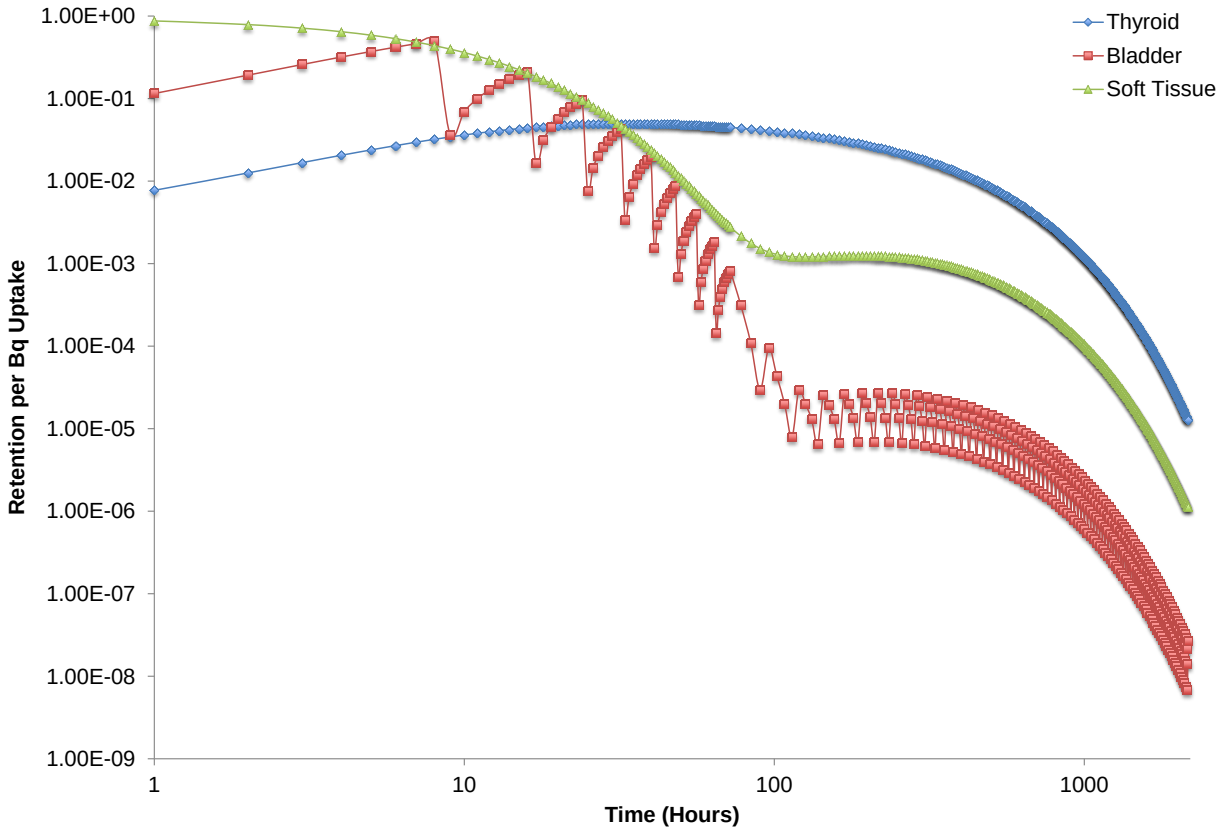


Figure A-17. Retained fraction of ^{131}I in the body as a function of time assuming a 8 hr periodic voiding pattern (DTC – 5% Thyroid Uptake).

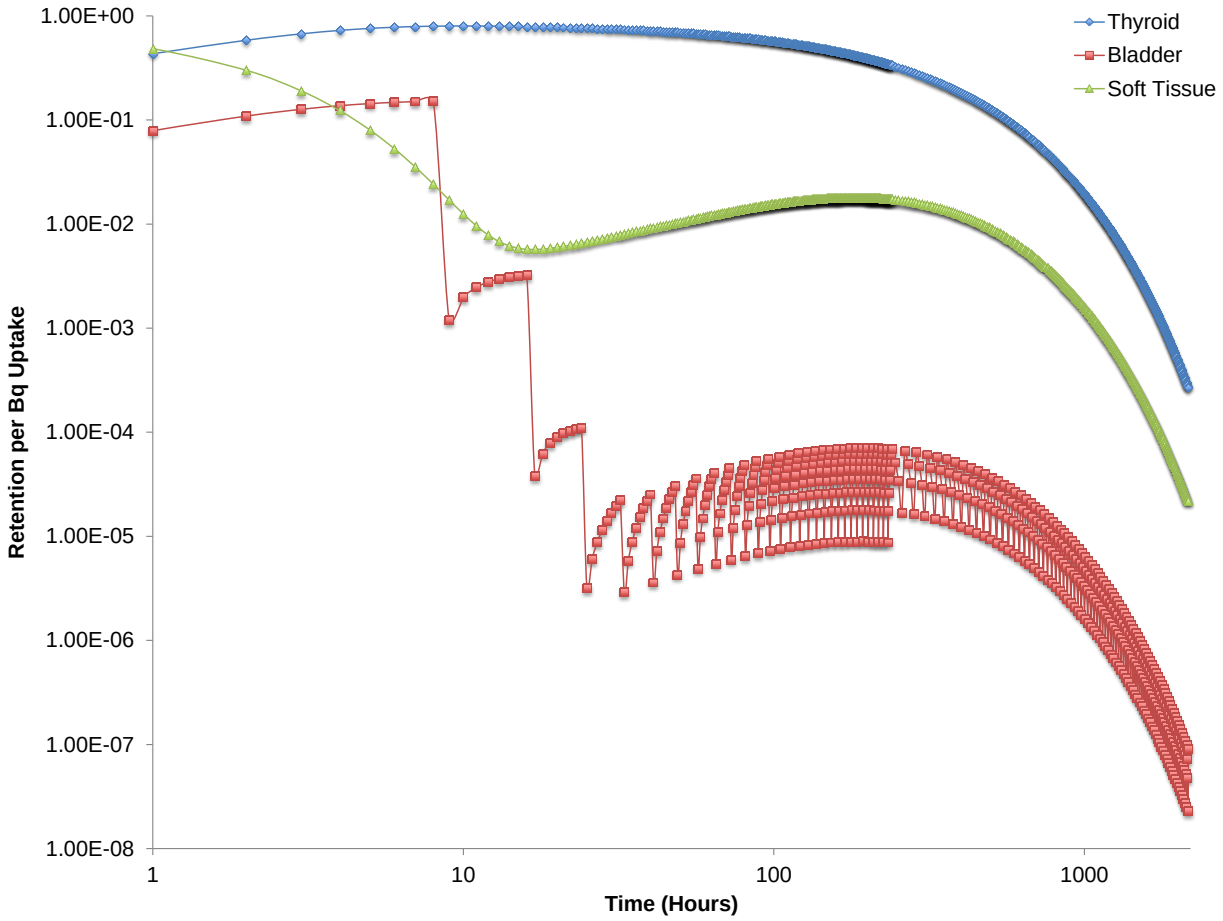


Figure A-18. Retained fraction of ^{131}I in the body as a function of time assuming a 8 hr periodic voiding pattern (Hyperthyroid – 80% Thyroid Uptake).

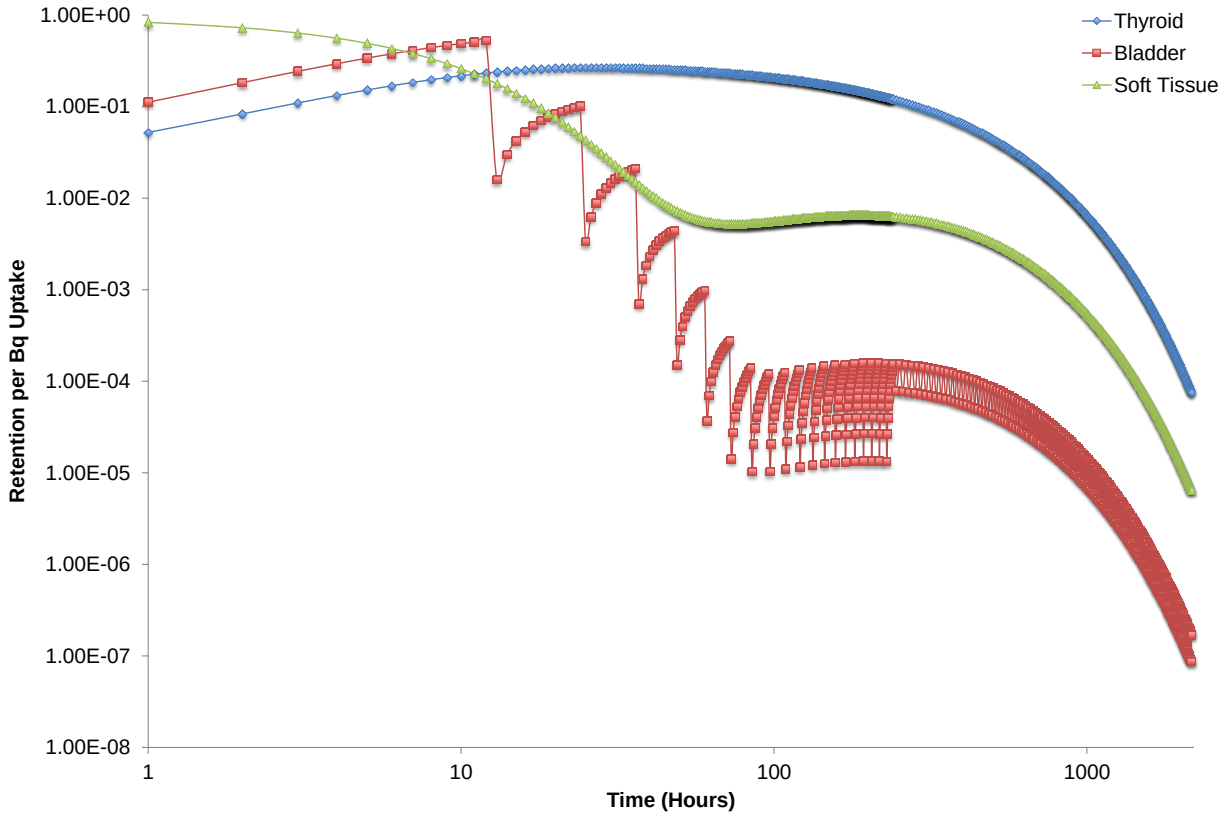


Figure A-19. Retained fraction of ^{131}I in the body as a function of time assuming a 12 hr periodic voiding pattern (Normal Thyroid Uptake).

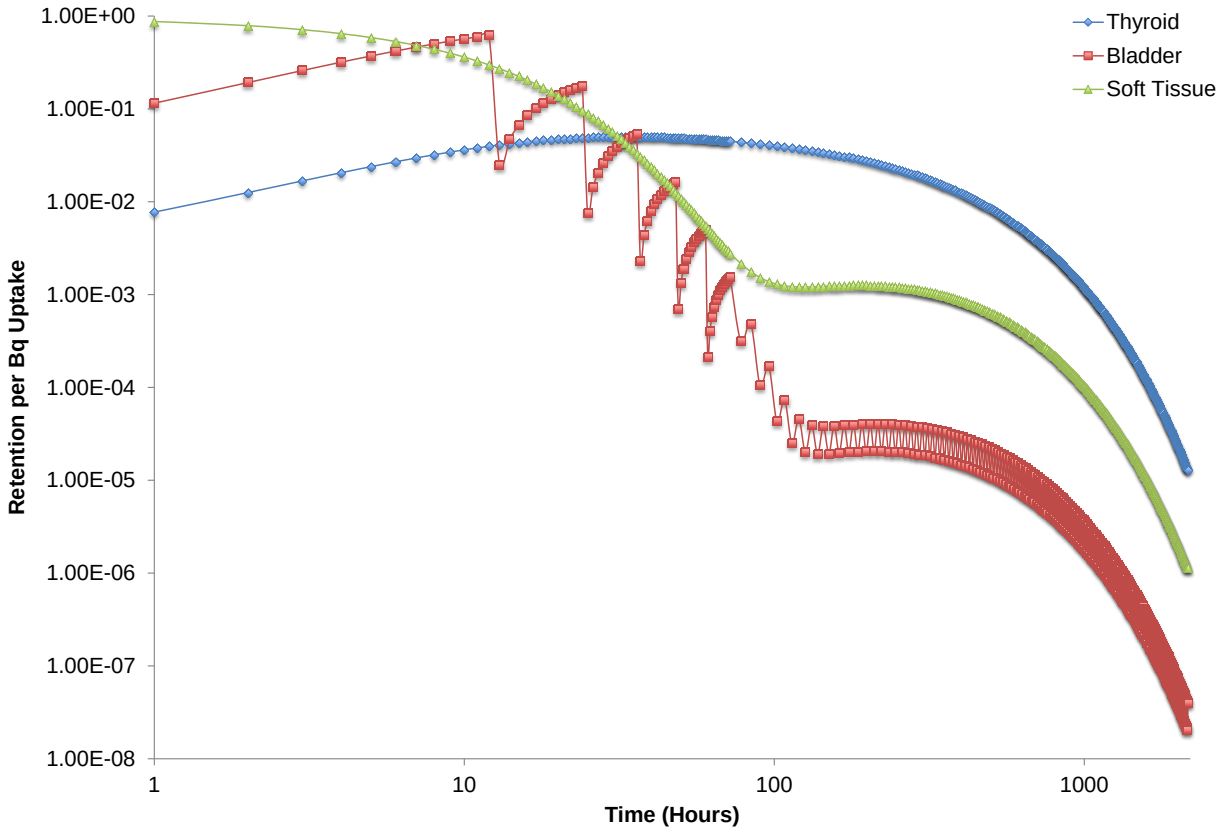


Figure A-20. Retained fraction of ^{131}I in the body as a function of time assuming a 12 hr periodic voiding pattern (DTC – 5% Thyroid Uptake).

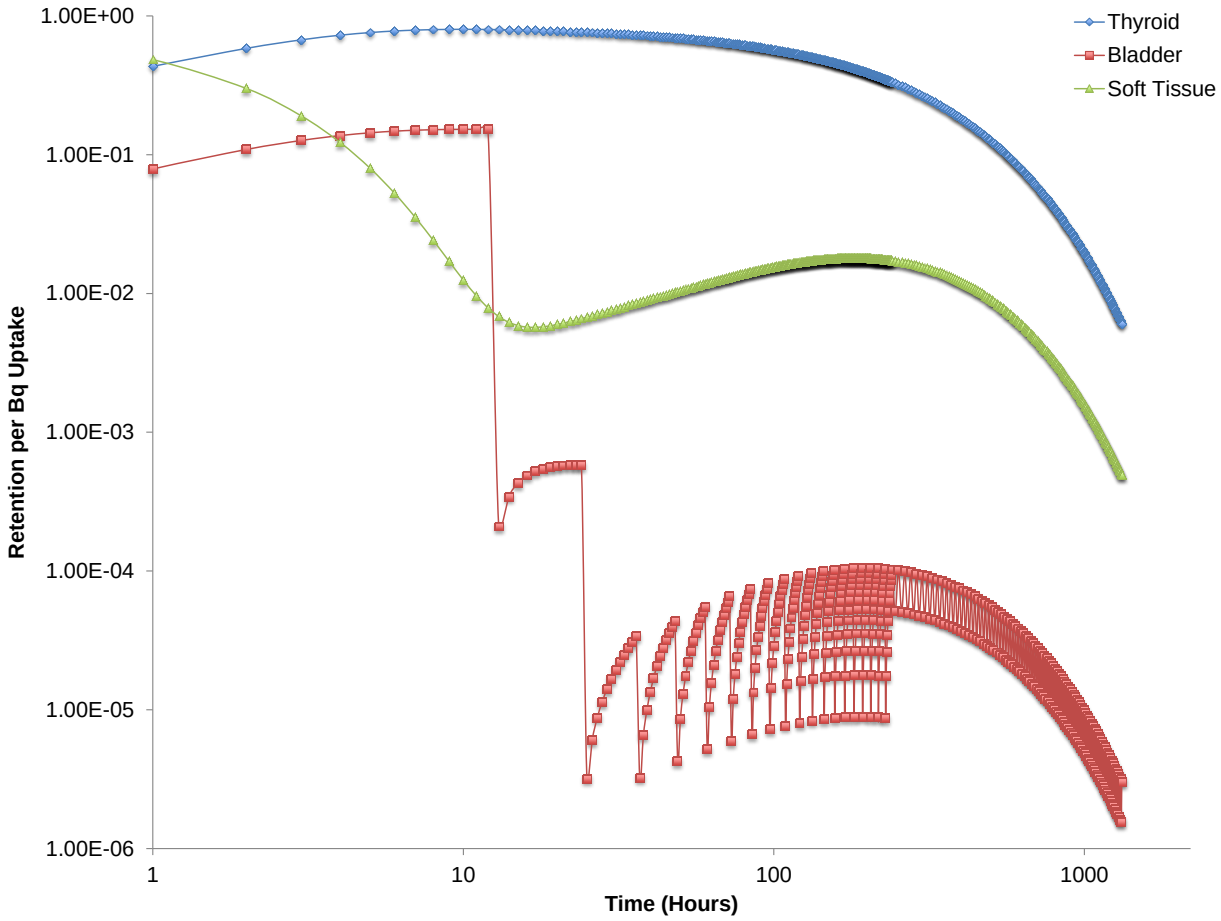


Figure A-21. Retained fraction of ^{131}I in the body as a function of time assuming a 12 hr periodic voiding pattern (Hyperthyroid – 80% Thyroid Uptake).

APPENDIX B. TABULATED DOSE RATES

APPENDIX B: TABULATED DOSE RATES

B.1 PUBLIC TRANSPORTATION:

B.1.1 i) Public Transportation: Face-to-Face

B.1.1.1 Comparison of Separation Distances

Dose rates are summarized for separation distances ranging from 10 cm to 30 0cm for an example case of a single void 4 hr after administration.

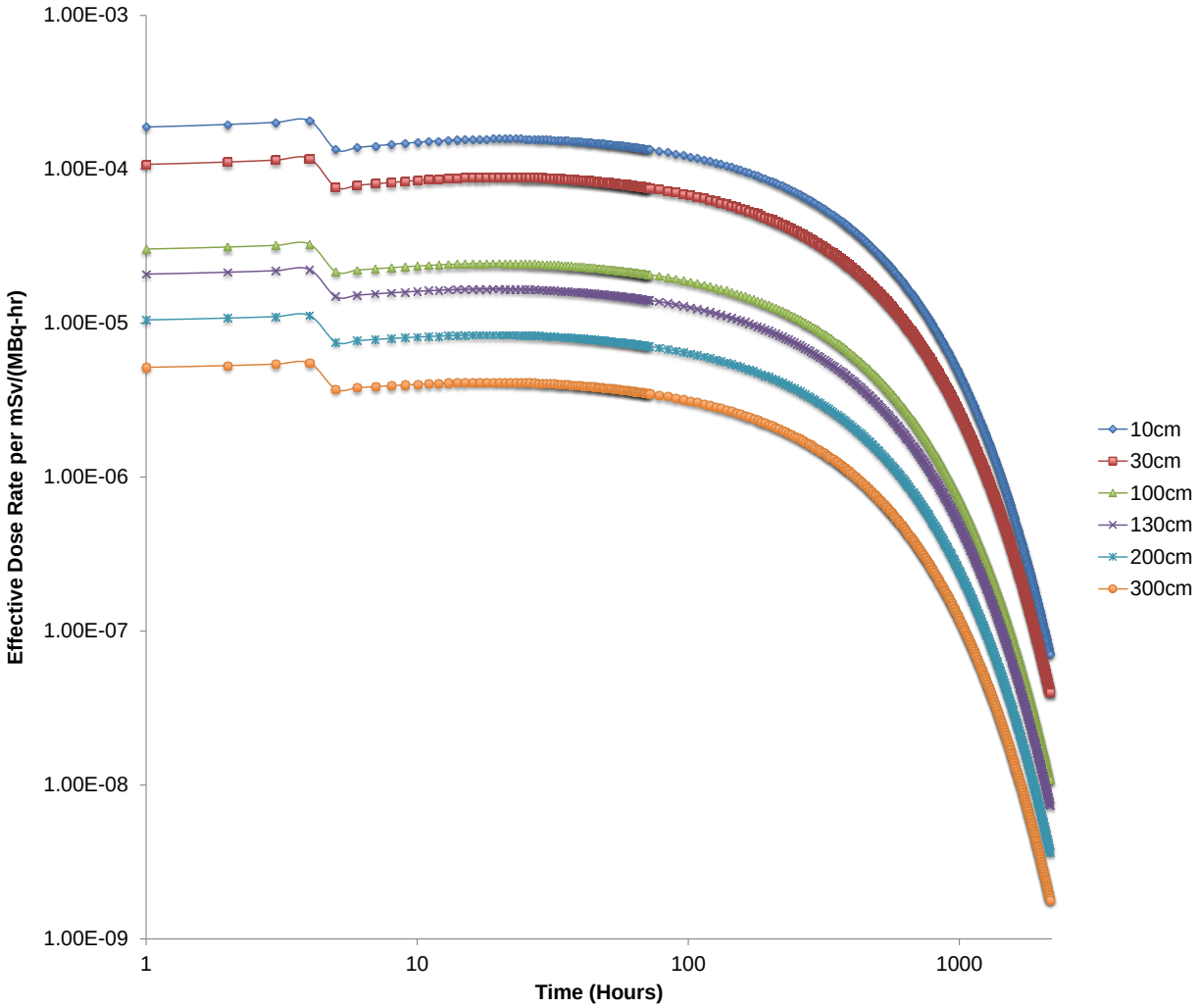


Figure B-22. Effective dose rate as a function of administered activity for patient facing member of public - various separation distances (normal thyroid uptake – single void at 4 hr).

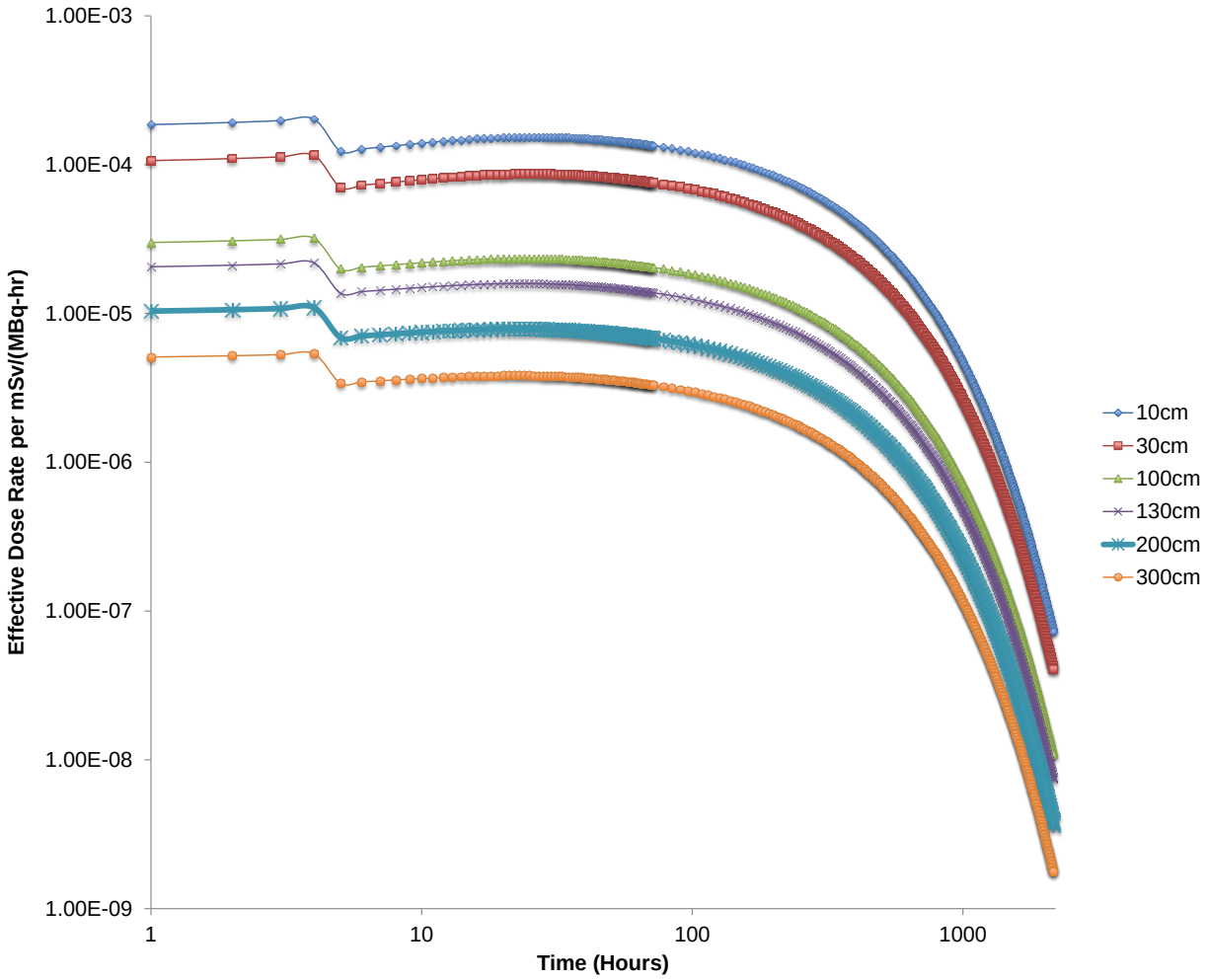


Figure B-23. Effective dose rate as a function of administered activity for patient facing member of public - various separation distances (DTC case – 5% thyroid uptake – single void at 4 hr).

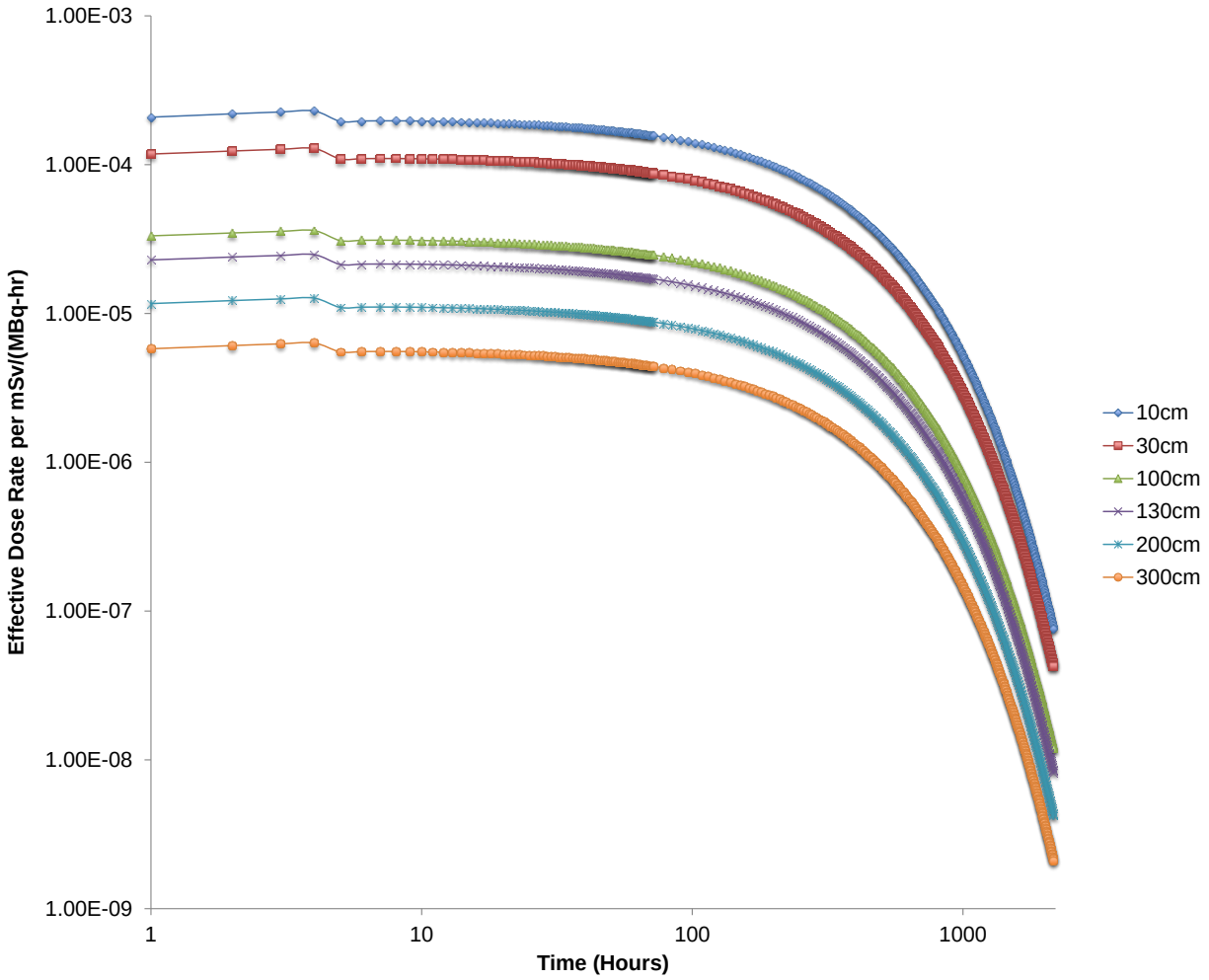


Figure B-24. Effective dose rate as a function of administered activity for patient facing member of public - various separation distances (hyperthyroid case – 80% thyroid uptake – single void at 4 hr).

B.1.1.2 Dose Rates for 10 cm Separation

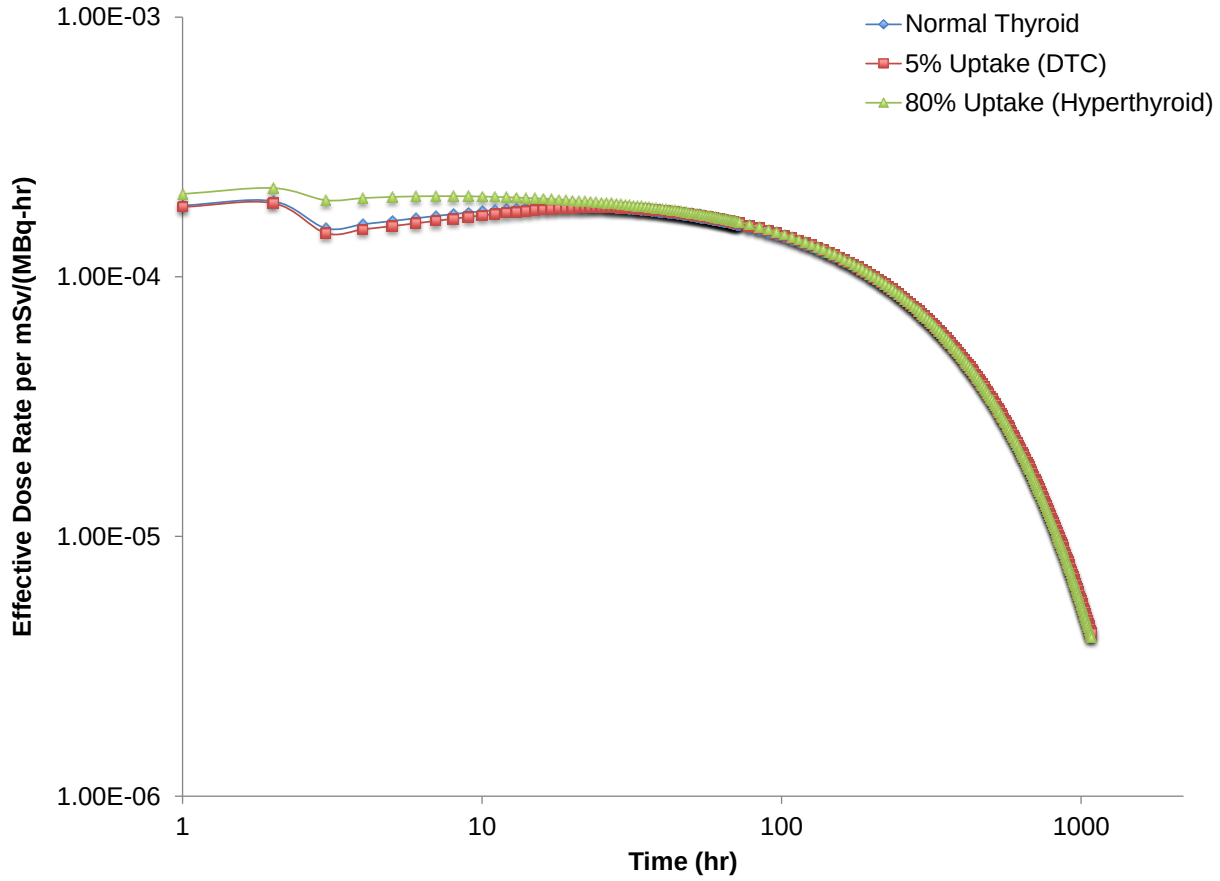


Figure B-25. Effective dose rate as a function of administered activity for patient facing member of public – 10 cm separation - (single void at 2 hr).

Table B-1. Effective dose rate (mSv/MBq-hr) for patient facing member of public – 10 cm separation - (single void at 2 hr)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	1.81E-04	1.80E-04	1.92E-04
0.5	**0.02**	1.84E-04	1.82E-04	1.99E-04
1	**0.04**	1.88E-04	1.86E-04	2.08E-04
2	**0.08**	1.96E-04	1.92E-04	2.20E-04
3	**0.13**	1.54E-04	1.47E-04	1.97E-04
4	**0.17**	1.59E-04	1.52E-04	2.01E-04
5	**0.21**	1.64E-04	1.57E-04	2.03E-04
6	**0.25**	1.68E-04	1.61E-04	2.04E-04
7	**0.29**	1.71E-04	1.64E-04	2.04E-04
8	**0.33**	1.74E-04	1.67E-04	2.04E-04
9	**0.38**	1.77E-04	1.70E-04	2.04E-04
10	**0.42**	1.79E-04	1.72E-04	2.04E-04
12	**0.50**	1.82E-04	1.76E-04	2.03E-04
24	**1.00**	1.86E-04	1.85E-04	1.94E-04
36	**1.50**	1.80E-04	1.82E-04	1.86E-04
48	**2.00**	1.72E-04	1.75E-04	1.77E-04
60	**2.50**	1.65E-04	1.68E-04	1.70E-04
72	**3.00**	1.58E-04	1.61E-04	1.62E-04
84	**3.50**	1.51E-04	1.54E-04	1.55E-04
96	**4.00**	1.45E-04	1.47E-04	1.49E-04
108	**4.50**	1.38E-04	1.41E-04	1.42E-04
120	**5.00**	1.33E-04	1.35E-04	1.36E-04
132	**5.50**	1.27E-04	1.29E-04	1.30E-04
144	**6.00**	1.21E-04	1.24E-04	1.25E-04
156	**6.50**	1.16E-04	1.19E-04	1.19E-04
168	**7.00**	1.11E-04	1.14E-04	1.14E-04
240	**10.00**	8.58E-05	8.76E-05	8.78E-05
360	**15.00**	5.56E-05	5.68E-05	5.66E-05
480	**20.00**	3.60E-05	3.69E-05	3.65E-05
600	**25.00**	2.33E-05	2.39E-05	2.35E-05
720	**30.00**	1.51E-05	1.55E-05	1.52E-05
840	**35.00**	9.80E-06	1.01E-05	9.79E-06
960	**40.00**	6.35E-06	6.54E-06	6.32E-06
1080	**45.00**	4.12E-06	4.25E-06	4.08E-06
1200	**50.00**	2.67E-06	2.76E-06	2.63E-06
1320	**55.00**	1.73E-06	1.79E-06	1.70E-06
1440	**60.00**	1.12E-06	1.16E-06	1.10E-06
1560	**65.00**	7.27E-07	7.53E-07	7.07E-07
1680	**70.00**	4.71E-07	4.89E-07	4.56E-07
1800	**75.00**	3.06E-07	3.17E-07	2.94E-07
1920	**80.00**	1.98E-07	2.06E-07	1.90E-07
2040	**85.00**	1.28E-07	1.34E-07	1.23E-07
2160	**90.00**	8.33E-08	8.68E-08	7.91E-08

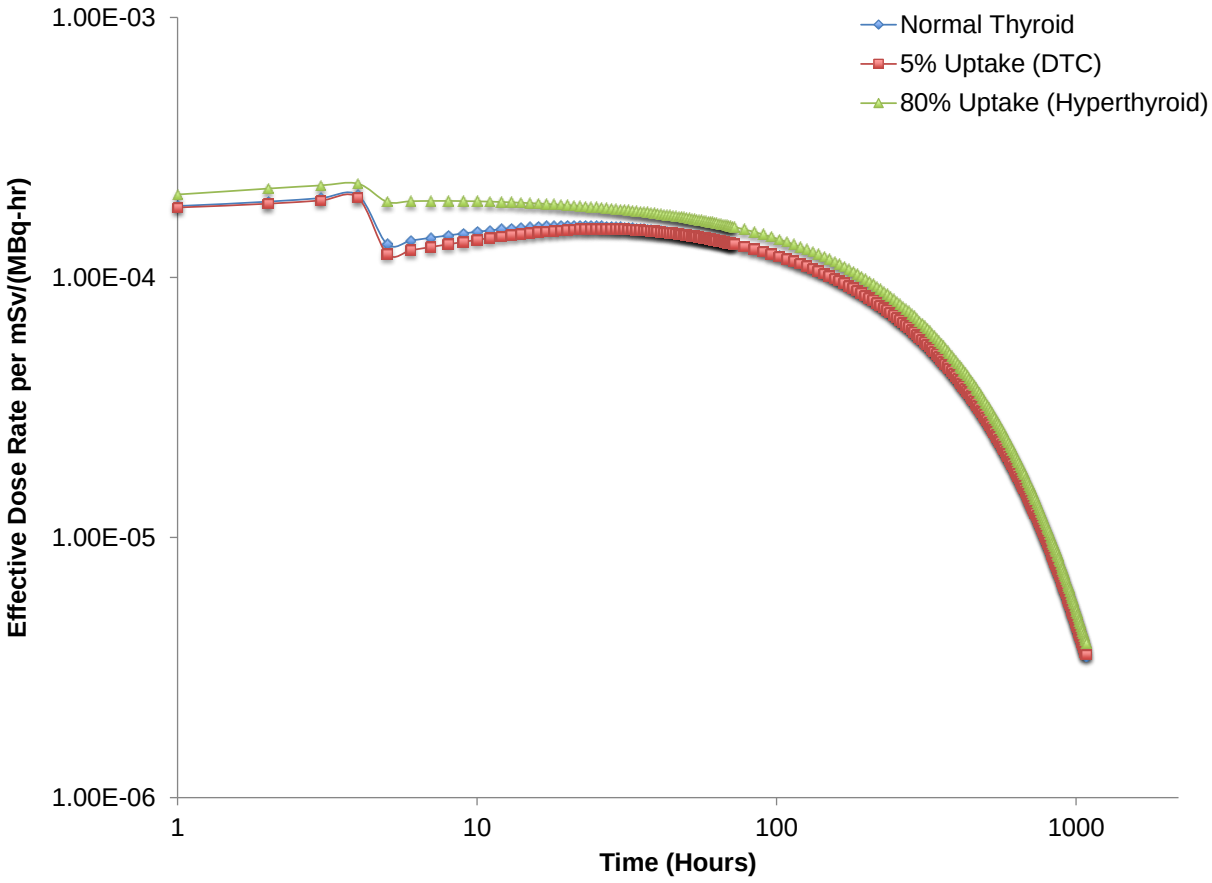


Figure B-26. Effective dose rate as a function of administered activity for patient facing member of public – 10 cm separation - (single void at 4 hr).

Table B-2. Effective dose rate (mSv/MBq-hr) for patient facing member of public – 10 cm separation - (single void at 4 hr)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	1.81E-04	1.80E-04	1.92E-04
0.5	**0.02**	1.84E-04	1.82E-04	1.99E-04
1	**0.04**	1.88E-04	1.86E-04	2.08E-04
2	**0.08**	1.96E-04	1.92E-04	2.20E-04
3	**0.13**	2.02E-04	1.98E-04	2.26E-04
4	**0.17**	2.07E-04	2.02E-04	2.29E-04
5	**0.21**	1.34E-04	1.23E-04	1.95E-04
6	**0.25**	1.39E-04	1.27E-04	1.96E-04
7	**0.29**	1.42E-04	1.31E-04	1.97E-04
8	**0.33**	1.45E-04	1.34E-04	1.97E-04
9	**0.38**	1.48E-04	1.37E-04	1.97E-04
10	**0.42**	1.50E-04	1.40E-04	1.96E-04
12	**0.50**	1.53E-04	1.44E-04	1.95E-04
24	**1.00**	1.58E-04	1.54E-04	1.87E-04
36	**1.50**	1.53E-04	1.52E-04	1.79E-04
48	**2.00**	1.47E-04	1.46E-04	1.71E-04
60	**2.50**	1.41E-04	1.40E-04	1.64E-04
72	**3.00**	1.35E-04	1.34E-04	1.56E-04
84	**3.50**	1.29E-04	1.29E-04	1.50E-04
96	**4.00**	1.23E-04	1.23E-04	1.43E-04
108	**4.50**	1.18E-04	1.18E-04	1.37E-04
120	**5.00**	1.13E-04	1.13E-04	1.31E-04
132	**5.50**	1.08E-04	1.08E-04	1.26E-04
144	**6.00**	1.04E-04	1.04E-04	1.20E-04
156	**6.50**	9.92E-05	9.91E-05	1.15E-04
168	**7.00**	9.49E-05	9.49E-05	1.10E-04
240	**10.00**	7.31E-05	7.32E-05	8.45E-05
360	**15.00**	4.73E-05	4.75E-05	5.45E-05
480	**20.00**	3.07E-05	3.08E-05	3.51E-05
600	**25.00**	1.99E-05	2.00E-05	2.26E-05
720	**30.00**	1.29E-05	1.30E-05	1.46E-05
840	**35.00**	8.34E-06	8.42E-06	9.42E-06
960	**40.00**	5.40E-06	5.47E-06	6.07E-06
1080	**45.00**	3.50E-06	3.55E-06	3.92E-06
1200	**50.00**	2.27E-06	2.30E-06	2.53E-06
1320	**55.00**	1.47E-06	1.49E-06	1.63E-06
1440	**60.00**	9.53E-07	9.70E-07	1.05E-06
1560	**65.00**	6.18E-07	6.30E-07	6.79E-07
1680	**70.00**	4.00E-07	4.09E-07	4.38E-07
1800	**75.00**	2.60E-07	2.65E-07	2.82E-07
1920	**80.00**	1.68E-07	1.72E-07	1.82E-07
2040	**85.00**	1.09E-07	1.12E-07	1.18E-07
2160	**90.00**	7.07E-08	7.25E-08	7.59E-08

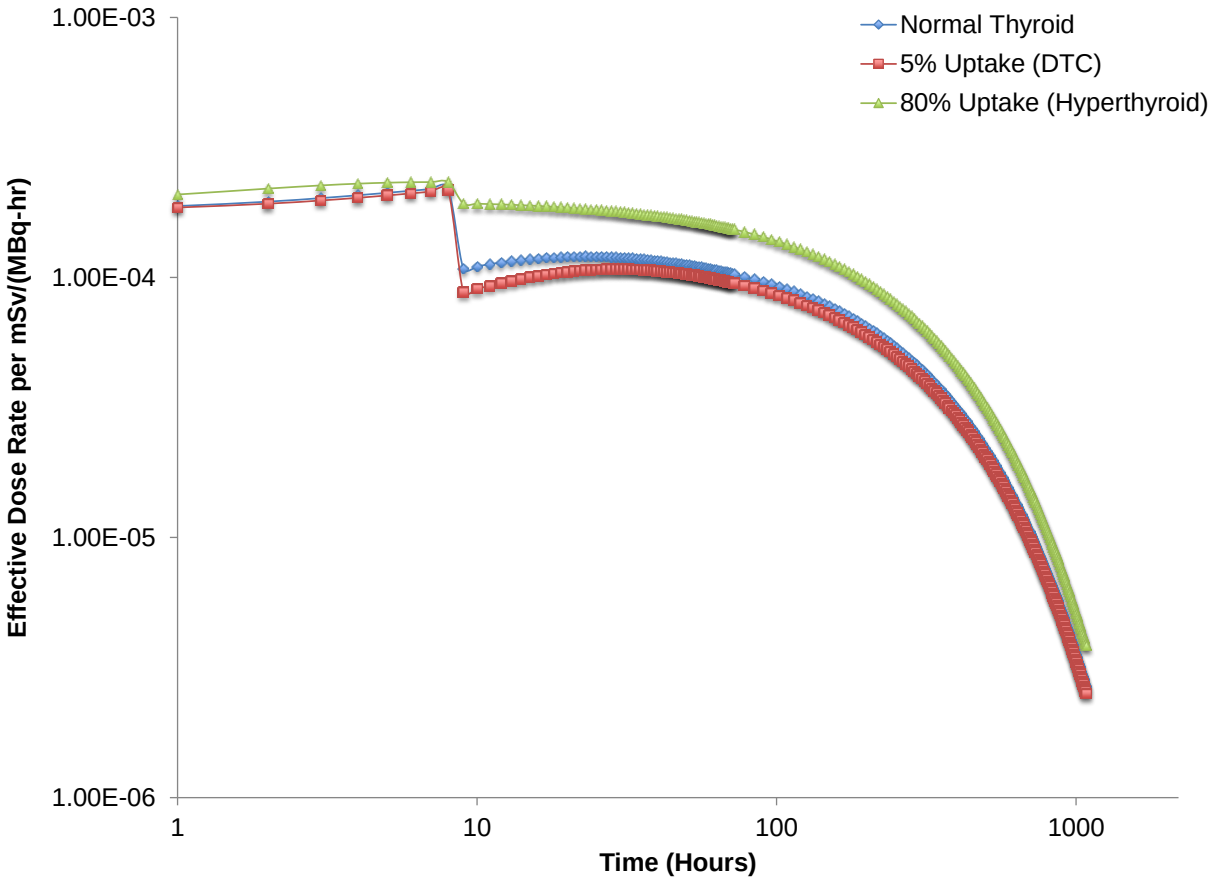


Figure B-27. Effective dose rate as a function of administered activity for patient facing member of public – 10 cm separation (single void at 8 hr).

Table B-3. Effective dose rate (mSv/MBq-hr) for patient facing member of public – 10 cm separation - (single void at 8 hr)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	1.81E-04	1.80E-04	1.92E-04
0.5	**0.02**	1.84E-04	1.82E-04	1.99E-04
1	**0.04**	1.88E-04	1.86E-04	2.08E-04
2	**0.08**	1.96E-04	1.92E-04	2.20E-04
3	**0.13**	2.02E-04	1.98E-04	2.26E-04
4	**0.17**	2.07E-04	2.02E-04	2.29E-04
5	**0.21**	2.12E-04	2.07E-04	2.31E-04
6	**0.25**	2.15E-04	2.10E-04	2.32E-04
7	**0.29**	2.19E-04	2.14E-04	2.33E-04
8	**0.33**	2.21E-04	2.17E-04	2.33E-04
9	**0.38**	1.08E-04	8.77E-05	1.92E-04
10	**0.42**	1.10E-04	9.04E-05	1.92E-04
12	**0.50**	1.14E-04	9.50E-05	1.91E-04
24	**1.00**	1.20E-04	1.07E-04	1.83E-04
36	**1.50**	1.17E-04	1.07E-04	1.75E-04
48	**2.00**	1.13E-04	1.04E-04	1.67E-04
60	**2.50**	1.08E-04	9.93E-05	1.60E-04
72	**3.00**	1.03E-04	9.51E-05	1.53E-04
84	**3.50**	9.86E-05	9.10E-05	1.47E-04
96	**4.00**	9.44E-05	8.71E-05	1.40E-04
108	**4.50**	9.03E-05	8.34E-05	1.34E-04
120	**5.00**	8.65E-05	7.99E-05	1.28E-04
132	**5.50**	8.28E-05	7.65E-05	1.23E-04
144	**6.00**	7.92E-05	7.32E-05	1.18E-04
156	**6.50**	7.59E-05	7.01E-05	1.12E-04
168	**7.00**	7.26E-05	6.72E-05	1.08E-04
240	**10.00**	5.59E-05	5.18E-05	8.27E-05
360	**15.00**	3.62E-05	3.36E-05	5.33E-05
480	**20.00**	2.34E-05	2.18E-05	3.43E-05
600	**25.00**	1.52E-05	1.41E-05	2.21E-05
720	**30.00**	9.81E-06	9.18E-06	1.43E-05
840	**35.00**	6.35E-06	5.95E-06	9.21E-06
960	**40.00**	4.11E-06	3.86E-06	5.94E-06
1080	**45.00**	2.67E-06	2.51E-06	3.83E-06
1200	**50.00**	1.73E-06	1.63E-06	2.47E-06
1320	**55.00**	1.12E-06	1.06E-06	1.59E-06
1440	**60.00**	7.25E-07	6.85E-07	1.03E-06
1560	**65.00**	4.69E-07	4.45E-07	6.63E-07
1680	**70.00**	3.04E-07	2.88E-07	4.28E-07
1800	**75.00**	1.97E-07	1.87E-07	2.76E-07
1920	**80.00**	1.28E-07	1.22E-07	1.78E-07
2040	**85.00**	8.27E-08	7.89E-08	1.15E-07
2160	**90.00**	5.36E-08	5.12E-08	7.41E-08

B.1.1.3 Contribution from Compartments Minimal (10 cm) Separation

- Contributions from each compartment at example of 4 hr voiding.

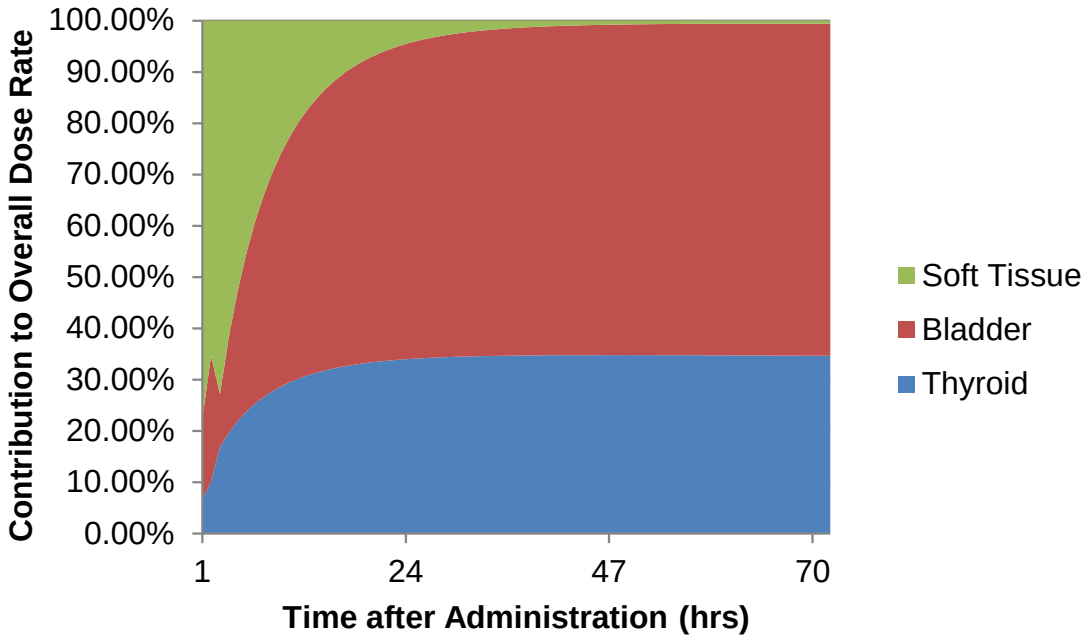


Figure B-28. Public transportation scenario: compartments driving contribution to dose rates for 10 cm face-to-face separation (normal thyroid uptake – single void at 4 hr).

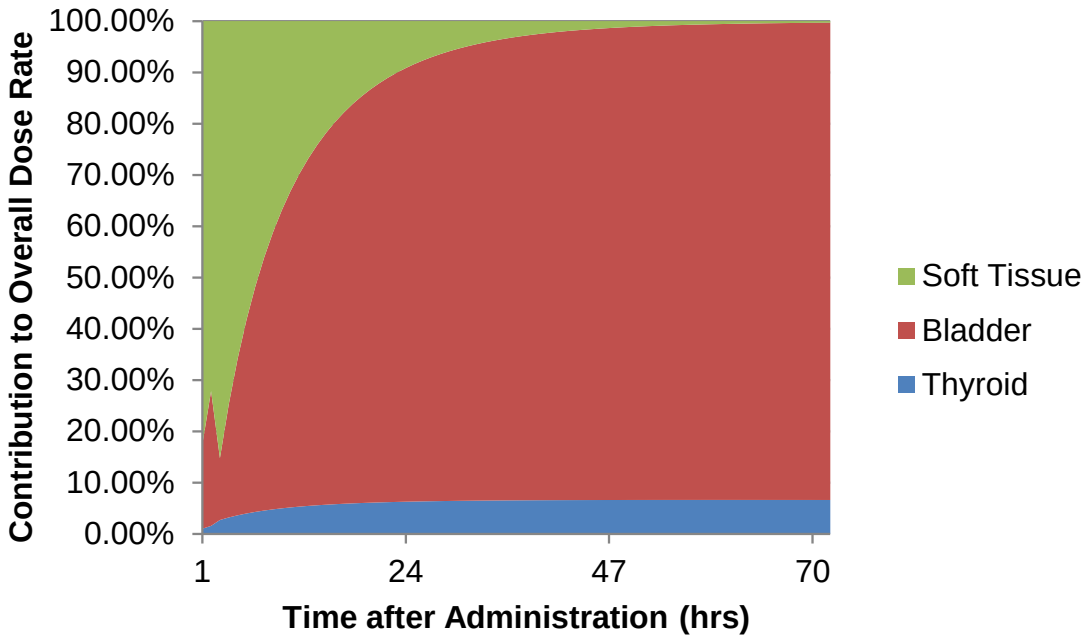


Figure B-29. Public transportation scenario: compartments driving contribution to dose rates for 10 cm face-to-face separation (DTC case – 5% thyroid uptake – single void at 4 hr).

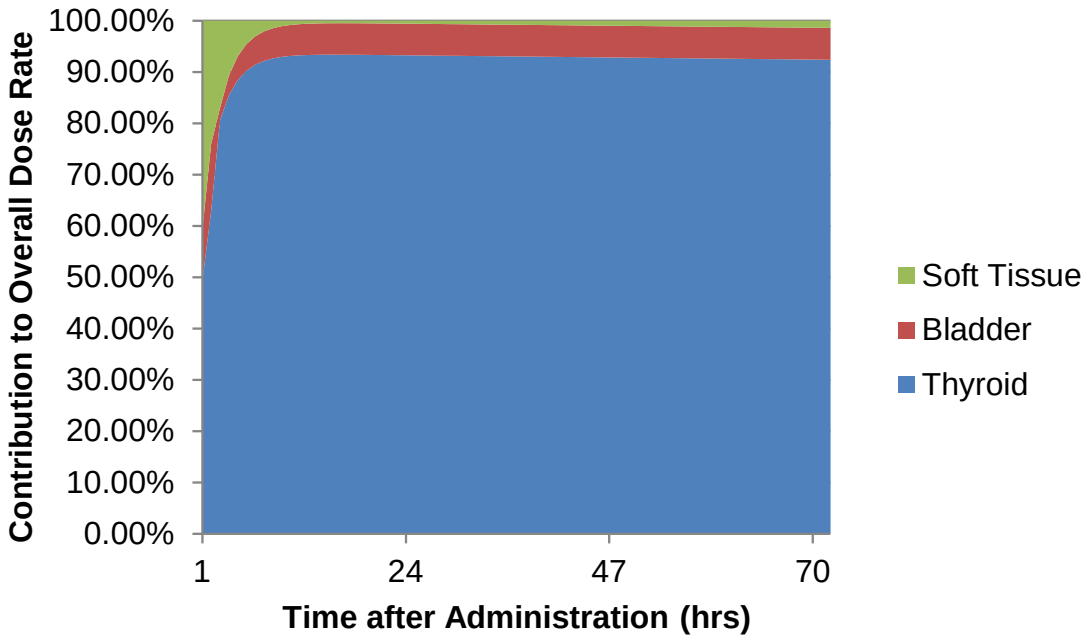


Figure B-30. Public transportation scenario: compartments driving contribution to dose rates for 10 cm face-to-face separation (hyperthyroid case – 80% thyroid uptake – single void at 4 hr).

B.1.2 ii) Public Transportation: Patient Seated in Front of Member of Public

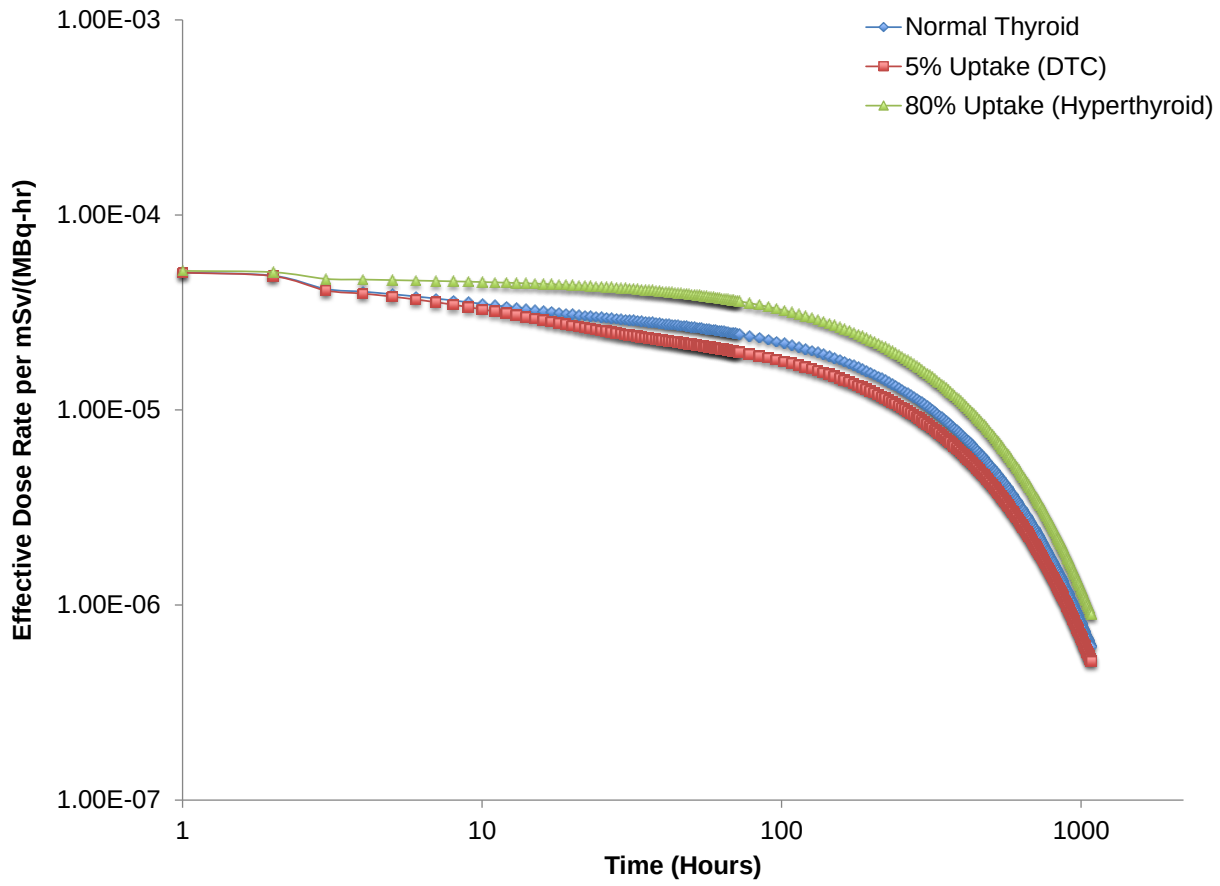


Figure B-31. Effective dose rate as a function of administered activity for public transportation scenario: patient seated in front of member of public (single void at 2 hr post-administration).

Table B-4. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated in front of member of public (single void at 2 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	5.23E-05	5.23E-05	5.26E-05
0.5	**0.02**	5.17E-05	5.16E-05	5.22E-05
1	**0.04**	5.06E-05	5.05E-05	5.16E-05
2	**0.08**	4.88E-05	4.86E-05	5.09E-05
3	**0.13**	4.18E-05	4.10E-05	4.70E-05
4	**0.17**	4.04E-05	3.95E-05	4.66E-05
5	**0.21**	3.92E-05	3.81E-05	4.63E-05
6	**0.25**	3.82E-05	3.68E-05	4.61E-05
7	**0.29**	3.73E-05	3.57E-05	4.59E-05
8	**0.33**	3.64E-05	3.46E-05	4.57E-05
9	**0.38**	3.57E-05	3.37E-05	4.55E-05
10	**0.42**	3.50E-05	3.28E-05	4.53E-05
12	**0.50**	3.39E-05	3.12E-05	4.49E-05
24	**1.00**	3.01E-05	2.58E-05	4.30E-05
36	**1.50**	2.83E-05	2.34E-05	4.12E-05
48	**2.00**	2.69E-05	2.19E-05	3.94E-05
60	**2.50**	2.57E-05	2.08E-05	3.77E-05
72	**3.00**	2.45E-05	1.98E-05	3.61E-05
84	**3.50**	2.35E-05	1.89E-05	3.46E-05
96	**4.00**	2.25E-05	1.81E-05	3.31E-05
108	**4.50**	2.15E-05	1.73E-05	3.17E-05
120	**5.00**	2.06E-05	1.66E-05	3.03E-05
132	**5.50**	1.97E-05	1.59E-05	2.90E-05
144	**6.00**	1.89E-05	1.52E-05	2.78E-05
156	**6.50**	1.81E-05	1.46E-05	2.66E-05
168	**7.00**	1.73E-05	1.40E-05	2.55E-05
240	**10.00**	1.33E-05	1.08E-05	1.96E-05
360	**15.00**	8.59E-06	6.97E-06	1.26E-05
480	**20.00**	5.54E-06	4.52E-06	8.15E-06
600	**25.00**	3.57E-06	2.93E-06	5.25E-06
720	**30.00**	2.30E-06	1.90E-06	3.38E-06
840	**35.00**	1.48E-06	1.23E-06	2.17E-06
960	**40.00**	9.54E-07	7.96E-07	1.40E-06
1080	**45.00**	6.15E-07	5.16E-07	9.00E-07
1200	**50.00**	3.96E-07	3.34E-07	5.79E-07
1320	**55.00**	2.55E-07	2.16E-07	3.73E-07
1440	**60.00**	1.65E-07	1.40E-07	2.40E-07
1560	**65.00**	1.06E-07	9.08E-08	1.54E-07
1680	**70.00**	6.84E-08	5.89E-08	9.93E-08
1800	**75.00**	4.41E-08	3.82E-08	6.39E-08
1920	**80.00**	2.84E-08	2.47E-08	4.11E-08
2040	**85.00**	1.83E-08	1.60E-08	2.65E-08
2160	**90.00**	1.18E-08	1.04E-08	1.70E-08

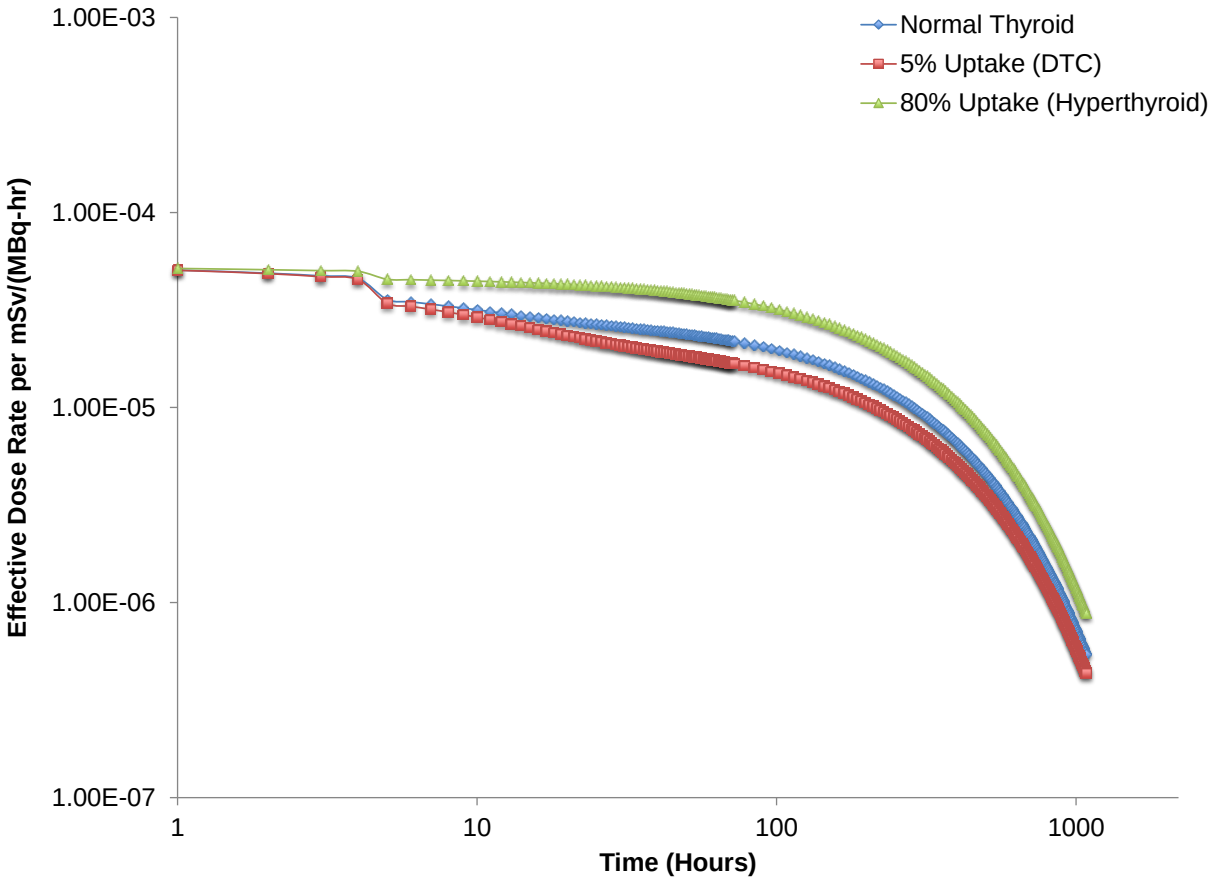


Figure B-32. Effective dose rate as a function of administered activity for public transportation scenario: patient seated in front of member of public (single void at 4 hr post-administration).

Table B-5. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated in front of member of public (single void at 4 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	5.23E-05	5.23E-05	5.26E-05
0.5	**0.02**	5.17E-05	5.16E-05	5.22E-05
1	**0.04**	5.06E-05	5.05E-05	5.16E-05
2	**0.08**	4.88E-05	4.86E-05	5.09E-05
3	**0.13**	4.73E-05	4.68E-05	5.03E-05
4	**0.17**	4.59E-05	4.53E-05	4.99E-05
5	**0.21**	3.58E-05	3.43E-05	4.55E-05
6	**0.25**	3.48E-05	3.30E-05	4.52E-05
7	**0.29**	3.39E-05	3.19E-05	4.50E-05
8	**0.33**	3.31E-05	3.08E-05	4.48E-05
9	**0.38**	3.23E-05	2.99E-05	4.46E-05
10	**0.42**	3.17E-05	2.90E-05	4.44E-05
12	**0.50**	3.06E-05	2.75E-05	4.41E-05
24	**1.00**	2.69E-05	2.22E-05	4.22E-05
36	**1.50**	2.52E-05	1.99E-05	4.04E-05
48	**2.00**	2.40E-05	1.86E-05	3.87E-05
60	**2.50**	2.29E-05	1.76E-05	3.70E-05
72	**3.00**	2.19E-05	1.68E-05	3.54E-05
84	**3.50**	2.09E-05	1.60E-05	3.39E-05
96	**4.00**	2.00E-05	1.53E-05	3.25E-05
108	**4.50**	1.92E-05	1.47E-05	3.11E-05
120	**5.00**	1.83E-05	1.40E-05	2.98E-05
132	**5.50**	1.76E-05	1.35E-05	2.85E-05
144	**6.00**	1.68E-05	1.29E-05	2.73E-05
156	**6.50**	1.61E-05	1.23E-05	2.61E-05
168	**7.00**	1.54E-05	1.18E-05	2.50E-05
240	**10.00**	1.19E-05	9.10E-06	1.92E-05
360	**15.00**	7.64E-06	5.90E-06	1.24E-05
480	**20.00**	4.92E-06	3.82E-06	7.99E-06
600	**25.00**	3.17E-06	2.47E-06	5.14E-06
720	**30.00**	2.04E-06	1.60E-06	3.31E-06
840	**35.00**	1.31E-06	1.04E-06	2.13E-06
960	**40.00**	8.45E-07	6.72E-07	1.37E-06
1080	**45.00**	5.44E-07	4.35E-07	8.82E-07
1200	**50.00**	3.50E-07	2.82E-07	5.67E-07
1320	**55.00**	2.25E-07	1.82E-07	3.65E-07
1440	**60.00**	1.45E-07	1.18E-07	2.35E-07
1560	**65.00**	9.34E-08	7.66E-08	1.51E-07
1680	**70.00**	6.02E-08	4.96E-08	9.72E-08
1800	**75.00**	3.88E-08	3.21E-08	6.25E-08
1920	**80.00**	2.50E-08	2.08E-08	4.02E-08
2040	**85.00**	1.61E-08	1.35E-08	2.59E-08
2160	**90.00**	1.04E-08	8.74E-09	1.67E-08

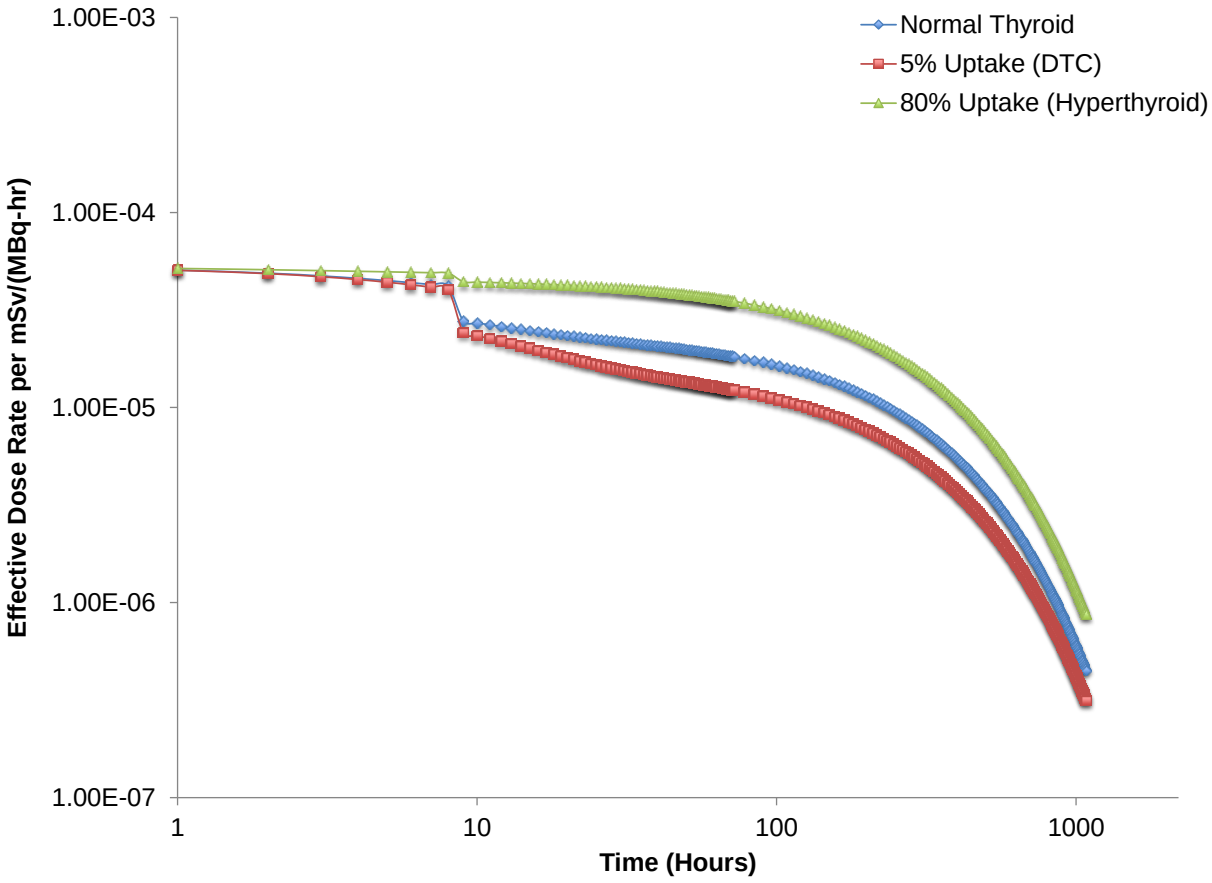


Figure B-33. Effective dose rate as a function of administered activity for public transportation scenario: patient seated in front of member of public (single void at 8 hr post-administration).

Table B-6. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated in front of member of public (single void at 8 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	5.23E-05	5.23E-05	5.26E-05
0.5	**0.02**	5.17E-05	5.16E-05	5.22E-05
1	**0.04**	5.06E-05	5.05E-05	5.16E-05
2	**0.08**	4.88E-05	4.86E-05	5.09E-05
3	**0.13**	4.73E-05	4.68E-05	5.03E-05
4	**0.17**	4.59E-05	4.53E-05	4.99E-05
5	**0.21**	4.47E-05	4.39E-05	4.96E-05
6	**0.25**	4.37E-05	4.26E-05	4.93E-05
7	**0.29**	4.27E-05	4.14E-05	4.91E-05
8	**0.33**	4.19E-05	4.03E-05	4.89E-05
9	**0.38**	2.78E-05	2.42E-05	4.41E-05
10	**0.42**	2.71E-05	2.33E-05	4.39E-05
12	**0.50**	2.60E-05	2.19E-05	4.36E-05
24	**1.00**	2.26E-05	1.68E-05	4.17E-05
36	**1.50**	2.11E-05	1.48E-05	3.99E-05
48	**2.00**	2.00E-05	1.37E-05	3.82E-05
60	**2.50**	1.91E-05	1.29E-05	3.66E-05
72	**3.00**	1.82E-05	1.23E-05	3.50E-05
84	**3.50**	1.74E-05	1.17E-05	3.35E-05
96	**4.00**	1.67E-05	1.12E-05	3.21E-05
108	**4.50**	1.60E-05	1.07E-05	3.07E-05
120	**5.00**	1.53E-05	1.02E-05	2.94E-05
132	**5.50**	1.46E-05	9.81E-06	2.82E-05
144	**6.00**	1.40E-05	9.39E-06	2.70E-05
156	**6.50**	1.34E-05	8.99E-06	2.58E-05
168	**7.00**	1.28E-05	8.61E-06	2.47E-05
240	**10.00**	9.87E-06	6.63E-06	1.90E-05
360	**15.00**	6.35E-06	4.30E-06	1.23E-05
480	**20.00**	4.09E-06	2.78E-06	7.90E-06
600	**25.00**	2.63E-06	1.80E-06	5.09E-06
720	**30.00**	1.69E-06	1.16E-06	3.27E-06
840	**35.00**	1.08E-06	7.52E-07	2.11E-06
960	**40.00**	6.96E-07	4.87E-07	1.35E-06
1080	**45.00**	4.47E-07	3.15E-07	8.72E-07
1200	**50.00**	2.87E-07	2.04E-07	5.61E-07
1320	**55.00**	1.85E-07	1.32E-07	3.61E-07
1440	**60.00**	1.19E-07	8.54E-08	2.32E-07
1560	**65.00**	7.63E-08	5.52E-08	1.49E-07
1680	**70.00**	4.91E-08	3.57E-08	9.60E-08
1800	**75.00**	3.16E-08	2.31E-08	6.17E-08
1920	**80.00**	2.03E-08	1.50E-08	3.97E-08
2040	**85.00**	1.31E-08	9.70E-09	2.56E-08
2160	**90.00**	8.40E-09	6.28E-09	1.64E-08

B.1.3 iii) Public Transportation: Patient Seated in Behind Member of Public

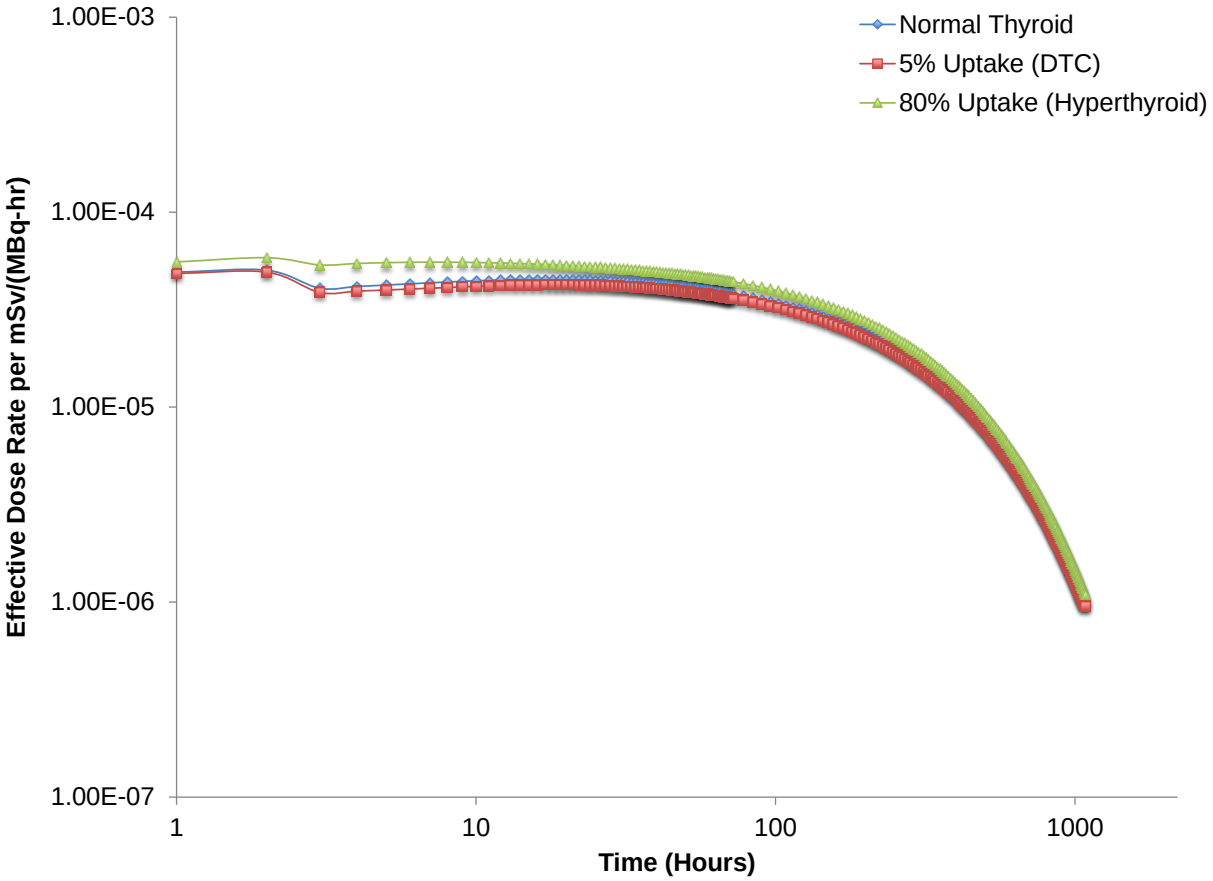


Figure B-34. Effective dose rate as a function of administered activity for public transportation scenario: patient seated behind member of public (single void at 2 hr post-administration).

Table B-7. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated behind member of public (single void at 2 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	4.80E-05	4.77E-05	5.15E-05
0.5	**0.02**	4.85E-05	4.80E-05	5.33E-05
1	**0.04**	4.92E-05	4.85E-05	5.56E-05
2	**0.08**	5.04E-05	4.92E-05	5.84E-05
3	**0.13**	4.07E-05	3.87E-05	5.36E-05
4	**0.17**	4.16E-05	3.93E-05	5.45E-05
5	**0.21**	4.23E-05	3.99E-05	5.50E-05
6	**0.25**	4.29E-05	4.03E-05	5.53E-05
7	**0.29**	4.34E-05	4.07E-05	5.54E-05
8	**0.33**	4.38E-05	4.10E-05	5.54E-05
9	**0.38**	4.41E-05	4.13E-05	5.53E-05
10	**0.42**	4.44E-05	4.16E-05	5.52E-05
12	**0.50**	4.48E-05	4.20E-05	5.48E-05
24	**1.00**	4.47E-05	4.23E-05	5.25E-05
36	**1.50**	4.32E-05	4.10E-05	5.02E-05
48	**2.00**	4.13E-05	3.94E-05	4.80E-05
60	**2.50**	3.95E-05	3.77E-05	4.60E-05
72	**3.00**	3.78E-05	3.61E-05	4.40E-05
84	**3.50**	3.62E-05	3.46E-05	4.21E-05
96	**4.00**	3.46E-05	3.31E-05	4.02E-05
108	**4.50**	3.32E-05	3.17E-05	3.85E-05
120	**5.00**	3.17E-05	3.03E-05	3.69E-05
132	**5.50**	3.04E-05	2.90E-05	3.53E-05
144	**6.00**	2.91E-05	2.78E-05	3.37E-05
156	**6.50**	2.78E-05	2.66E-05	3.23E-05
168	**7.00**	2.67E-05	2.55E-05	3.09E-05
240	**10.00**	2.05E-05	1.97E-05	2.37E-05
360	**15.00**	1.33E-05	1.28E-05	1.53E-05
480	**20.00**	8.58E-06	8.27E-06	9.84E-06
600	**25.00**	5.55E-06	5.37E-06	6.34E-06
720	**30.00**	3.59E-06	3.48E-06	4.09E-06
840	**35.00**	2.32E-06	2.26E-06	2.63E-06
960	**40.00**	1.50E-06	1.47E-06	1.70E-06
1080	**45.00**	9.73E-07	9.51E-07	1.09E-06
1200	**50.00**	6.29E-07	6.17E-07	7.05E-07
1320	**55.00**	4.07E-07	4.00E-07	4.55E-07
1440	**60.00**	2.64E-07	2.60E-07	2.93E-07
1560	**65.00**	1.71E-07	1.68E-07	1.89E-07
1680	**70.00**	1.10E-07	1.09E-07	1.22E-07
1800	**75.00**	7.15E-08	7.09E-08	7.85E-08
1920	**80.00**	4.63E-08	4.60E-08	5.06E-08
2040	**85.00**	3.00E-08	2.98E-08	3.26E-08
2160	**90.00**	1.94E-08	1.94E-08	2.10E-08

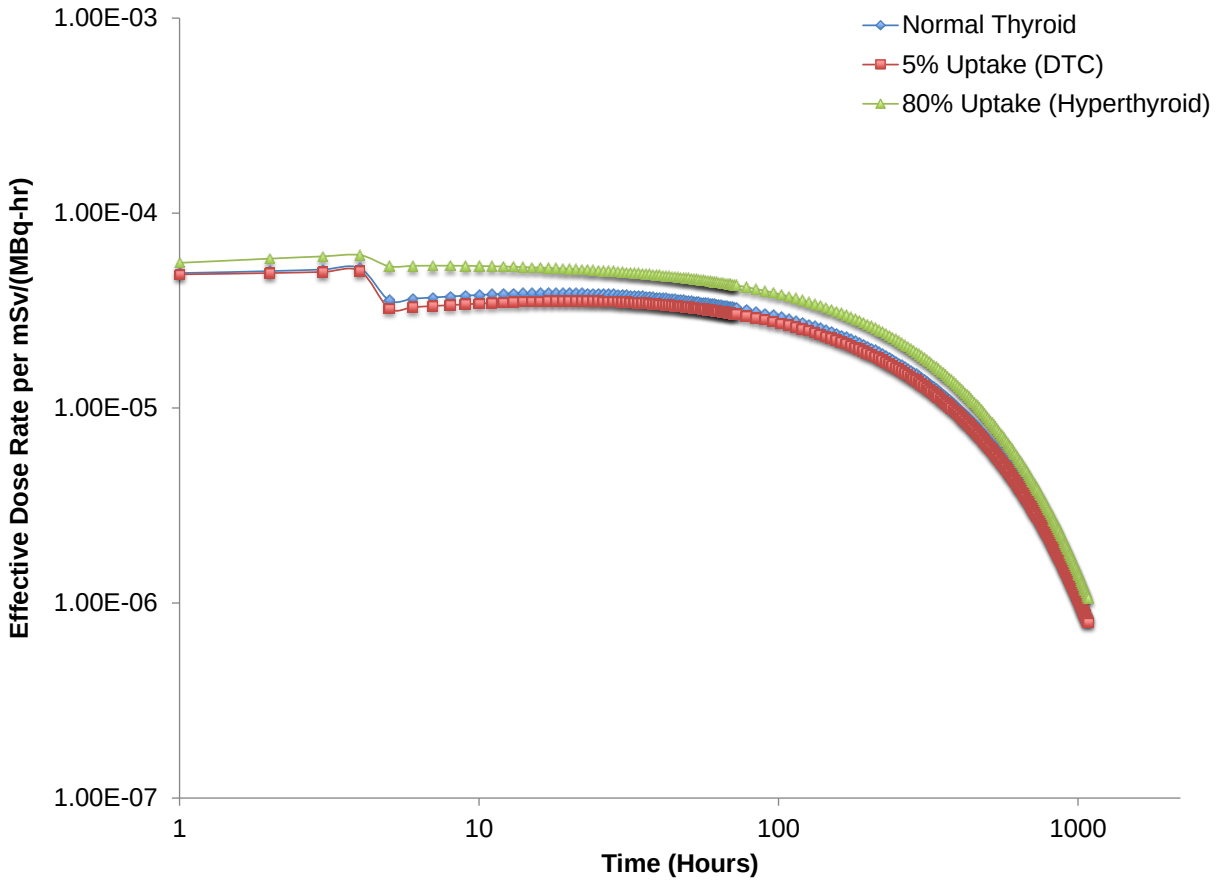


Figure B-35. Effective dose rate as a function of administered activity for public transportation scenario: patient seated behind member of public (single void at 4 hr post-administration).

Table B-8. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated behind member of public (single void at 4 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	4.80E-05	4.77E-05	5.15E-05
0.5	**0.02**	4.85E-05	4.80E-05	5.33E-05
1	**0.04**	4.92E-05	4.85E-05	5.56E-05
2	**0.08**	5.04E-05	4.92E-05	5.84E-05
3	**0.13**	5.13E-05	4.99E-05	5.99E-05
4	**0.17**	5.21E-05	5.04E-05	6.08E-05
5	**0.21**	3.57E-05	3.24E-05	5.34E-05
6	**0.25**	3.64E-05	3.29E-05	5.36E-05
7	**0.29**	3.69E-05	3.34E-05	5.37E-05
8	**0.33**	3.73E-05	3.37E-05	5.37E-05
9	**0.38**	3.77E-05	3.40E-05	5.36E-05
10	**0.42**	3.80E-05	3.43E-05	5.35E-05
12	**0.50**	3.85E-05	3.48E-05	5.32E-05
24	**1.00**	3.87E-05	3.54E-05	5.09E-05
36	**1.50**	3.73E-05	3.44E-05	4.87E-05
48	**2.00**	3.57E-05	3.31E-05	4.66E-05
60	**2.50**	3.42E-05	3.17E-05	4.46E-05
72	**3.00**	3.27E-05	3.03E-05	4.26E-05
84	**3.50**	3.13E-05	2.90E-05	4.08E-05
96	**4.00**	2.99E-05	2.77E-05	3.90E-05
108	**4.50**	2.86E-05	2.66E-05	3.74E-05
120	**5.00**	2.74E-05	2.54E-05	3.57E-05
132	**5.50**	2.62E-05	2.43E-05	3.42E-05
144	**6.00**	2.51E-05	2.33E-05	3.27E-05
156	**6.50**	2.41E-05	2.23E-05	3.13E-05
168	**7.00**	2.30E-05	2.14E-05	3.00E-05
240	**10.00**	1.77E-05	1.65E-05	2.30E-05
360	**15.00**	1.15E-05	1.07E-05	1.48E-05
480	**20.00**	7.40E-06	6.93E-06	9.54E-06
600	**25.00**	4.79E-06	4.50E-06	6.14E-06
720	**30.00**	3.09E-06	2.92E-06	3.96E-06
840	**35.00**	2.00E-06	1.89E-06	2.55E-06
960	**40.00**	1.29E-06	1.23E-06	1.64E-06
1080	**45.00**	8.37E-07	7.96E-07	1.06E-06
1200	**50.00**	5.41E-07	5.16E-07	6.83E-07
1320	**55.00**	3.50E-07	3.35E-07	4.40E-07
1440	**60.00**	2.26E-07	2.17E-07	2.83E-07
1560	**65.00**	1.47E-07	1.41E-07	1.83E-07
1680	**70.00**	9.48E-08	9.14E-08	1.18E-07
1800	**75.00**	6.13E-08	5.93E-08	7.59E-08
1920	**80.00**	3.97E-08	3.85E-08	4.89E-08
2040	**85.00**	2.57E-08	2.50E-08	3.15E-08
2160	**90.00**	1.66E-08	1.62E-08	2.03E-08

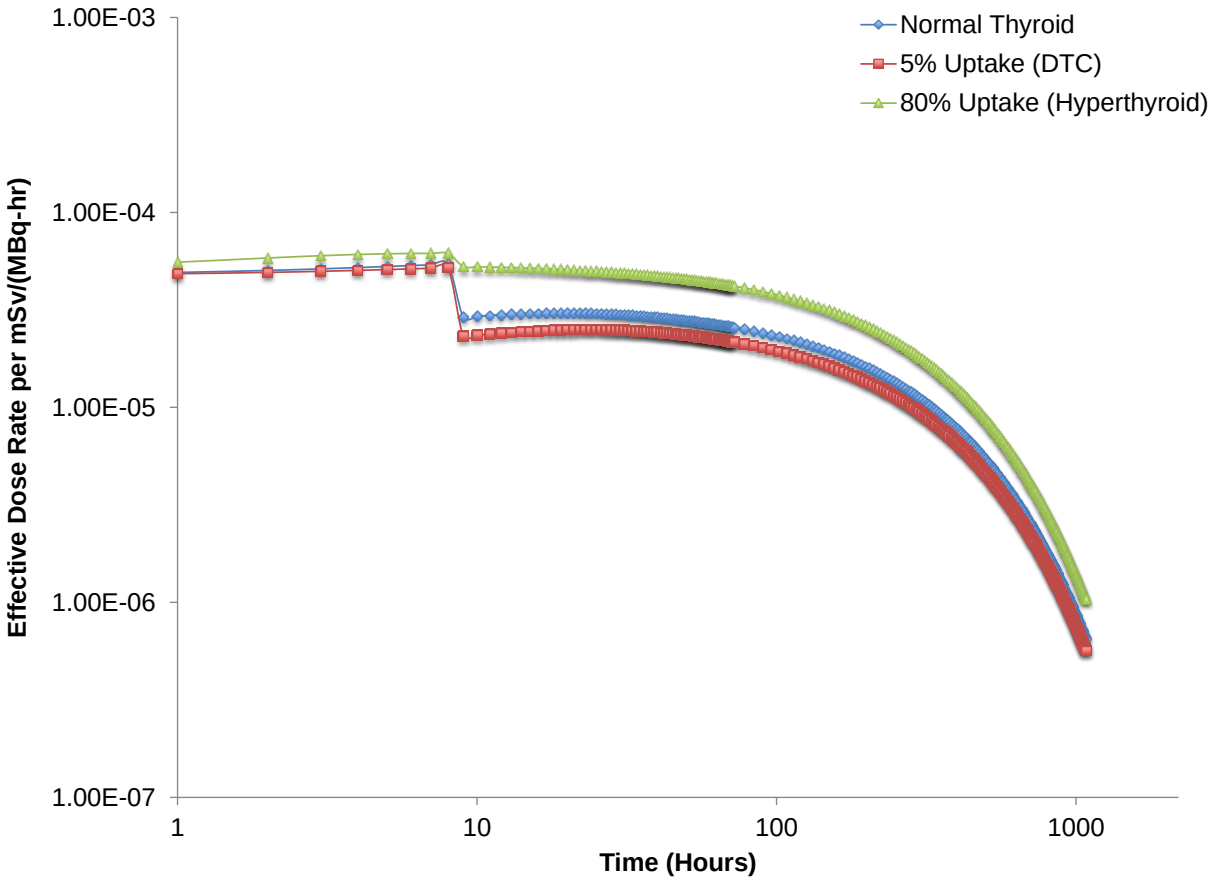


Figure B-36. Effective dose rate as a function of administered activity for public transportation scenario: patient seated behind member of public (single void at 8 hr post-administration).

Table B-9. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated behind member of public (single void at 8 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	4.80E-05	4.77E-05	5.15E-05
0.5	**0.02**	4.85E-05	4.80E-05	5.33E-05
1	**0.04**	4.92E-05	4.85E-05	5.56E-05
2	**0.08**	5.04E-05	4.92E-05	5.84E-05
3	**0.13**	5.13E-05	4.99E-05	5.99E-05
4	**0.17**	5.21E-05	5.04E-05	6.08E-05
5	**0.21**	5.28E-05	5.09E-05	6.13E-05
6	**0.25**	5.34E-05	5.13E-05	6.16E-05
7	**0.29**	5.38E-05	5.17E-05	6.16E-05
8	**0.33**	5.42E-05	5.20E-05	6.16E-05
9	**0.38**	2.90E-05	2.31E-05	5.27E-05
10	**0.42**	2.93E-05	2.35E-05	5.26E-05
12	**0.50**	2.98E-05	2.40E-05	5.23E-05
24	**1.00**	3.04E-05	2.51E-05	5.00E-05
36	**1.50**	2.94E-05	2.45E-05	4.79E-05
48	**2.00**	2.81E-05	2.36E-05	4.58E-05
60	**2.50**	2.69E-05	2.26E-05	4.38E-05
72	**3.00**	2.57E-05	2.16E-05	4.19E-05
84	**3.50**	2.46E-05	2.07E-05	4.01E-05
96	**4.00**	2.35E-05	1.98E-05	3.84E-05
108	**4.50**	2.25E-05	1.89E-05	3.67E-05
120	**5.00**	2.16E-05	1.81E-05	3.51E-05
132	**5.50**	2.06E-05	1.74E-05	3.36E-05
144	**6.00**	1.98E-05	1.66E-05	3.21E-05
156	**6.50**	1.89E-05	1.59E-05	3.08E-05
168	**7.00**	1.81E-05	1.52E-05	2.94E-05
240	**10.00**	1.39E-05	1.18E-05	2.26E-05
360	**15.00**	8.98E-06	7.62E-06	1.45E-05
480	**20.00**	5.80E-06	4.94E-06	9.37E-06
600	**25.00**	3.75E-06	3.20E-06	6.03E-06
720	**30.00**	2.42E-06	2.08E-06	3.89E-06
840	**35.00**	1.56E-06	1.35E-06	2.50E-06
960	**40.00**	1.01E-06	8.73E-07	1.61E-06
1080	**45.00**	6.52E-07	5.66E-07	1.04E-06
1200	**50.00**	4.21E-07	3.67E-07	6.70E-07
1320	**55.00**	2.72E-07	2.38E-07	4.32E-07
1440	**60.00**	1.76E-07	1.54E-07	2.78E-07
1560	**65.00**	1.14E-07	1.00E-07	1.79E-07
1680	**70.00**	7.35E-08	6.49E-08	1.15E-07
1800	**75.00**	4.75E-08	4.21E-08	7.44E-08
1920	**80.00**	3.07E-08	2.73E-08	4.80E-08
2040	**85.00**	1.99E-08	1.77E-08	3.09E-08
2160	**90.00**	1.28E-08	1.15E-08	1.99E-08

B.1.4 iv) Public Transportation: Patient Seated Beside Member of Public

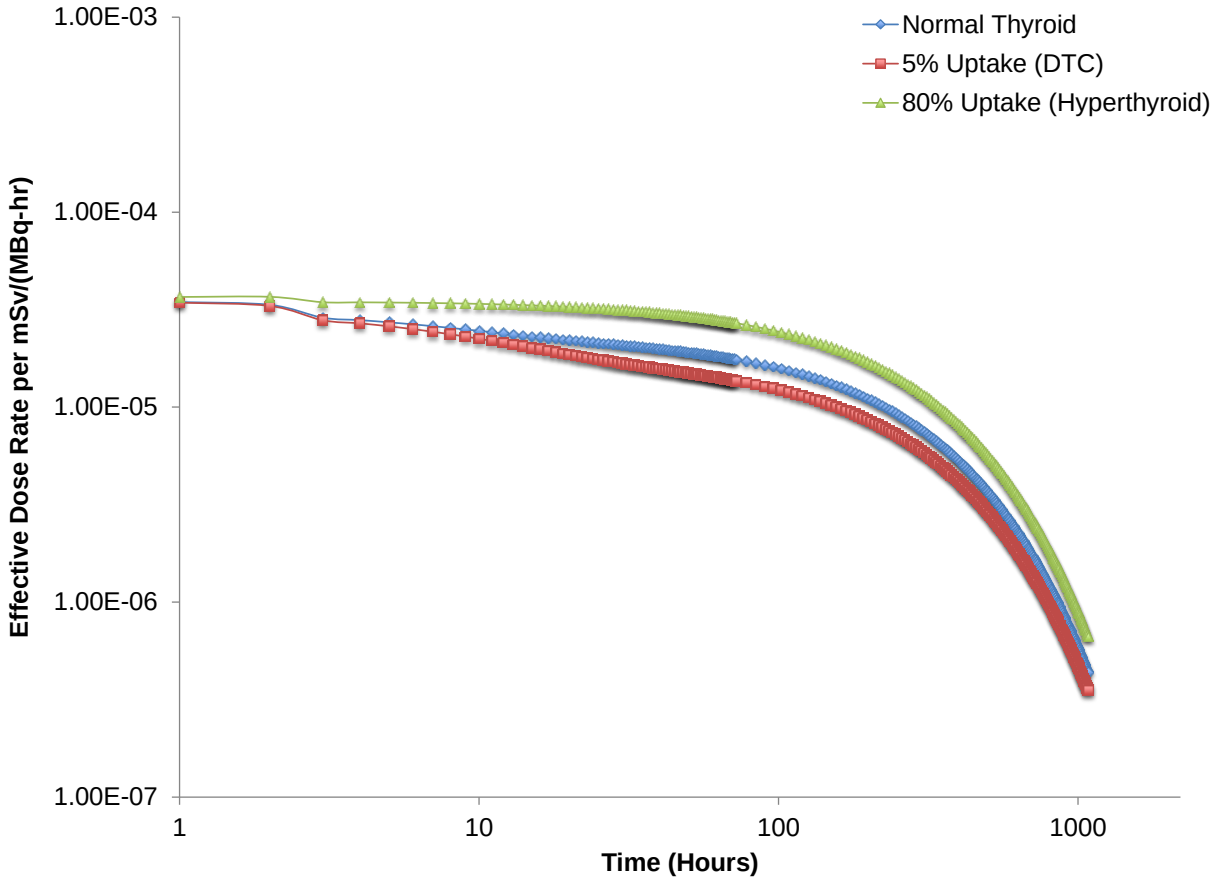


Figure B-37. Effective dose rate as a function of administered activity for public transportation scenario: patient seated beside member of public (single void at 2 hr post-administration).

Table B-10. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated beside member of public (single void at 2 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.56E-05	3.55E-05	3.66E-05
0.5	**0.02**	3.52E-05	3.51E-05	3.66E-05
1	**0.04**	3.46E-05	3.43E-05	3.67E-05
2	**0.08**	3.35E-05	3.30E-05	3.68E-05
3	**0.13**	2.88E-05	2.79E-05	3.45E-05
4	**0.17**	2.79E-05	2.69E-05	3.45E-05
5	**0.21**	2.72E-05	2.60E-05	3.44E-05
6	**0.25**	2.66E-05	2.51E-05	3.43E-05
7	**0.29**	2.60E-05	2.43E-05	3.42E-05
8	**0.33**	2.55E-05	2.36E-05	3.41E-05
9	**0.38**	2.50E-05	2.30E-05	3.40E-05
10	**0.42**	2.46E-05	2.24E-05	3.38E-05
12	**0.50**	2.39E-05	2.14E-05	3.36E-05
24	**1.00**	2.15E-05	1.77E-05	3.22E-05
36	**1.50**	2.02E-05	1.61E-05	3.08E-05
48	**2.00**	1.92E-05	1.51E-05	2.94E-05
60	**2.50**	1.84E-05	1.43E-05	2.82E-05
72	**3.00**	1.76E-05	1.36E-05	2.70E-05
84	**3.50**	1.68E-05	1.30E-05	2.58E-05
96	**4.00**	1.61E-05	1.25E-05	2.47E-05
108	**4.50**	1.54E-05	1.19E-05	2.36E-05
120	**5.00**	1.47E-05	1.14E-05	2.26E-05
132	**5.50**	1.41E-05	1.09E-05	2.17E-05
144	**6.00**	1.35E-05	1.05E-05	2.07E-05
156	**6.50**	1.29E-05	1.00E-05	1.99E-05
168	**7.00**	1.24E-05	9.61E-06	1.90E-05
240	**10.00**	9.51E-06	7.41E-06	1.46E-05
360	**15.00**	6.13E-06	4.80E-06	9.40E-06
480	**20.00**	3.95E-06	3.11E-06	6.06E-06
600	**25.00**	2.54E-06	2.01E-06	3.90E-06
720	**30.00**	1.64E-06	1.30E-06	2.51E-06
840	**35.00**	1.05E-06	8.44E-07	1.61E-06
960	**40.00**	6.78E-07	5.47E-07	1.04E-06
1080	**45.00**	4.36E-07	3.54E-07	6.68E-07
1200	**50.00**	2.81E-07	2.29E-07	4.29E-07
1320	**55.00**	1.81E-07	1.48E-07	2.76E-07
1440	**60.00**	1.16E-07	9.62E-08	1.78E-07
1560	**65.00**	7.50E-08	6.23E-08	1.14E-07
1680	**70.00**	4.83E-08	4.04E-08	7.35E-08
1800	**75.00**	3.11E-08	2.62E-08	4.73E-08
1920	**80.00**	2.01E-08	1.69E-08	3.04E-08
2040	**85.00**	1.29E-08	1.10E-08	1.96E-08
2160	**90.00**	8.33E-09	7.11E-09	1.26E-08

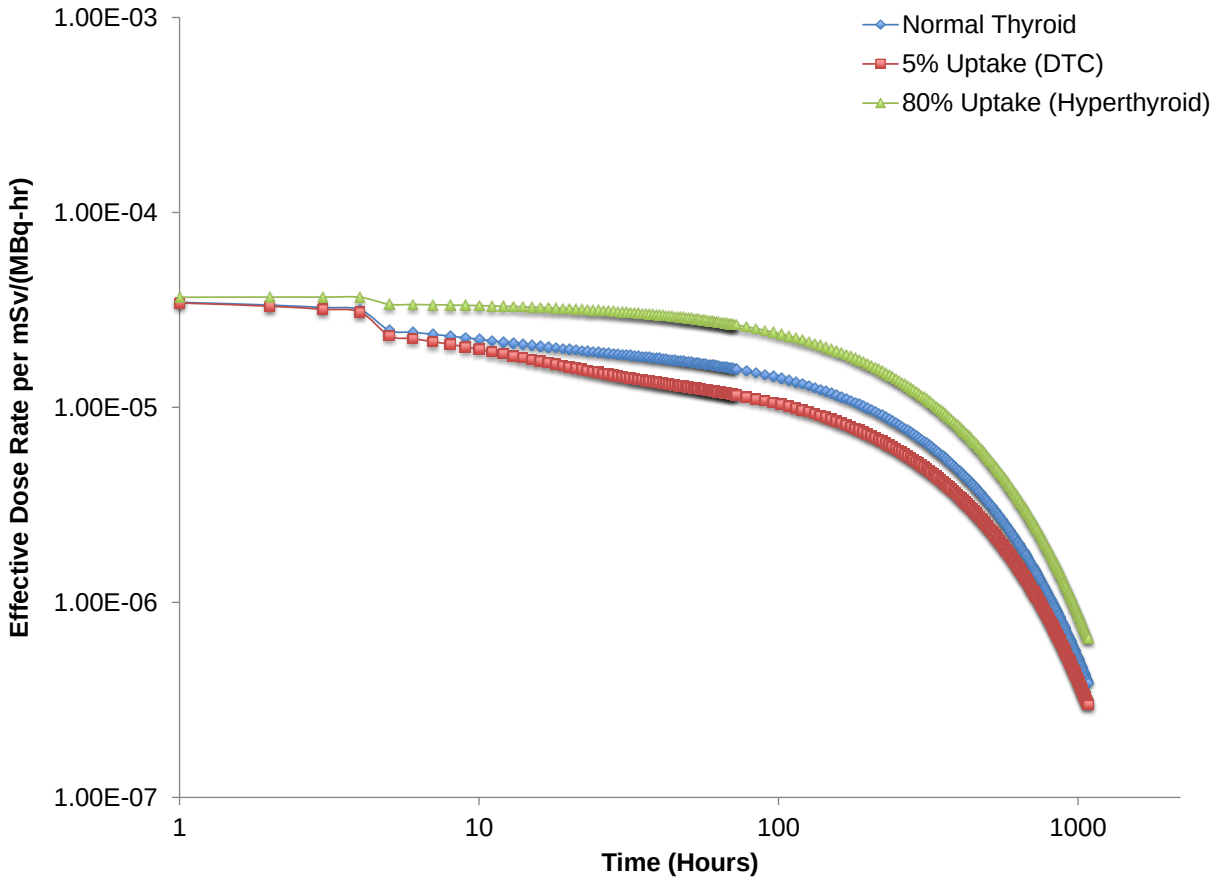


Figure B-38. Effective dose rate as a function of administered activity for public transportation scenario: patient seated beside member of public (single void at 4 hr post-administration).

Table B-11. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated beside member of public (single void at 4 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.56E-05	3.55E-05	3.66E-05
0.5	**0.02**	3.52E-05	3.51E-05	3.66E-05
1	**0.04**	3.46E-05	3.43E-05	3.67E-05
2	**0.08**	3.35E-05	3.30E-05	3.68E-05
3	**0.13**	3.25E-05	3.19E-05	3.68E-05
4	**0.17**	3.17E-05	3.08E-05	3.67E-05
5	**0.21**	2.49E-05	2.33E-05	3.38E-05
6	**0.25**	2.43E-05	2.25E-05	3.37E-05
7	**0.29**	2.37E-05	2.17E-05	3.36E-05
8	**0.33**	2.32E-05	2.10E-05	3.35E-05
9	**0.38**	2.27E-05	2.04E-05	3.34E-05
10	**0.42**	2.23E-05	1.98E-05	3.33E-05
12	**0.50**	2.16E-05	1.88E-05	3.30E-05
24	**1.00**	1.93E-05	1.53E-05	3.16E-05
36	**1.50**	1.81E-05	1.37E-05	3.02E-05
48	**2.00**	1.73E-05	1.28E-05	2.89E-05
60	**2.50**	1.65E-05	1.22E-05	2.77E-05
72	**3.00**	1.57E-05	1.16E-05	2.65E-05
84	**3.50**	1.51E-05	1.11E-05	2.54E-05
96	**4.00**	1.44E-05	1.06E-05	2.43E-05
108	**4.50**	1.38E-05	1.01E-05	2.32E-05
120	**5.00**	1.32E-05	9.70E-06	2.22E-05
132	**5.50**	1.26E-05	9.28E-06	2.13E-05
144	**6.00**	1.21E-05	8.89E-06	2.04E-05
156	**6.50**	1.16E-05	8.51E-06	1.95E-05
168	**7.00**	1.11E-05	8.15E-06	1.87E-05
240	**10.00**	8.52E-06	6.28E-06	1.43E-05
360	**15.00**	5.48E-06	4.07E-06	9.24E-06
480	**20.00**	3.53E-06	2.63E-06	5.95E-06
600	**25.00**	2.27E-06	1.70E-06	3.83E-06
720	**30.00**	1.46E-06	1.10E-06	2.46E-06
840	**35.00**	9.38E-07	7.14E-07	1.58E-06
960	**40.00**	6.03E-07	4.62E-07	1.02E-06
1080	**45.00**	3.88E-07	2.99E-07	6.55E-07
1200	**50.00**	2.49E-07	1.94E-07	4.21E-07
1320	**55.00**	1.60E-07	1.25E-07	2.71E-07
1440	**60.00**	1.03E-07	8.12E-08	1.74E-07
1560	**65.00**	6.64E-08	5.26E-08	1.12E-07
1680	**70.00**	4.27E-08	3.41E-08	7.21E-08
1800	**75.00**	2.75E-08	2.21E-08	4.64E-08
1920	**80.00**	1.77E-08	1.43E-08	2.98E-08
2040	**85.00**	1.14E-08	9.25E-09	1.92E-08
2160	**90.00**	7.34E-09	5.99E-09	1.23E-08

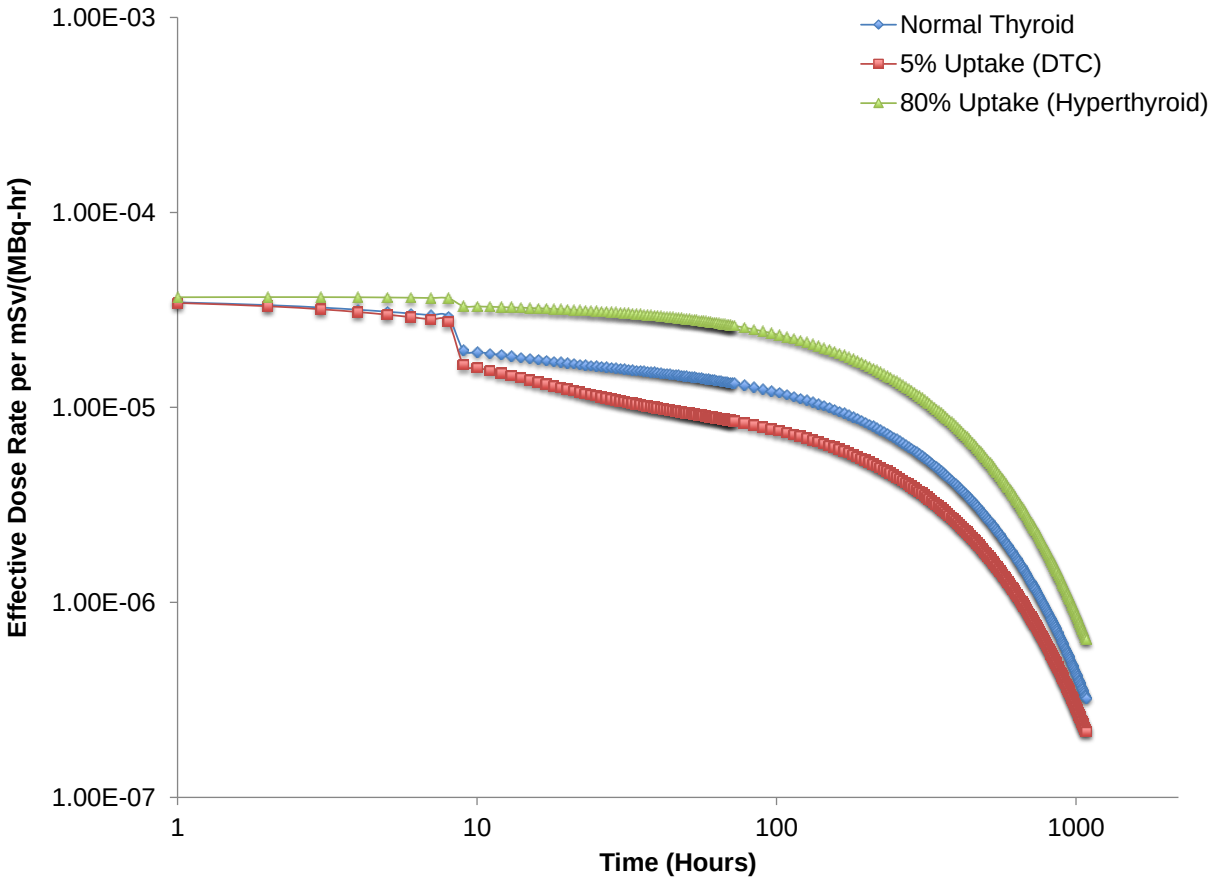


Figure B-39. Effective dose rate as a function of administered activity for public transportation scenario: patient seated beside member of public (single void at 8 hr post-administration).

Table B-12. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated beside member of public (single void at 8 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.56E-05	3.55E-05	3.66E-05
0.5	**0.02**	3.52E-05	3.51E-05	3.66E-05
1	**0.04**	3.46E-05	3.43E-05	3.67E-05
2	**0.08**	3.35E-05	3.30E-05	3.68E-05
3	**0.13**	3.25E-05	3.19E-05	3.68E-05
4	**0.17**	3.17E-05	3.08E-05	3.67E-05
5	**0.21**	3.10E-05	2.99E-05	3.66E-05
6	**0.25**	3.03E-05	2.90E-05	3.65E-05
7	**0.29**	2.97E-05	2.82E-05	3.64E-05
8	**0.33**	2.92E-05	2.75E-05	3.63E-05
9	**0.38**	1.96E-05	1.65E-05	3.30E-05
10	**0.42**	1.92E-05	1.60E-05	3.29E-05
12	**0.50**	1.86E-05	1.50E-05	3.27E-05
24	**1.00**	1.64E-05	1.16E-05	3.13E-05
36	**1.50**	1.53E-05	1.02E-05	2.99E-05
48	**2.00**	1.46E-05	9.48E-06	2.86E-05
60	**2.50**	1.39E-05	8.94E-06	2.74E-05
72	**3.00**	1.33E-05	8.51E-06	2.62E-05
84	**3.50**	1.27E-05	8.12E-06	2.51E-05
96	**4.00**	1.21E-05	7.76E-06	2.40E-05
108	**4.50**	1.16E-05	7.43E-06	2.30E-05
120	**5.00**	1.11E-05	7.11E-06	2.20E-05
132	**5.50**	1.06E-05	6.80E-06	2.11E-05
144	**6.00**	1.02E-05	6.51E-06	2.02E-05
156	**6.50**	9.75E-06	6.24E-06	1.93E-05
168	**7.00**	9.33E-06	5.97E-06	1.85E-05
240	**10.00**	7.17E-06	4.60E-06	1.42E-05
360	**15.00**	4.61E-06	2.98E-06	9.15E-06
480	**20.00**	2.96E-06	1.92E-06	5.89E-06
600	**25.00**	1.90E-06	1.24E-06	3.79E-06
720	**30.00**	1.22E-06	8.05E-07	2.44E-06
840	**35.00**	7.83E-07	5.20E-07	1.57E-06
960	**40.00**	5.02E-07	3.36E-07	1.01E-06
1080	**45.00**	3.22E-07	2.18E-07	6.48E-07
1200	**50.00**	2.07E-07	1.41E-07	4.17E-07
1320	**55.00**	1.33E-07	9.10E-08	2.68E-07
1440	**60.00**	8.53E-08	5.89E-08	1.72E-07
1560	**65.00**	5.48E-08	3.81E-08	1.11E-07
1680	**70.00**	3.52E-08	2.46E-08	7.13E-08
1800	**75.00**	2.26E-08	1.59E-08	4.58E-08
1920	**80.00**	1.45E-08	1.03E-08	2.95E-08
2040	**85.00**	9.33E-09	6.68E-09	1.90E-08
2160	**90.00**	6.00E-09	4.32E-09	1.22E-08

B.1.5 v) Public Transportation: Patient Standing Beside Seated Member of Public

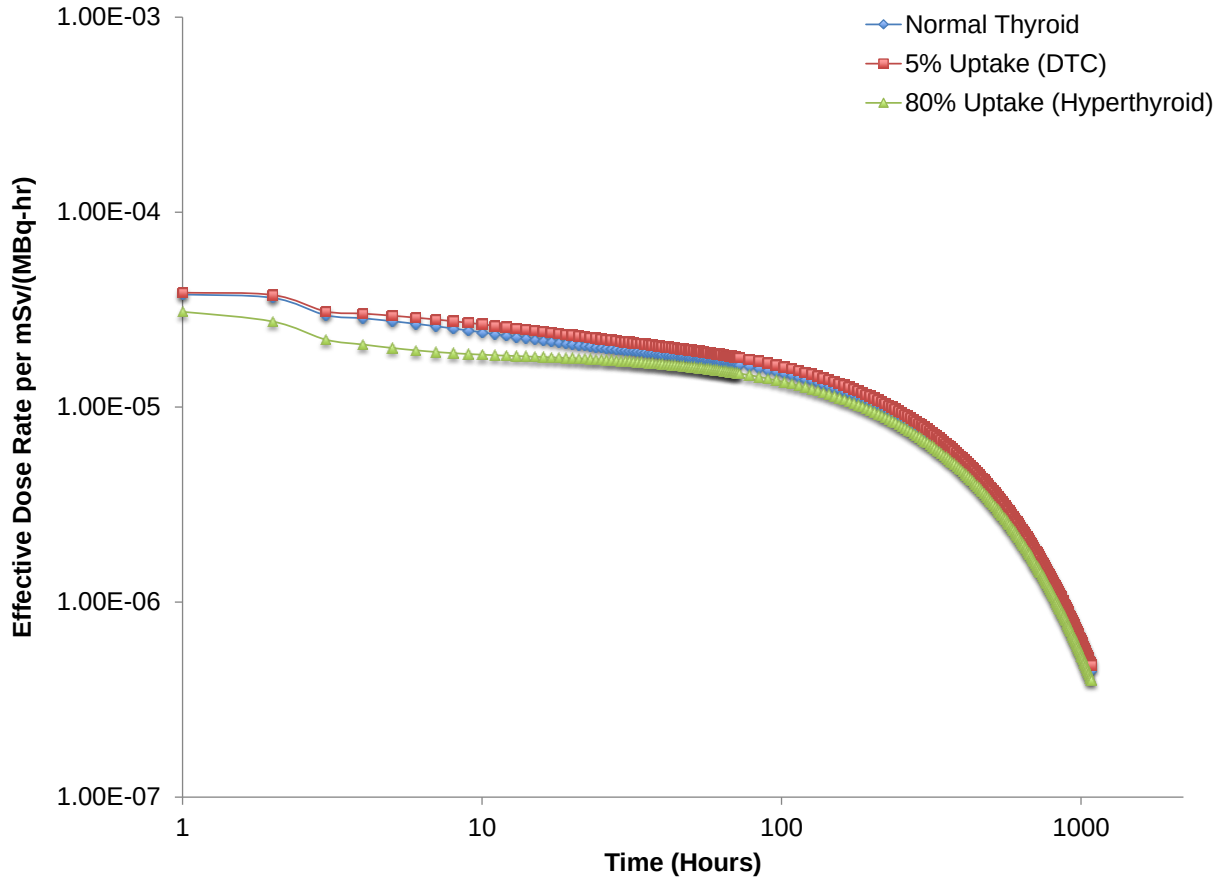


Figure B-40. Effective dose rate as a function of administered activity for public transportation scenario: patient standing beside seated member of public (single void at 2 hr post-administration)

Table B-13. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient standing beside seated member of public (single void at 2 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.92E-05	3.95E-05	3.54E-05
0.5	**0.02**	3.87E-05	3.92E-05	3.34E-05
1	**0.04**	3.78E-05	3.86E-05	3.08E-05
2	**0.08**	3.63E-05	3.76E-05	2.75E-05
3	**0.13**	2.96E-05	3.10E-05	2.22E-05
4	**0.17**	2.86E-05	3.02E-05	2.09E-05
5	**0.21**	2.76E-05	2.94E-05	2.01E-05
6	**0.25**	2.67E-05	2.88E-05	1.96E-05
7	**0.29**	2.60E-05	2.81E-05	1.92E-05
8	**0.33**	2.53E-05	2.76E-05	1.89E-05
9	**0.38**	2.47E-05	2.70E-05	1.87E-05
10	**0.42**	2.42E-05	2.66E-05	1.86E-05
12	**0.50**	2.33E-05	2.57E-05	1.84E-05
24	**1.00**	2.04E-05	2.25E-05	1.76E-05
36	**1.50**	1.91E-05	2.09E-05	1.69E-05
48	**2.00**	1.81E-05	1.97E-05	1.62E-05
60	**2.50**	1.73E-05	1.88E-05	1.55E-05
72	**3.00**	1.66E-05	1.79E-05	1.49E-05
84	**3.50**	1.59E-05	1.72E-05	1.43E-05
96	**4.00**	1.52E-05	1.64E-05	1.37E-05
108	**4.50**	1.46E-05	1.57E-05	1.32E-05
120	**5.00**	1.40E-05	1.51E-05	1.26E-05
132	**5.50**	1.34E-05	1.44E-05	1.21E-05
144	**6.00**	1.28E-05	1.38E-05	1.16E-05
156	**6.50**	1.23E-05	1.32E-05	1.12E-05
168	**7.00**	1.18E-05	1.27E-05	1.07E-05
240	**10.00**	9.11E-06	9.78E-06	8.31E-06
360	**15.00**	5.93E-06	6.35E-06	5.42E-06
480	**20.00**	3.86E-06	4.13E-06	3.52E-06
600	**25.00**	2.51E-06	2.68E-06	2.28E-06
720	**30.00**	1.63E-06	1.74E-06	1.48E-06
840	**35.00**	1.06E-06	1.13E-06	9.55E-07
960	**40.00**	6.86E-07	7.33E-07	6.17E-07
1080	**45.00**	4.45E-07	4.76E-07	3.99E-07
1200	**50.00**	2.89E-07	3.09E-07	2.58E-07
1320	**55.00**	1.88E-07	2.01E-07	1.66E-07
1440	**60.00**	1.22E-07	1.30E-07	1.07E-07
1560	**65.00**	7.90E-08	8.45E-08	6.94E-08
1680	**70.00**	5.13E-08	5.49E-08	4.48E-08
1800	**75.00**	3.33E-08	3.56E-08	2.90E-08
1920	**80.00**	2.16E-08	2.31E-08	1.87E-08
2040	**85.00**	1.40E-08	1.50E-08	1.21E-08
2160	**90.00**	9.10E-09	9.75E-09	7.81E-09

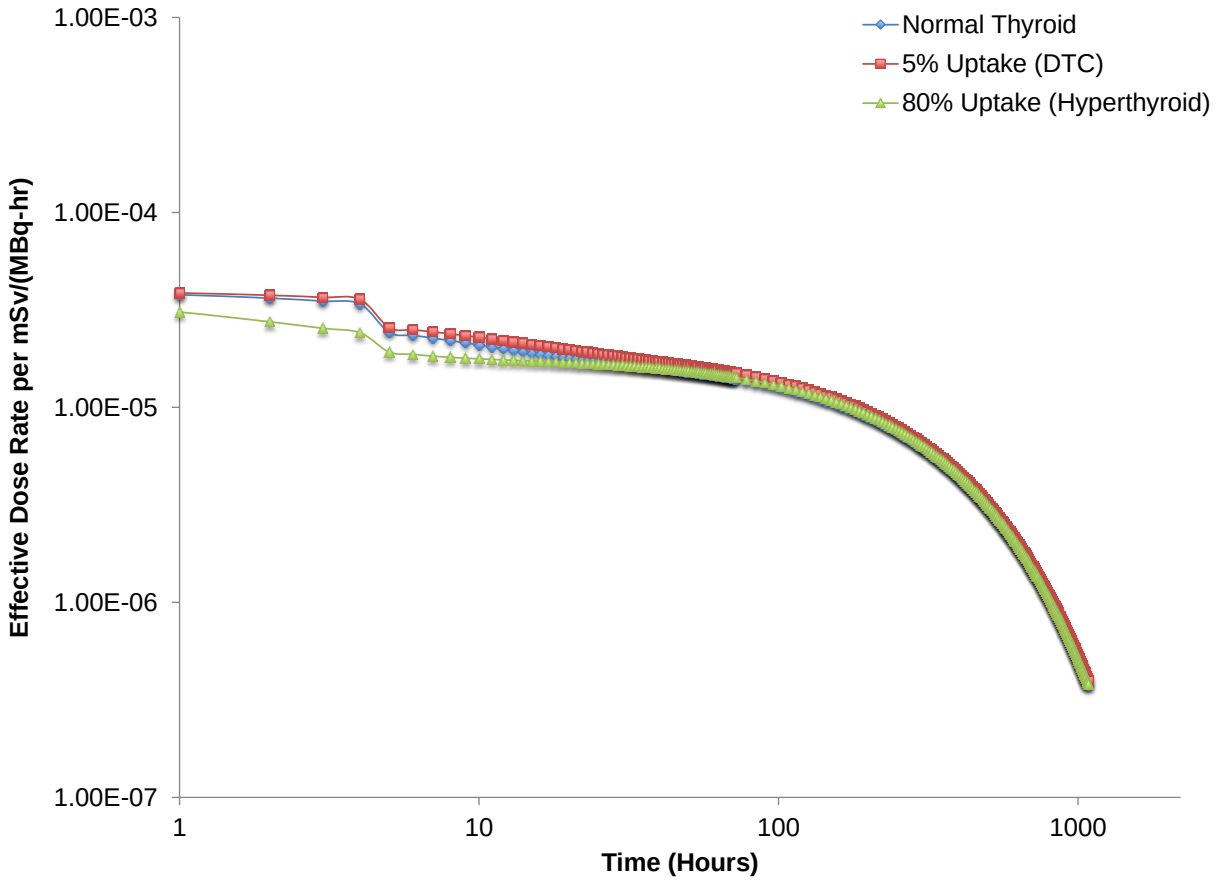


Figure B-41. Effective dose rate as a function of administered activity for public transportation scenario: patient standing beside seated member of public (single void at 4 hr post-administration)

Table B-14. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient standing beside seated member of public (single void at 4 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.92E-05	3.95E-05	3.54E-05
0.5	**0.02**	3.87E-05	3.92E-05	3.34E-05
1	**0.04**	3.78E-05	3.86E-05	3.08E-05
2	**0.08**	3.63E-05	3.76E-05	2.75E-05
3	**0.13**	3.51E-05	3.67E-05	2.54E-05
4	**0.17**	3.39E-05	3.58E-05	2.42E-05
5	**0.21**	2.43E-05	2.57E-05	1.93E-05
6	**0.25**	2.34E-05	2.50E-05	1.87E-05
7	**0.29**	2.27E-05	2.44E-05	1.83E-05
8	**0.33**	2.20E-05	2.38E-05	1.81E-05
9	**0.38**	2.14E-05	2.33E-05	1.79E-05
10	**0.42**	2.09E-05	2.29E-05	1.77E-05
12	**0.50**	2.00E-05	2.20E-05	1.75E-05
24	**1.00**	1.72E-05	1.90E-05	1.68E-05
36	**1.50**	1.61E-05	1.75E-05	1.61E-05
48	**2.00**	1.53E-05	1.65E-05	1.54E-05
60	**2.50**	1.46E-05	1.57E-05	1.48E-05
72	**3.00**	1.40E-05	1.50E-05	1.42E-05
84	**3.50**	1.34E-05	1.43E-05	1.37E-05
96	**4.00**	1.28E-05	1.37E-05	1.31E-05
108	**4.50**	1.23E-05	1.31E-05	1.26E-05
120	**5.00**	1.18E-05	1.26E-05	1.21E-05
132	**5.50**	1.13E-05	1.20E-05	1.16E-05
144	**6.00**	1.08E-05	1.15E-05	1.11E-05
156	**6.50**	1.04E-05	1.10E-05	1.07E-05
168	**7.00**	9.92E-06	1.06E-05	1.02E-05
240	**10.00**	7.68E-06	8.16E-06	7.94E-06
360	**15.00**	5.00E-06	5.30E-06	5.18E-06
480	**20.00**	3.25E-06	3.44E-06	3.37E-06
600	**25.00**	2.12E-06	2.24E-06	2.18E-06
720	**30.00**	1.37E-06	1.45E-06	1.41E-06
840	**35.00**	8.92E-07	9.42E-07	9.13E-07
960	**40.00**	5.79E-07	6.12E-07	5.90E-07
1080	**45.00**	3.76E-07	3.97E-07	3.81E-07
1200	**50.00**	2.44E-07	2.58E-07	2.46E-07
1320	**55.00**	1.58E-07	1.67E-07	1.59E-07
1440	**60.00**	1.03E-07	1.09E-07	1.03E-07
1560	**65.00**	6.67E-08	7.05E-08	6.63E-08
1680	**70.00**	4.33E-08	4.58E-08	4.28E-08
1800	**75.00**	2.81E-08	2.97E-08	2.76E-08
1920	**80.00**	1.82E-08	1.93E-08	1.78E-08
2040	**85.00**	1.18E-08	1.25E-08	1.15E-08
2160	**90.00**	7.68E-09	8.13E-09	7.44E-09

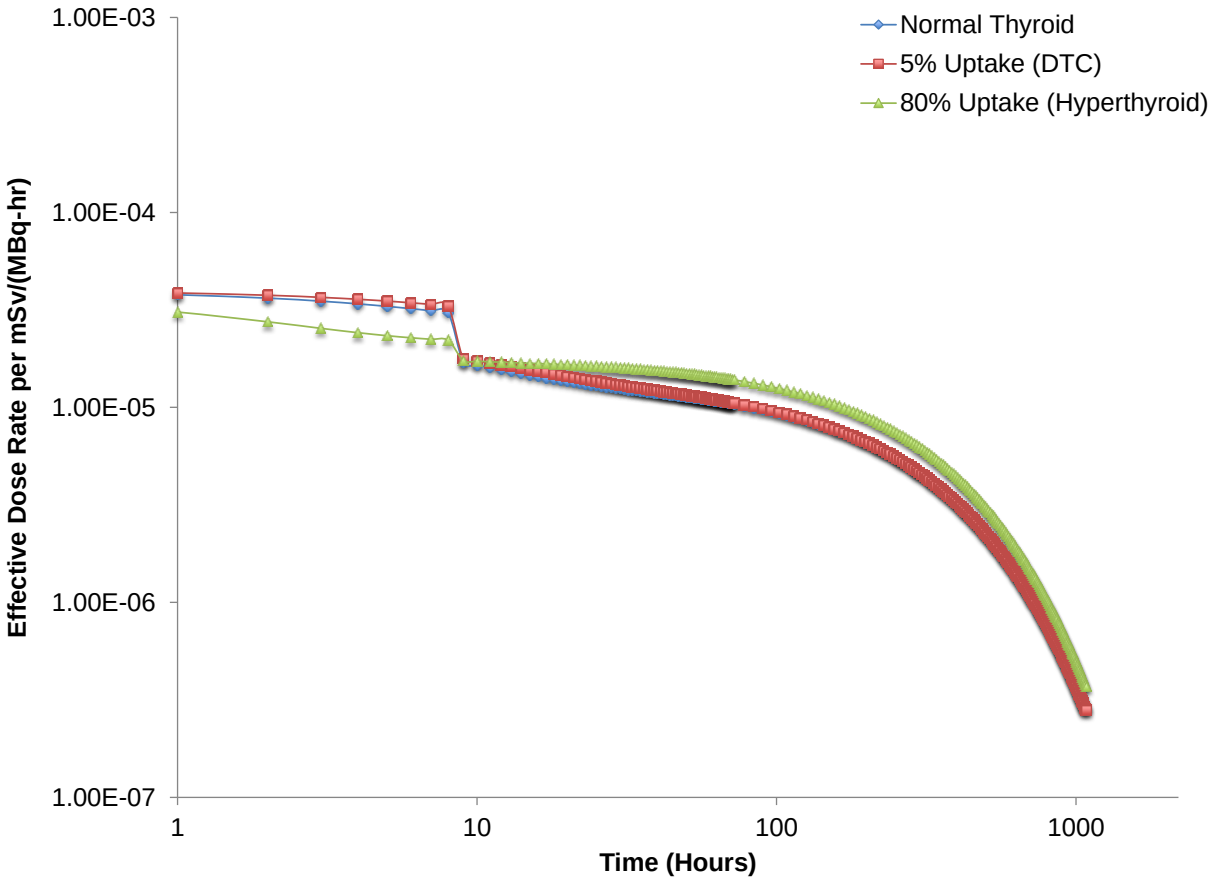


Figure B-42. Effective dose rate as a function of administered activity for public transportation scenario: patient standing beside seated member of public (single void at 8 hr post-administration).

Table B-15. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient standing beside seated member of public (single void at 8 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.92E-05	3.95E-05	3.54E-05
0.5	**0.02**	3.87E-05	3.92E-05	3.34E-05
1	**0.04**	3.78E-05	3.86E-05	3.08E-05
2	**0.08**	3.63E-05	3.76E-05	2.75E-05
3	**0.13**	3.51E-05	3.67E-05	2.54E-05
4	**0.17**	3.39E-05	3.58E-05	2.42E-05
5	**0.21**	3.30E-05	3.51E-05	2.33E-05
6	**0.25**	3.21E-05	3.44E-05	2.28E-05
7	**0.29**	3.13E-05	3.37E-05	2.24E-05
8	**0.33**	3.06E-05	3.32E-05	2.21E-05
9	**0.38**	1.70E-05	1.78E-05	1.74E-05
10	**0.42**	1.65E-05	1.73E-05	1.73E-05
12	**0.50**	1.56E-05	1.65E-05	1.71E-05
24	**1.00**	1.30E-05	1.37E-05	1.63E-05
36	**1.50**	1.20E-05	1.25E-05	1.57E-05
48	**2.00**	1.14E-05	1.17E-05	1.50E-05
60	**2.50**	1.09E-05	1.11E-05	1.44E-05
72	**3.00**	1.04E-05	1.05E-05	1.38E-05
84	**3.50**	9.95E-06	1.01E-05	1.33E-05
96	**4.00**	9.54E-06	9.63E-06	1.28E-05
108	**4.50**	9.14E-06	9.22E-06	1.22E-05
120	**5.00**	8.76E-06	8.83E-06	1.17E-05
132	**5.50**	8.40E-06	8.45E-06	1.13E-05
144	**6.00**	8.05E-06	8.10E-06	1.08E-05
156	**6.50**	7.72E-06	7.75E-06	1.04E-05
168	**7.00**	7.40E-06	7.43E-06	9.95E-06
240	**10.00**	5.74E-06	5.74E-06	7.73E-06
360	**15.00**	3.74E-06	3.73E-06	5.05E-06
480	**20.00**	2.44E-06	2.42E-06	3.28E-06
600	**25.00**	1.58E-06	1.57E-06	2.12E-06
720	**30.00**	1.03E-06	1.02E-06	1.37E-06
840	**35.00**	6.68E-07	6.63E-07	8.89E-07
960	**40.00**	4.34E-07	4.31E-07	5.74E-07
1080	**45.00**	2.81E-07	2.80E-07	3.71E-07
1200	**50.00**	1.83E-07	1.82E-07	2.39E-07
1320	**55.00**	1.18E-07	1.18E-07	1.55E-07
1440	**60.00**	7.69E-08	7.65E-08	9.98E-08
1560	**65.00**	4.99E-08	4.97E-08	6.45E-08
1680	**70.00**	3.24E-08	3.22E-08	4.16E-08
1800	**75.00**	2.10E-08	2.09E-08	2.69E-08
1920	**80.00**	1.36E-08	1.36E-08	1.74E-08
2040	**85.00**	8.85E-09	8.82E-09	1.12E-08
2160	**90.00**	5.74E-09	5.73E-09	7.24E-09

B.1.6 vi) Public Transportation: Patient Seated Beside Standing Member of Public

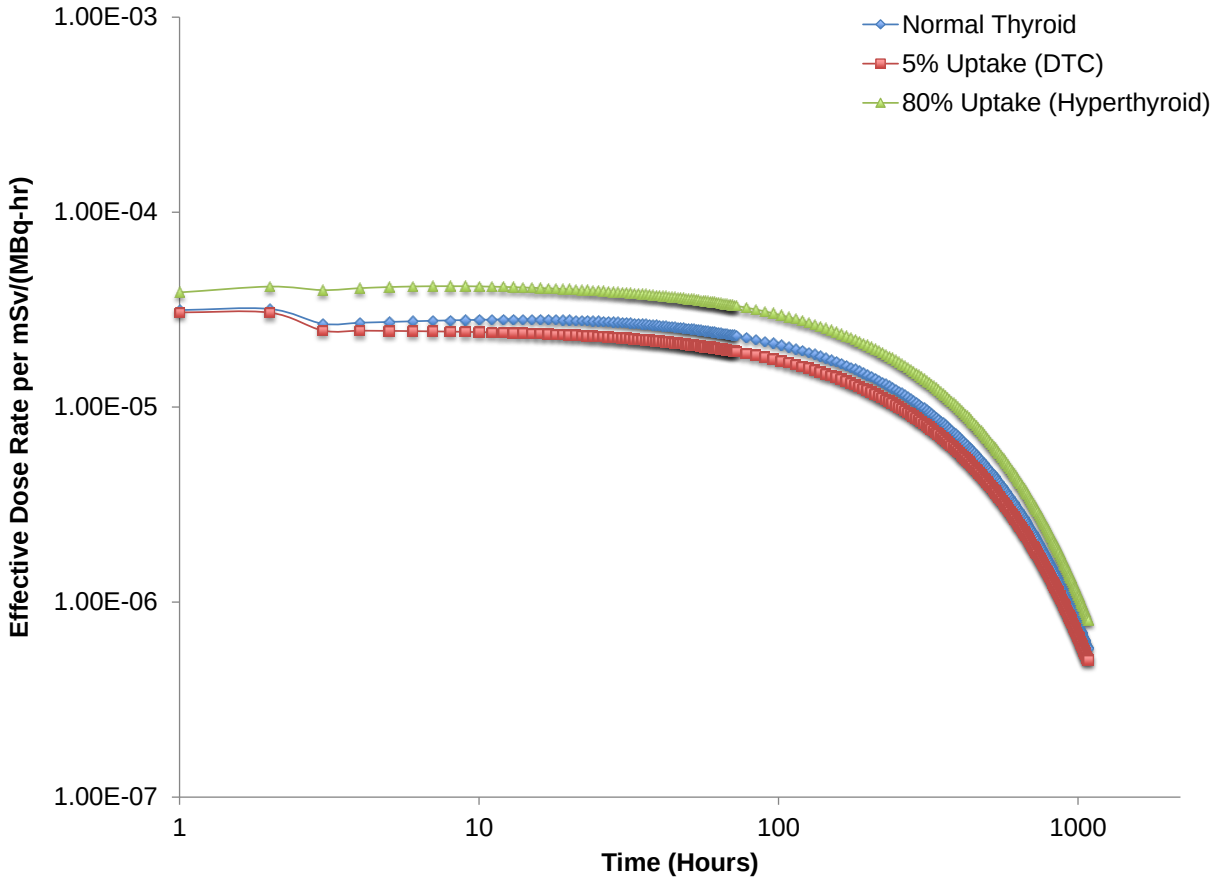


Figure B-43. Effective dose rate as a function of administered activity for public transportation scenario: patient seated beside standing member of public (single void at 2 hr post-administration).

Table B-16. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated beside standing member of public (single void at 2 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.10E-05	3.06E-05	3.48E-05
0.5	**0.02**	3.12E-05	3.06E-05	3.65E-05
1	**0.04**	3.14E-05	3.06E-05	3.88E-05
2	**0.08**	3.19E-05	3.05E-05	4.15E-05
3	**0.13**	2.68E-05	2.47E-05	3.98E-05
4	**0.17**	2.71E-05	2.47E-05	4.07E-05
5	**0.21**	2.73E-05	2.46E-05	4.13E-05
6	**0.25**	2.76E-05	2.45E-05	4.16E-05
7	**0.29**	2.77E-05	2.45E-05	4.17E-05
8	**0.33**	2.79E-05	2.44E-05	4.17E-05
9	**0.38**	2.80E-05	2.43E-05	4.17E-05
10	**0.42**	2.80E-05	2.42E-05	4.16E-05
12	**0.50**	2.81E-05	2.41E-05	4.14E-05
24	**1.00**	2.77E-05	2.31E-05	3.96E-05
36	**1.50**	2.66E-05	2.21E-05	3.79E-05
48	**2.00**	2.54E-05	2.11E-05	3.62E-05
60	**2.50**	2.43E-05	2.02E-05	3.46E-05
72	**3.00**	2.32E-05	1.93E-05	3.31E-05
84	**3.50**	2.22E-05	1.84E-05	3.17E-05
96	**4.00**	2.13E-05	1.76E-05	3.03E-05
108	**4.50**	2.04E-05	1.69E-05	2.90E-05
120	**5.00**	1.95E-05	1.62E-05	2.77E-05
132	**5.50**	1.86E-05	1.55E-05	2.65E-05
144	**6.00**	1.78E-05	1.48E-05	2.54E-05
156	**6.50**	1.71E-05	1.42E-05	2.43E-05
168	**7.00**	1.63E-05	1.36E-05	2.32E-05
240	**10.00**	1.26E-05	1.05E-05	1.78E-05
360	**15.00**	8.09E-06	6.79E-06	1.14E-05
480	**20.00**	5.21E-06	4.40E-06	7.35E-06
600	**25.00**	3.36E-06	2.85E-06	4.73E-06
720	**30.00**	2.16E-06	1.85E-06	3.04E-06
840	**35.00**	1.39E-06	1.20E-06	1.96E-06
960	**40.00**	8.99E-07	7.75E-07	1.26E-06
1080	**45.00**	5.80E-07	5.02E-07	8.10E-07
1200	**50.00**	3.74E-07	3.25E-07	5.21E-07
1320	**55.00**	2.41E-07	2.11E-07	3.36E-07
1440	**60.00**	1.56E-07	1.37E-07	2.16E-07
1560	**65.00**	1.00E-07	8.86E-08	1.39E-07
1680	**70.00**	6.47E-08	5.74E-08	8.95E-08
1800	**75.00**	4.18E-08	3.72E-08	5.76E-08
1920	**80.00**	2.70E-08	2.41E-08	3.71E-08
2040	**85.00**	1.74E-08	1.56E-08	2.39E-08
2160	**90.00**	1.12E-08	1.01E-08	1.54E-08

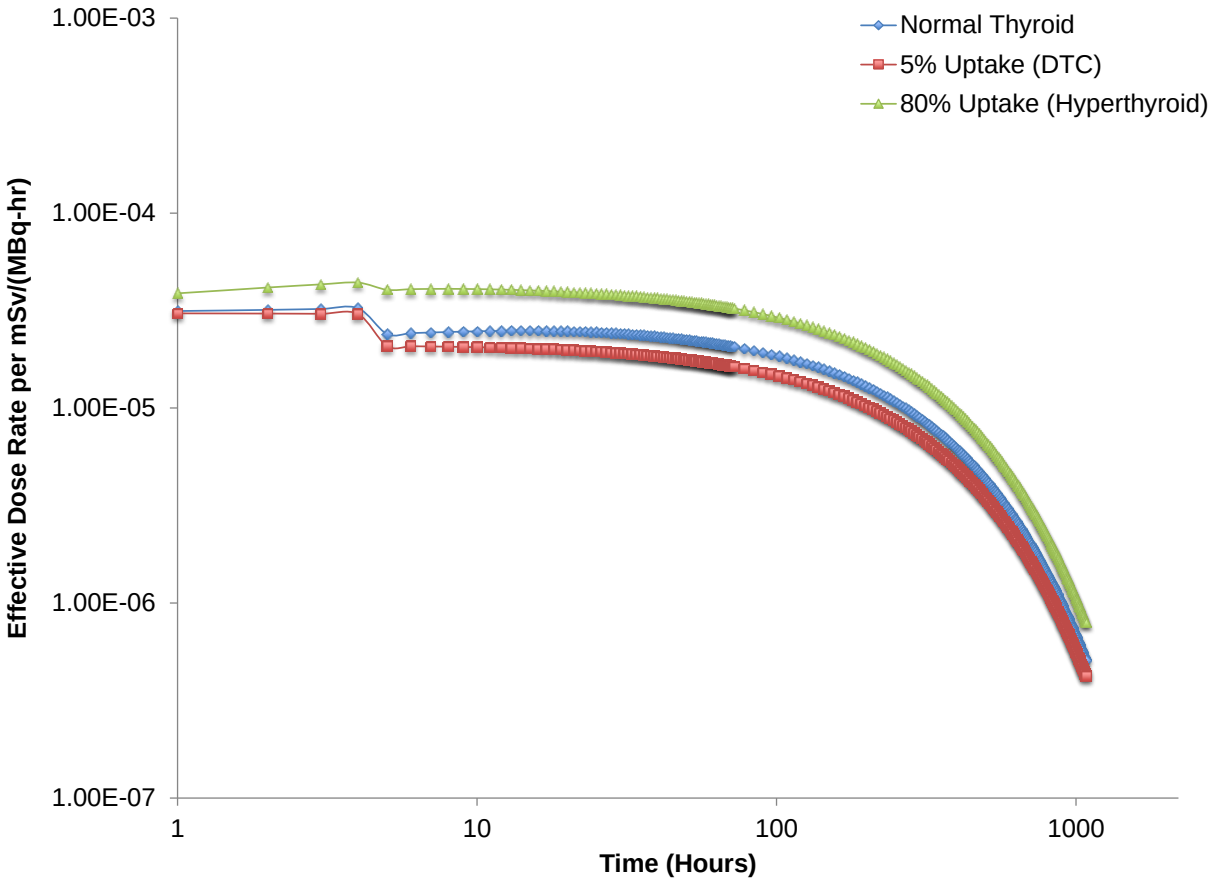


Figure B-44. Effective dose rate as a function of administered activity for public transportation scenario: patient seated beside standing member of public (single void at 4 hr post-administration).

Table B-17. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated beside standing member of public (single void at 4 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.10E-05	3.06E-05	3.48E-05
0.5	**0.02**	3.12E-05	3.06E-05	3.65E-05
1	**0.04**	3.14E-05	3.06E-05	3.88E-05
2	**0.08**	3.19E-05	3.05E-05	4.15E-05
3	**0.13**	3.22E-05	3.04E-05	4.31E-05
4	**0.17**	3.25E-05	3.04E-05	4.40E-05
5	**0.21**	2.40E-05	2.08E-05	4.04E-05
6	**0.25**	2.42E-05	2.07E-05	4.07E-05
7	**0.29**	2.44E-05	2.07E-05	4.08E-05
8	**0.33**	2.45E-05	2.06E-05	4.09E-05
9	**0.38**	2.47E-05	2.06E-05	4.08E-05
10	**0.42**	2.47E-05	2.05E-05	4.07E-05
12	**0.50**	2.49E-05	2.04E-05	4.05E-05
24	**1.00**	2.45E-05	1.96E-05	3.88E-05
36	**1.50**	2.36E-05	1.87E-05	3.71E-05
48	**2.00**	2.26E-05	1.78E-05	3.55E-05
60	**2.50**	2.16E-05	1.70E-05	3.39E-05
72	**3.00**	2.06E-05	1.63E-05	3.24E-05
84	**3.50**	1.97E-05	1.56E-05	3.10E-05
96	**4.00**	1.89E-05	1.49E-05	2.97E-05
108	**4.50**	1.80E-05	1.43E-05	2.84E-05
120	**5.00**	1.73E-05	1.37E-05	2.71E-05
132	**5.50**	1.65E-05	1.31E-05	2.60E-05
144	**6.00**	1.58E-05	1.25E-05	2.48E-05
156	**6.50**	1.51E-05	1.20E-05	2.38E-05
168	**7.00**	1.45E-05	1.15E-05	2.27E-05
240	**10.00**	1.11E-05	8.85E-06	1.74E-05
360	**15.00**	7.15E-06	5.73E-06	1.12E-05
480	**20.00**	4.61E-06	3.71E-06	7.19E-06
600	**25.00**	2.97E-06	2.40E-06	4.63E-06
720	**30.00**	1.91E-06	1.56E-06	2.98E-06
840	**35.00**	1.23E-06	1.01E-06	1.91E-06
960	**40.00**	7.92E-07	6.53E-07	1.23E-06
1080	**45.00**	5.10E-07	4.23E-07	7.93E-07
1200	**50.00**	3.29E-07	2.74E-07	5.10E-07
1320	**55.00**	2.12E-07	1.78E-07	3.28E-07
1440	**60.00**	1.36E-07	1.15E-07	2.11E-07
1560	**65.00**	8.80E-08	7.46E-08	1.36E-07
1680	**70.00**	5.67E-08	4.83E-08	8.74E-08
1800	**75.00**	3.66E-08	3.13E-08	5.63E-08
1920	**80.00**	2.36E-08	2.03E-08	3.62E-08
2040	**85.00**	1.52E-08	1.32E-08	2.33E-08
2160	**90.00**	9.81E-09	8.52E-09	1.50E-08

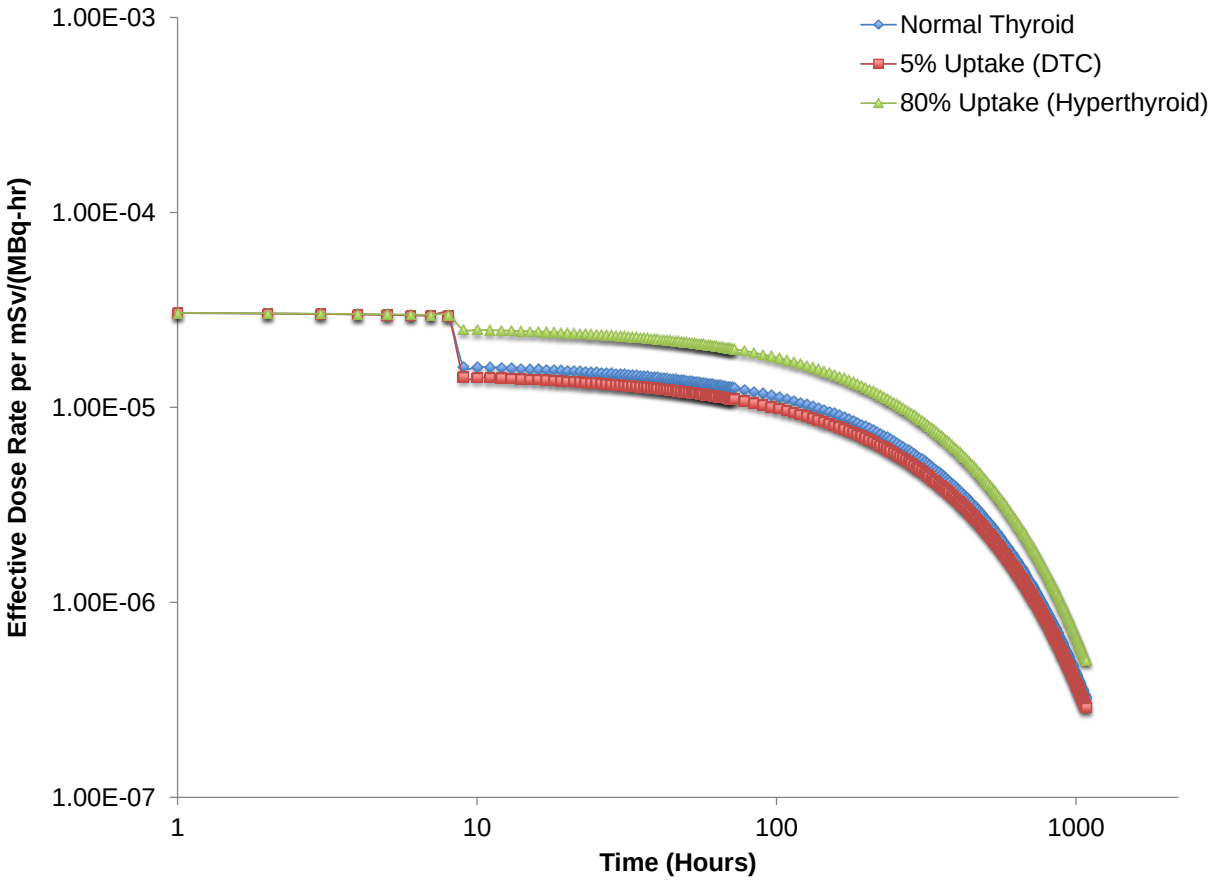


Figure B-45. Effective dose rate as a function of administered activity for public transportation scenario: patient seated beside standing member of public (single void at 8 hr post-administration).

Table B-18. Effective dose rate (mSv/MBq-hr) for public transportation scenario: patient seated beside standing member of public (single void at 8 hr post-administration)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.06E-05	3.06E-05	3.06E-05
0.5	**0.02**	3.05E-05	3.05E-05	3.06E-05
1	**0.04**	3.04E-05	3.04E-05	3.05E-05
2	**0.08**	3.03E-05	3.03E-05	3.04E-05
3	**0.13**	3.01E-05	3.01E-05	3.02E-05
4	**0.17**	3.00E-05	3.00E-05	3.01E-05
5	**0.21**	2.98E-05	2.98E-05	3.00E-05
6	**0.25**	2.97E-05	2.97E-05	2.99E-05
7	**0.29**	2.96E-05	2.95E-05	2.98E-05
8	**0.33**	2.94E-05	2.94E-05	2.97E-05
9	**0.38**	1.62E-05	1.43E-05	2.51E-05
10	**0.42**	1.61E-05	1.43E-05	2.50E-05
12	**0.50**	1.60E-05	1.41E-05	2.48E-05
24	**1.00**	1.52E-05	1.33E-05	2.37E-05
36	**1.50**	1.45E-05	1.27E-05	2.27E-05
48	**2.00**	1.38E-05	1.21E-05	2.18E-05
60	**2.50**	1.32E-05	1.15E-05	2.08E-05
72	**3.00**	1.26E-05	1.10E-05	1.99E-05
84	**3.50**	1.21E-05	1.05E-05	1.91E-05
96	**4.00**	1.16E-05	1.00E-05	1.83E-05
108	**4.50**	1.11E-05	9.62E-06	1.75E-05
120	**5.00**	1.06E-05	9.21E-06	1.68E-05
132	**5.50**	1.02E-05	8.82E-06	1.60E-05
144	**6.00**	9.72E-06	8.44E-06	1.54E-05
156	**6.50**	9.31E-06	8.09E-06	1.47E-05
168	**7.00**	8.91E-06	7.75E-06	1.41E-05
240	**10.00**	6.87E-06	5.98E-06	1.08E-05
360	**15.00**	4.44E-06	3.88E-06	7.00E-06
480	**20.00**	2.87E-06	2.51E-06	4.52E-06
600	**25.00**	1.86E-06	1.63E-06	2.91E-06
720	**30.00**	1.20E-06	1.06E-06	1.88E-06
840	**35.00**	7.77E-07	6.86E-07	1.21E-06
960	**40.00**	5.02E-07	4.45E-07	7.80E-07
1080	**45.00**	3.25E-07	2.88E-07	5.03E-07
1200	**50.00**	2.10E-07	1.87E-07	3.24E-07
1320	**55.00**	1.36E-07	1.21E-07	2.09E-07
1440	**60.00**	8.78E-08	7.87E-08	1.35E-07
1560	**65.00**	5.68E-08	5.11E-08	8.68E-08
1680	**70.00**	3.67E-08	3.31E-08	5.60E-08
1800	**75.00**	2.38E-08	2.15E-08	3.61E-08
1920	**80.00**	1.54E-08	1.39E-08	2.33E-08
2040	**85.00**	9.95E-09	9.04E-09	1.50E-08
2160	**90.00**	6.44E-09	5.86E-09	9.67E-09

B.1.7 Comparison of Public Transportation: Seated Scenarios

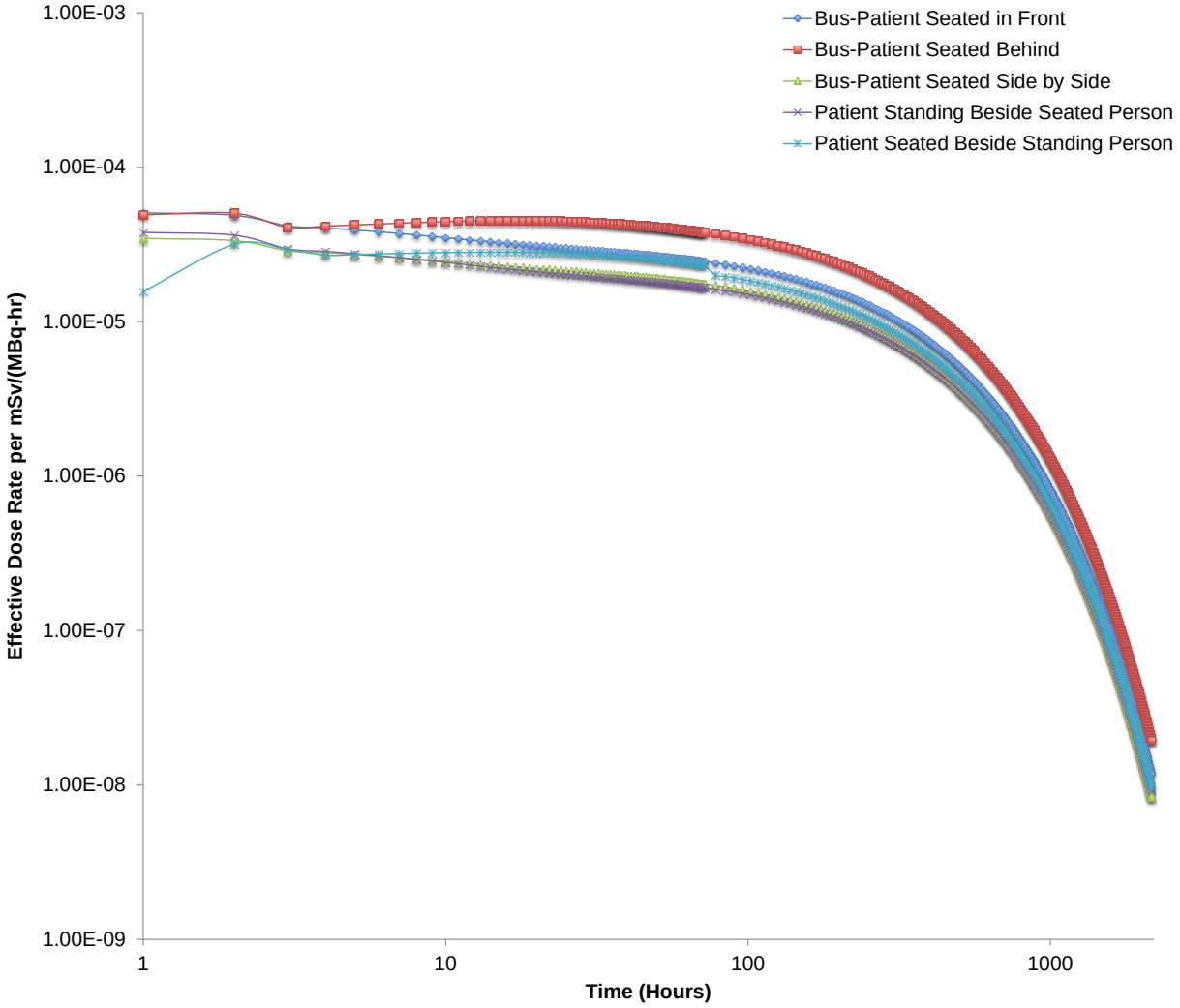


Figure B-46. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (normal thyroid uptake – single void at 2 hr).

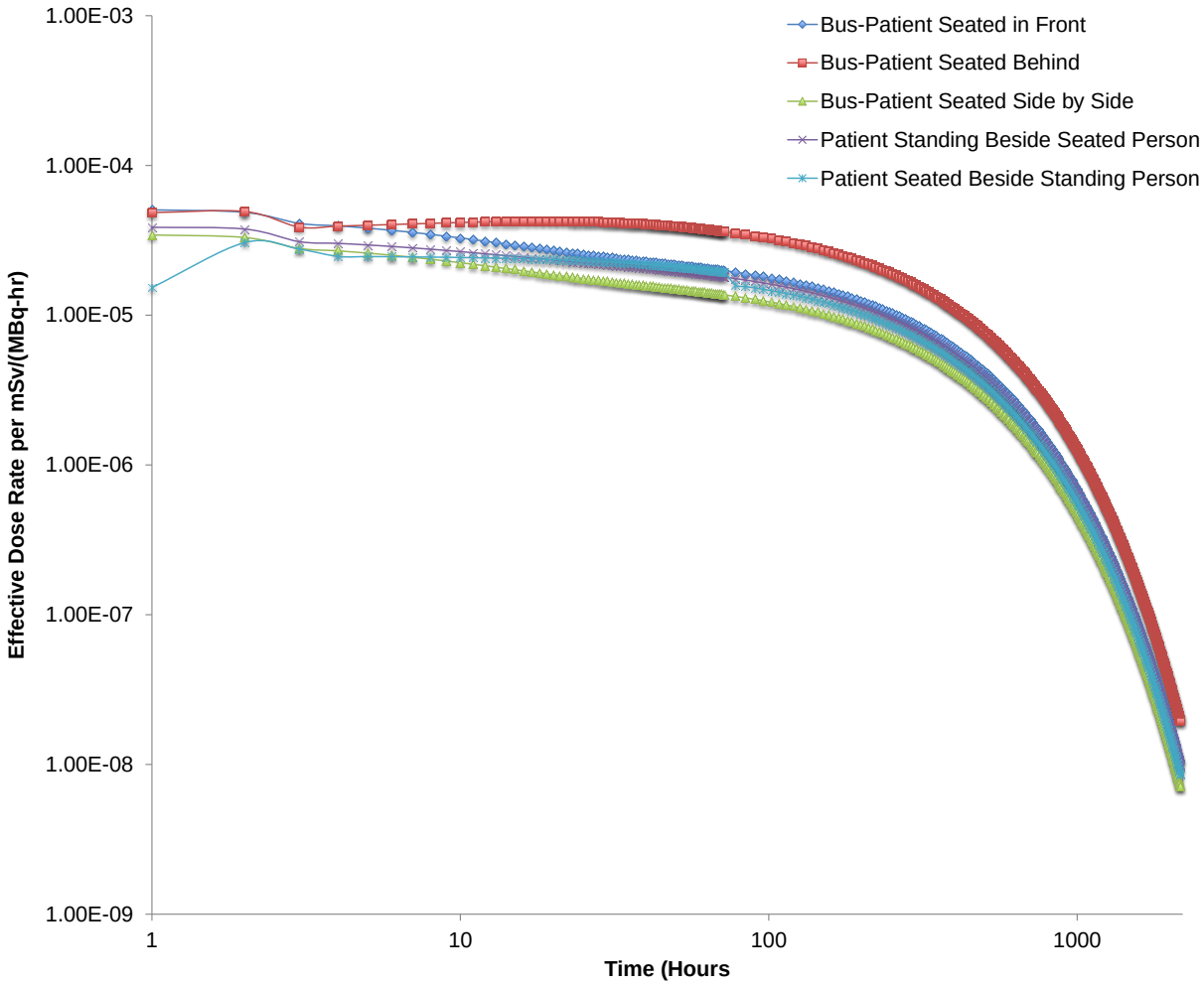


Figure B-47. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (DTC 5% thyroid uptake – single void at 2 hr).

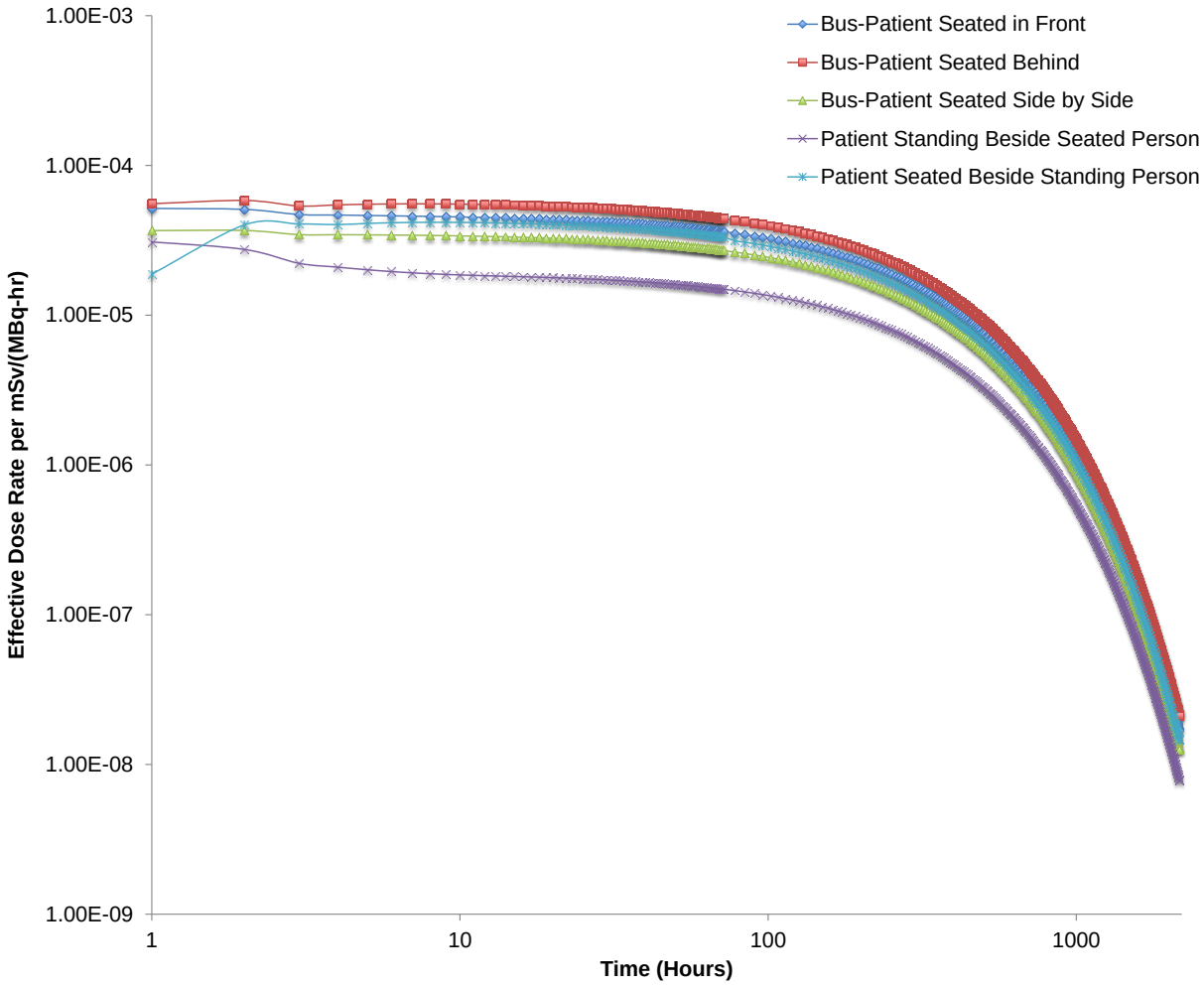


Figure B-48. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (hyperthyroid 80% thyroid uptake – single void at 2 hr).

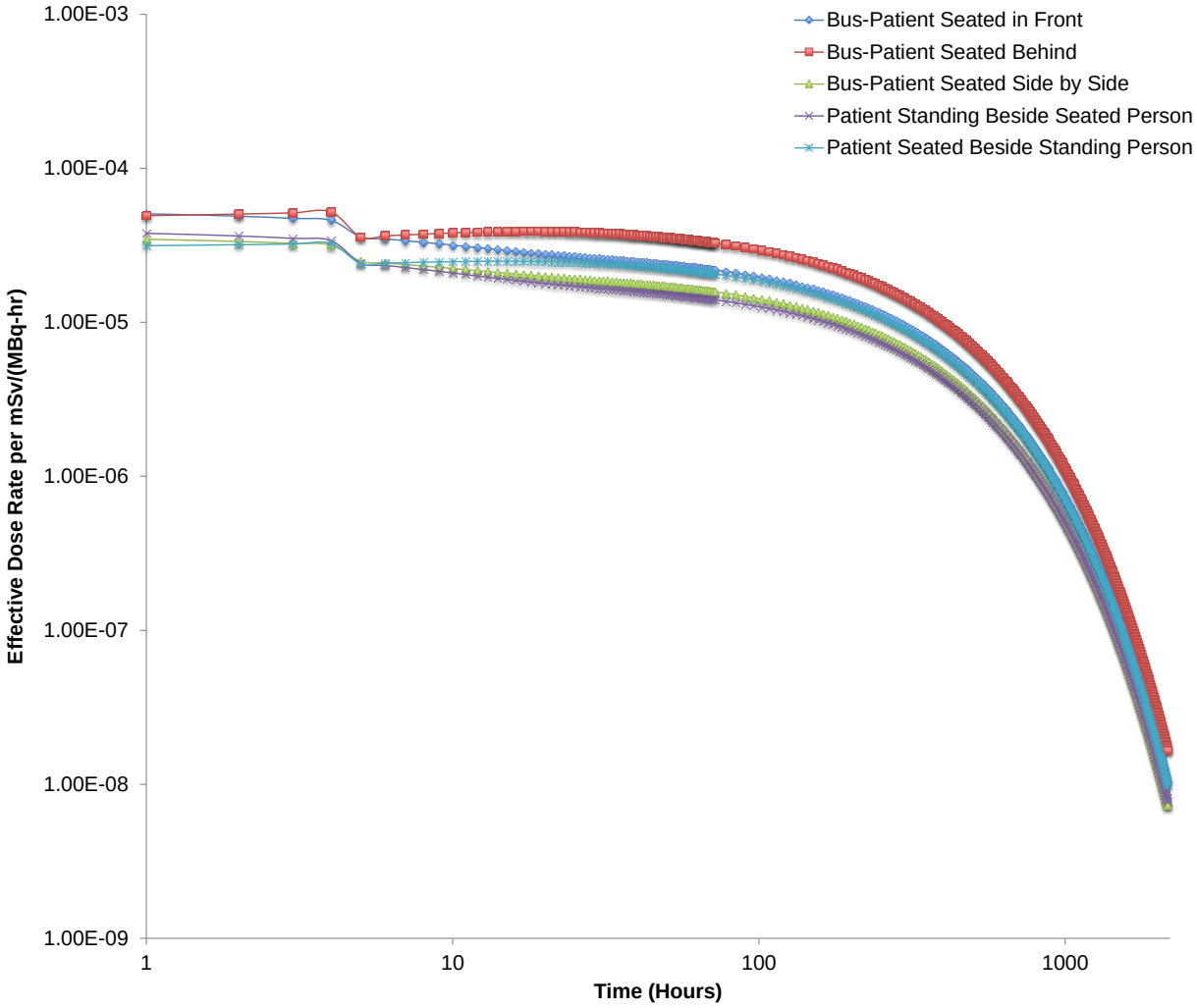


Figure B-49. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (normal thyroid uptake – single void at 4 hr).

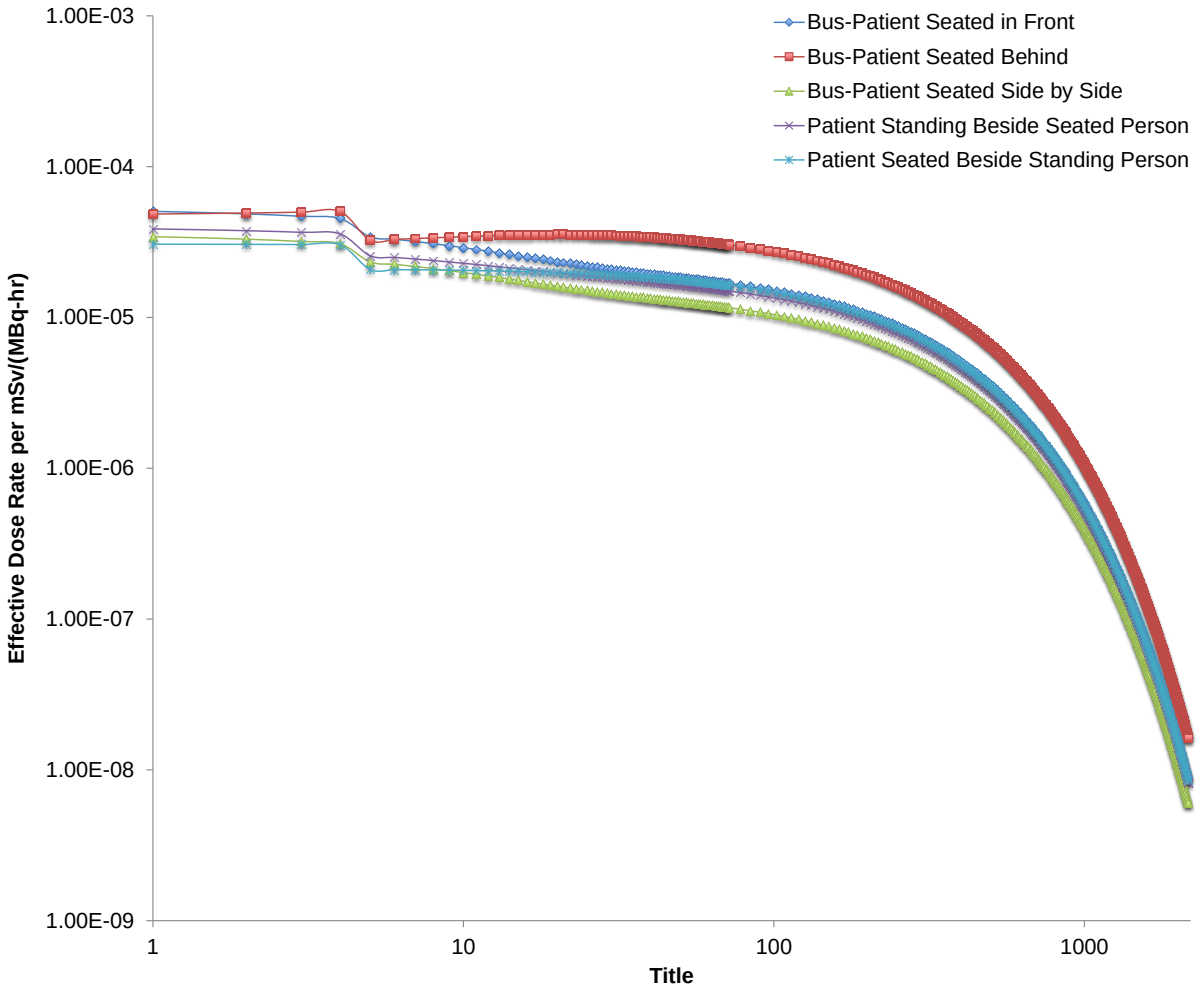


Figure B-50. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (DTC 5% thyroid uptake – single void at 4 hr).

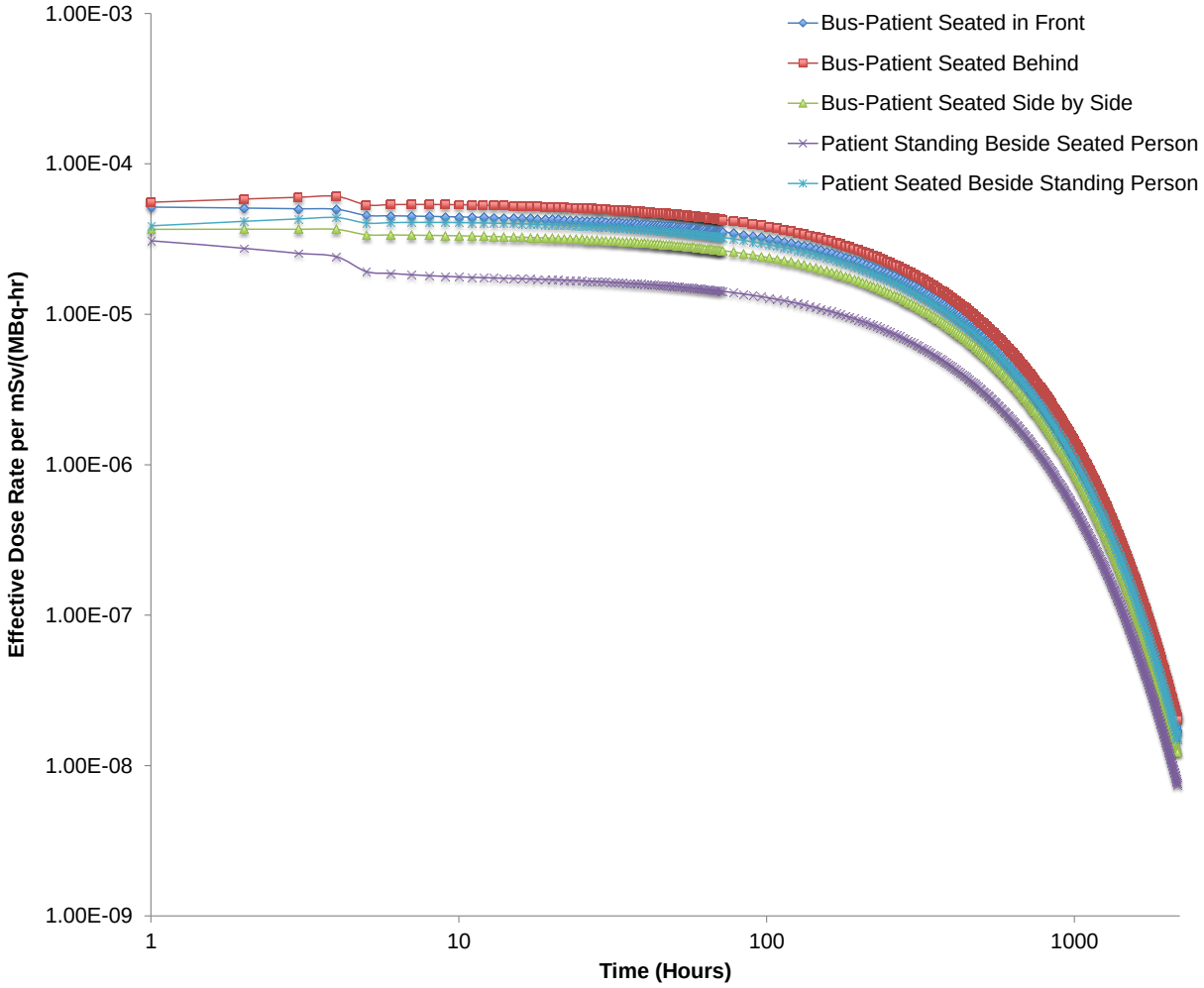


Figure B-51. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (hyperthyroid 80% thyroid uptake – single void at 8 hr).

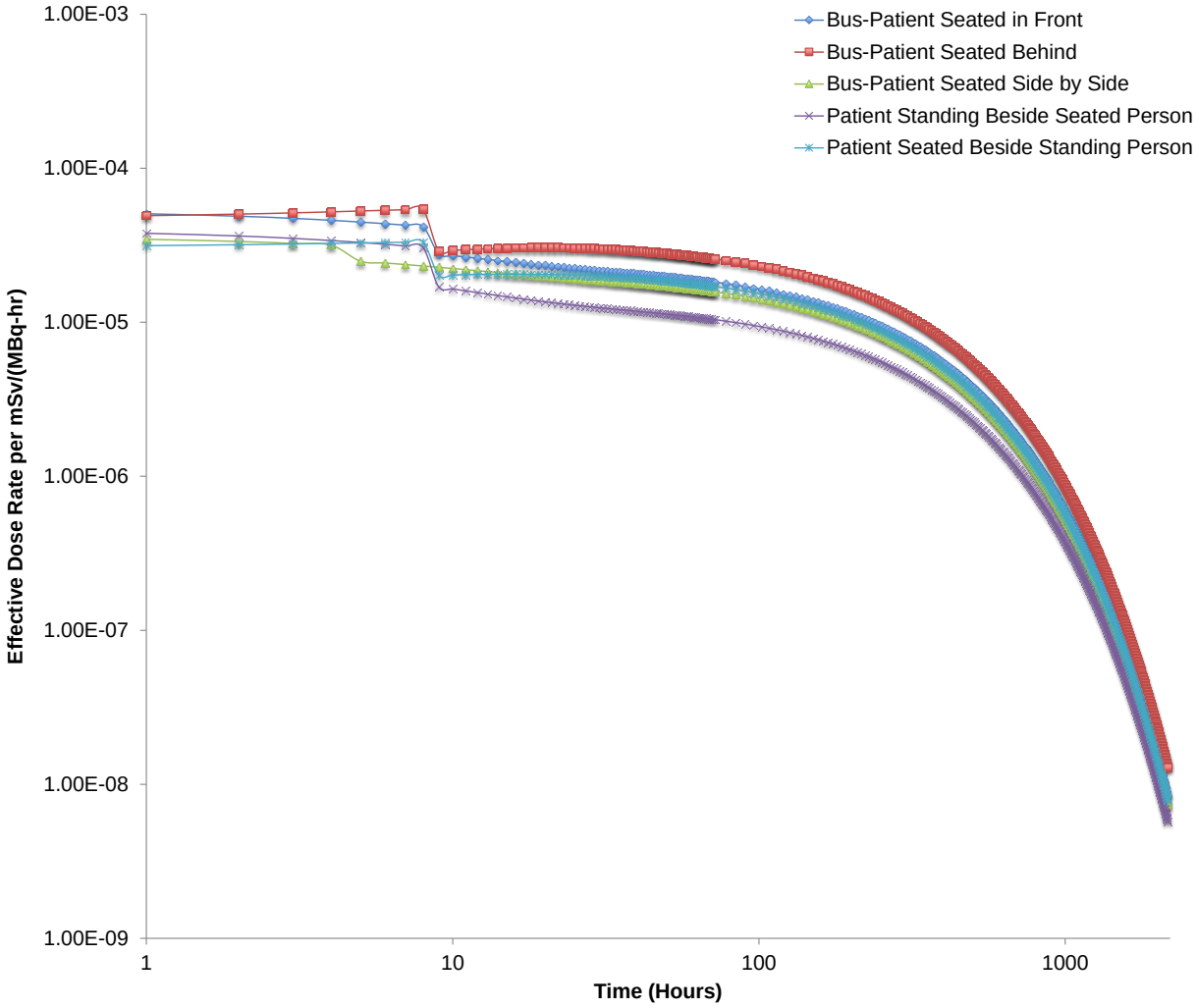


Figure B-52. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (normal thyroid uptake – single void at 8 hr).

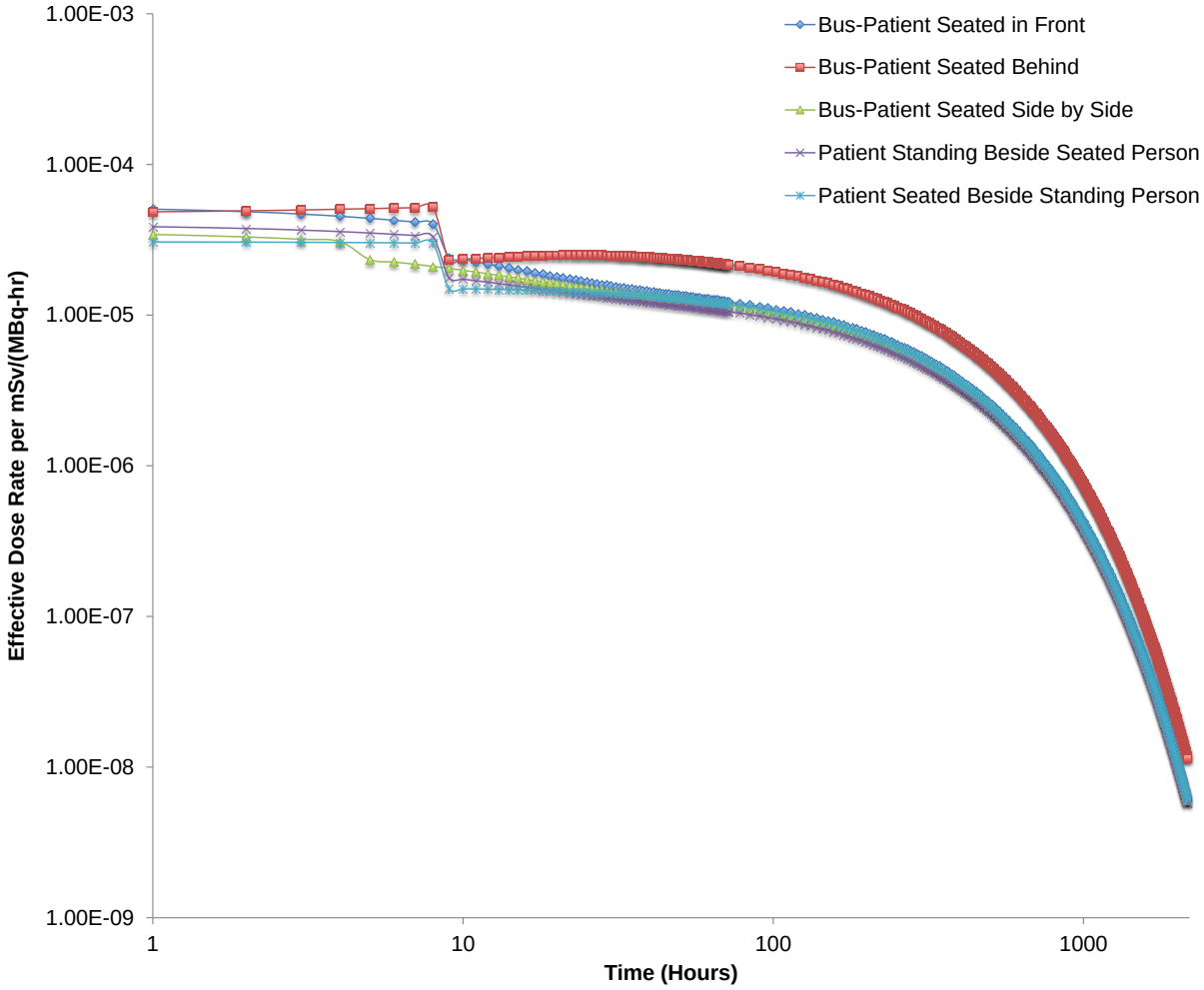


Figure B-53. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (DTC 5% thyroid uptake – single void at 8 hr).

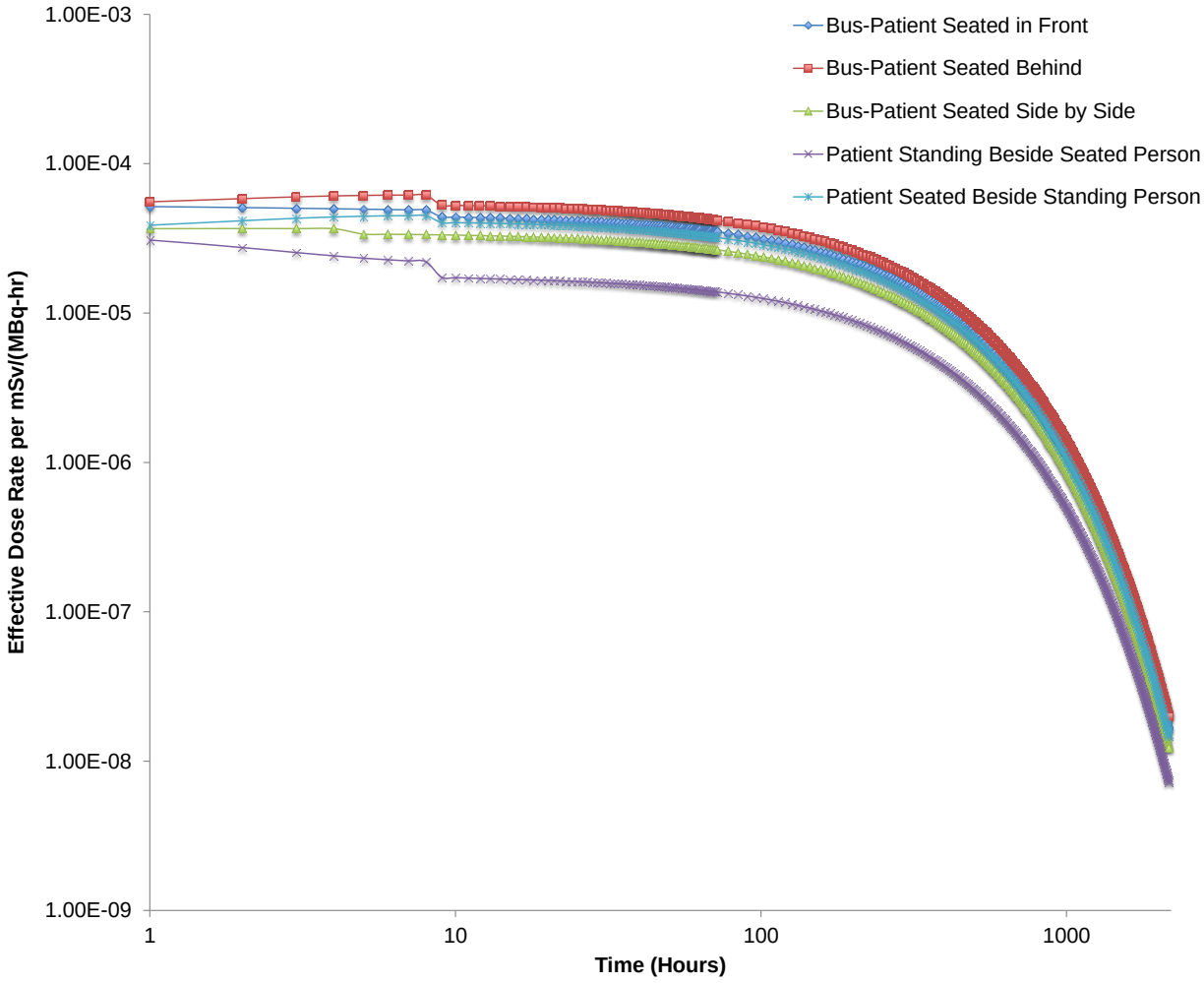


Figure B-54. Comparison of effective dose rates as a function of administered activity for public transportation scenario: seated scenarios (hyperthyroid 80% thyroid uptake – single void at 8 hr).

B.2 HOME/NURSING HOME SCENARIO

B.2.1 Caregiver Seated 30 cm from Patient in Bed

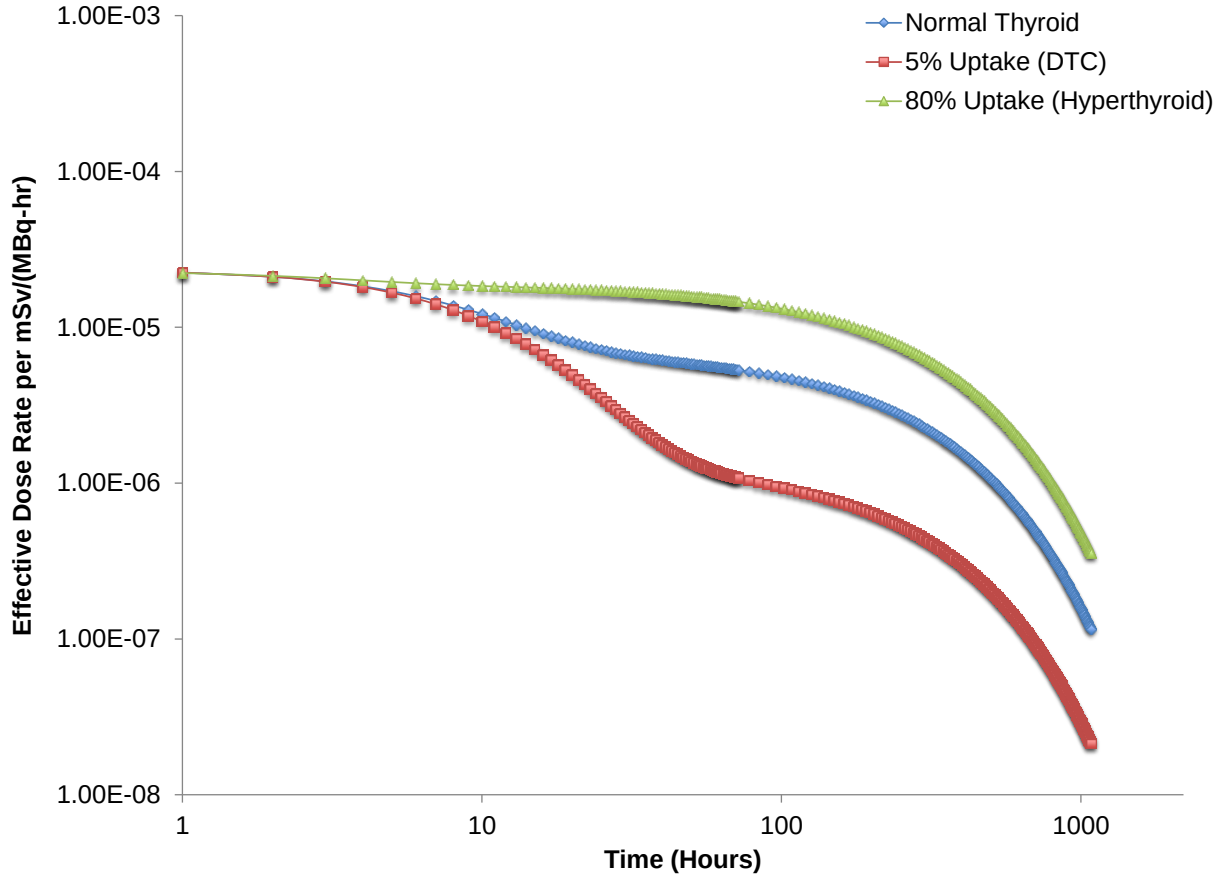


Figure B-55. Effective dose rate as a function of administered activity for home/nursing home scenario: caregiver seated 30 cm from patient seated in bed (continuous voiding).

Table B-19. Effective dose rate (mSv/MBq-hr) for home/nursing home scenario: caregiver seated 30 cm from patient seated in bed (continuous voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	2.31E-05	2.31E-05	2.30E-05
0.5	**0.02**	2.29E-05	2.29E-05	2.27E-05
1	**0.04**	2.24E-05	2.24E-05	2.23E-05
2	**0.08**	2.11E-05	2.11E-05	2.14E-05
3	**0.13**	1.97E-05	1.96E-05	2.06E-05
4	**0.17**	1.83E-05	1.81E-05	2.00E-05
5	**0.21**	1.70E-05	1.67E-05	1.95E-05
6	**0.25**	1.58E-05	1.53E-05	1.92E-05
7	**0.29**	1.48E-05	1.41E-05	1.89E-05
8	**0.33**	1.38E-05	1.29E-05	1.87E-05
9	**0.38**	1.29E-05	1.18E-05	1.85E-05
10	**0.42**	1.22E-05	1.09E-05	1.84E-05
12	**0.50**	1.09E-05	9.19E-06	1.82E-05
24	**1.00**	7.31E-06	3.76E-06	1.73E-05
36	**1.50**	6.31E-06	2.03E-06	1.66E-05
48	**2.00**	5.88E-06	1.43E-06	1.59E-05
60	**2.50**	5.58E-06	1.19E-06	1.52E-05
72	**3.00**	5.32E-06	1.08E-06	1.46E-05
84	**3.50**	5.08E-06	1.00E-06	1.39E-05
96	**4.00**	4.86E-06	9.50E-07	1.34E-05
108	**4.50**	4.65E-06	9.05E-07	1.28E-05
120	**5.00**	4.45E-06	8.64E-07	1.22E-05
132	**5.50**	4.25E-06	8.26E-07	1.17E-05
144	**6.00**	4.07E-06	7.89E-07	1.12E-05
156	**6.50**	3.90E-06	7.55E-07	1.07E-05
168	**7.00**	3.73E-06	7.22E-07	1.03E-05
240	**10.00**	2.85E-06	5.51E-07	7.91E-06
360	**15.00**	1.82E-06	3.49E-07	5.09E-06
480	**20.00**	1.15E-06	2.20E-07	3.27E-06
600	**25.00**	7.30E-07	1.39E-07	2.10E-06
720	**30.00**	4.61E-07	8.70E-08	1.35E-06
840	**35.00**	2.91E-07	5.45E-08	8.66E-07
960	**40.00**	1.84E-07	3.42E-08	5.56E-07
1080	**45.00**	1.16E-07	2.14E-08	3.57E-07
1200	**50.00**	7.33E-08	1.34E-08	2.29E-07
1320	**55.00**	4.63E-08	8.39E-09	1.47E-07
1440	**60.00**	2.92E-08	5.25E-09	9.41E-08
1560	**65.00**	1.84E-08	3.29E-09	6.04E-08
1680	**70.00**	1.16E-08	2.06E-09	3.87E-08
1800	**75.00**	7.33E-09	1.29E-09	2.48E-08
1920	**80.00**	4.62E-09	8.06E-10	1.59E-08
2040	**85.00**	2.92E-09	5.04E-10	1.02E-08
2160	**90.00**	1.84E-09	3.16E-10	6.55E-09

B.2.2 Patient in Adjacent Beds in Nursing Home

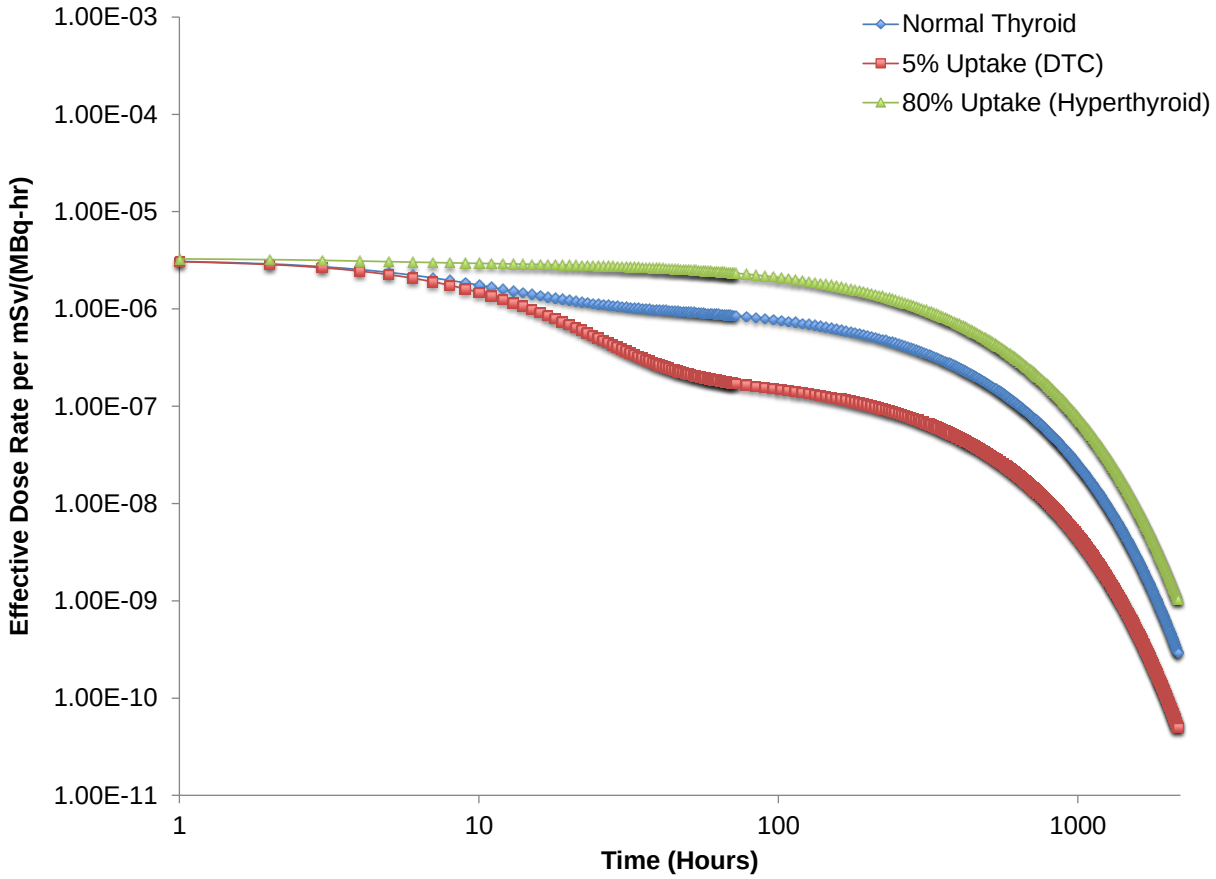


Figure B-56. Effective dose rate as a function of administered activity for home/nursing home scenario: seated person in adjacent nuring home bed 250 cm from patient seated in bed (continuous voiding).

Table B-20. Effective dose rate (mSv/MBq-hr) for home/nursing home scenario: seated person in adjacent nursing home bed 250 cm from patient seated in bed (continuous voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	3.20E-06	3.20E-06	3.28E-06
0.5	**0.02**	3.16E-06	3.15E-06	3.28E-06
1	**0.04**	3.08E-06	3.06E-06	3.27E-06
2	**0.08**	2.90E-06	2.86E-06	3.21E-06
3	**0.13**	2.72E-06	2.65E-06	3.16E-06
4	**0.17**	2.54E-06	2.45E-06	3.10E-06
5	**0.21**	2.37E-06	2.25E-06	3.06E-06
6	**0.25**	2.22E-06	2.07E-06	3.03E-06
7	**0.29**	2.09E-06	1.90E-06	3.00E-06
8	**0.33**	1.96E-06	1.75E-06	2.98E-06
9	**0.38**	1.86E-06	1.61E-06	2.96E-06
10	**0.42**	1.76E-06	1.48E-06	2.94E-06
12	**0.50**	1.60E-06	1.25E-06	2.91E-06
24	**1.00**	1.14E-06	5.33E-07	2.78E-06
36	**1.50**	1.00E-06	3.02E-07	2.66E-06
48	**2.00**	9.39E-07	2.21E-07	2.55E-06
60	**2.50**	8.92E-07	1.88E-07	2.44E-06
72	**3.00**	8.51E-07	1.71E-07	2.33E-06
84	**3.50**	8.13E-07	1.60E-07	2.23E-06
96	**4.00**	7.77E-07	1.52E-07	2.14E-06
108	**4.50**	7.43E-07	1.45E-07	2.04E-06
120	**5.00**	7.11E-07	1.38E-07	1.96E-06
132	**5.50**	6.80E-07	1.32E-07	1.87E-06
144	**6.00**	6.50E-07	1.26E-07	1.79E-06
156	**6.50**	6.22E-07	1.20E-07	1.72E-06
168	**7.00**	5.95E-07	1.15E-07	1.64E-06
240	**10.00**	4.54E-07	8.78E-08	1.26E-06
360	**15.00**	2.89E-07	5.56E-08	8.10E-07
480	**20.00**	1.83E-07	3.50E-08	5.21E-07
600	**25.00**	1.16E-07	2.20E-08	3.34E-07
720	**30.00**	7.33E-08	1.38E-08	2.14E-07
840	**35.00**	4.63E-08	8.66E-09	1.38E-07
960	**40.00**	2.92E-08	5.42E-09	8.83E-08
1080	**45.00**	1.84E-08	3.40E-09	5.66E-08
1200	**50.00**	1.16E-08	2.13E-09	3.63E-08
1320	**55.00**	7.34E-09	1.33E-09	2.33E-08
1440	**60.00**	4.63E-09	8.33E-10	1.49E-08
1560	**65.00**	2.92E-09	5.21E-10	9.59E-09
1680	**70.00**	1.84E-09	3.26E-10	6.15E-09
1800	**75.00**	1.16E-09	2.04E-10	3.94E-09
1920	**80.00**	7.34E-10	1.28E-10	2.53E-09
2040	**85.00**	4.63E-10	8.00E-11	1.62E-09
2160	**90.00**	2.92E-10	5.01E-11	1.04E-09

B.3 HOTEL ROOM

B.3.1 Patient Seated in Bed Back-to-Back with Adjacent Room Guest

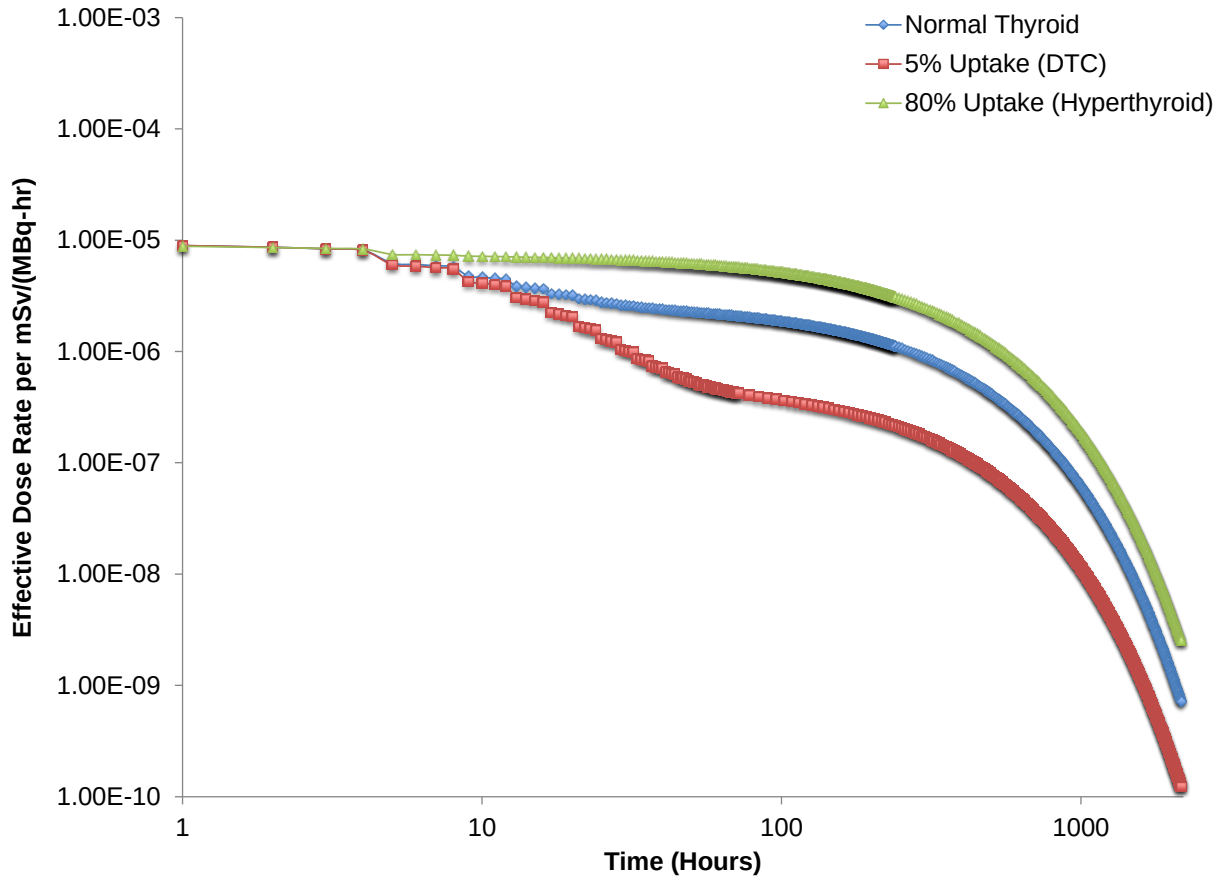


Figure B-57. Effective dose rate as a function of administered activity for hotel room scenario: seated person in adjacent hotel room bed to seated patient (4 hr periodic voiding).

Table B-21. Effective dose rate (mSv/MBq-hr) for hotel room scenario: seated person in adjacent hotel room bed to seated patient (4 hour periodic voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	9.23E-06	9.24E-06	9.13E-06
0.5	**0.02**	9.12E-06	9.13E-06	9.00E-06
1	**0.04**	8.94E-06	8.95E-06	8.82E-06
2	**0.08**	8.63E-06	8.64E-06	8.59E-06
3	**0.13**	8.36E-06	8.36E-06	8.44E-06
4	**0.17**	8.13E-06	8.11E-06	8.33E-06
5	**0.21**	6.23E-06	6.05E-06	7.46E-06
6	**0.25**	6.05E-06	5.84E-06	7.41E-06
7	**0.29**	5.89E-06	5.66E-06	7.36E-06
8	**0.33**	5.75E-06	5.49E-06	7.32E-06
9	**0.38**	4.76E-06	4.26E-06	7.19E-06
10	**0.42**	4.65E-06	4.12E-06	7.16E-06
12	**0.50**	4.55E-06	3.99E-06	7.13E-06
24	**1.00**	4.46E-06	3.88E-06	7.11E-06
36	**1.50**	3.87E-06	3.05E-06	7.06E-06
48	**2.00**	3.80E-06	2.96E-06	7.04E-06
60	**2.50**	3.74E-06	2.87E-06	7.01E-06
72	**3.00**	3.68E-06	2.79E-06	6.99E-06
84	**3.50**	3.33E-06	3.93E-07	6.96E-06
96	**4.00**	3.28E-06	3.72E-07	6.93E-06
108	**4.50**	1.82E-06	3.54E-07	5.00E-06
120	**5.00**	3.24E-06	3.38E-07	6.91E-06
132	**5.50**	3.20E-06	3.23E-07	6.88E-06
144	**6.00**	2.57E-06	3.09E-07	6.59E-06
156	**6.50**	2.35E-06	2.95E-07	6.31E-06
168	**7.00**	2.22E-06	2.82E-07	6.04E-06
240	**10.00**	1.69E-06	2.16E-07	4.65E-06
360	**15.00**	1.57E-06	1.37E-07	4.33E-06
480	**20.00**	1.46E-06	8.63E-08	4.02E-06
600	**25.00**	1.35E-06	5.43E-08	3.74E-06
720	**30.00**	1.26E-06	3.41E-08	3.48E-06
840	**35.00**	1.17E-06	2.14E-08	3.23E-06
960	**40.00**	9.33E-07	1.34E-08	2.60E-06
1080	**45.00**	5.93E-07	8.39E-09	1.67E-06
1200	**50.00**	3.76E-07	5.25E-09	1.07E-06
1320	**55.00**	2.38E-07	3.29E-09	6.90E-07
1440	**60.00**	1.50E-07	2.06E-09	4.43E-07
1560	**65.00**	9.50E-08	1.29E-09	2.84E-07
1680	**70.00**	6.00E-08	8.06E-10	1.82E-07
1800	**75.00**	3.79E-08	5.05E-10	1.17E-07
1920	**80.00**	2.39E-08	3.16E-10	7.50E-08
2040	**85.00**	1.51E-08	1.98E-10	4.81E-08
2160	**90.00**	9.51E-09	1.24E-10	3.09E-08

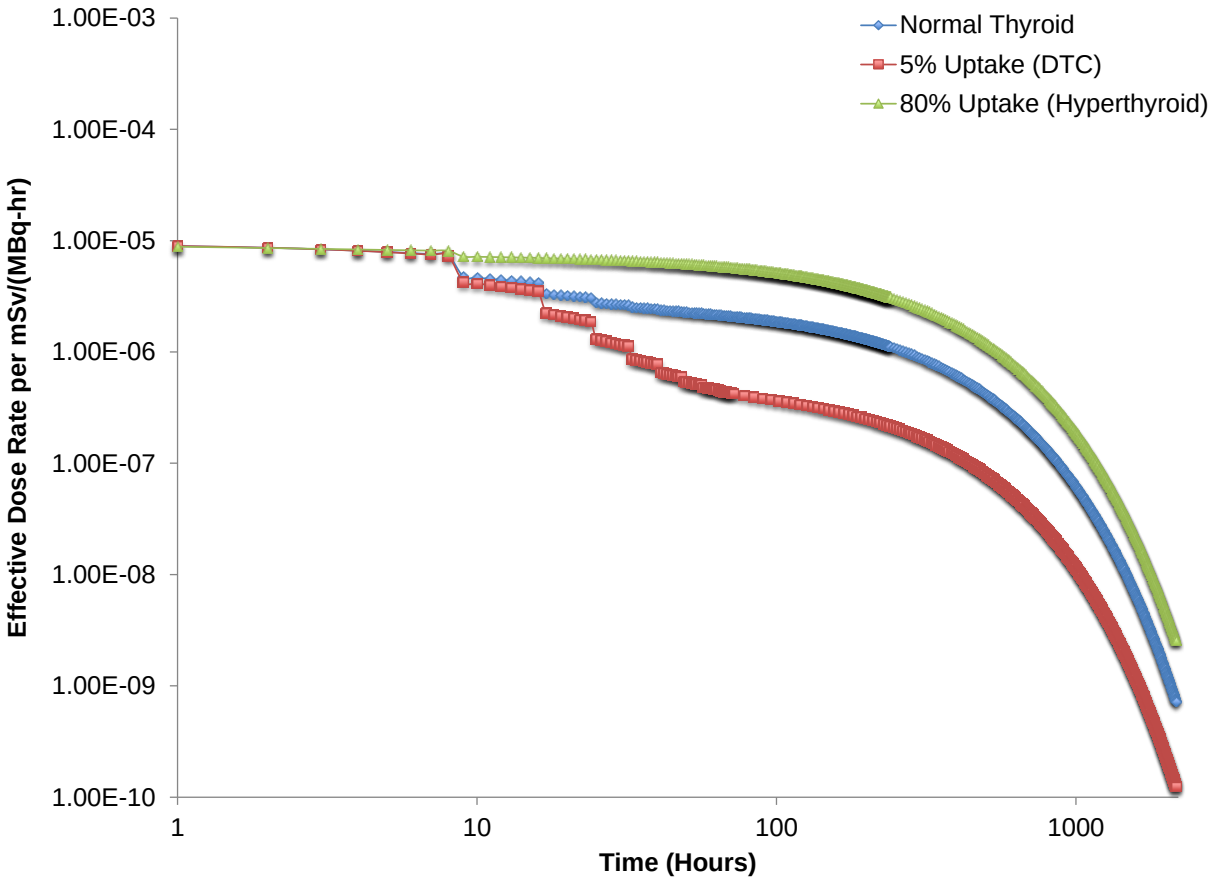


Figure B-58. Effective dose rate as a function of administered activity for hotel room scenario: seated person in adjacent hotel room bed to seated patient (8 hr periodic voiding).

Table B-22. Effective dose rate (mSv/MBq-hr) for hotel room scenario: seated person in adjacent hotel room bed to seated patient (8 hr periodic voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	9.23E-06	9.24E-06	9.13E-06
0.5	**0.02**	9.12E-06	9.13E-06	9.00E-06
1	**0.04**	8.94E-06	8.95E-06	8.82E-06
2	**0.08**	8.63E-06	8.64E-06	8.59E-06
3	**0.13**	8.36E-06	8.36E-06	8.44E-06
4	**0.17**	8.13E-06	8.11E-06	8.33E-06
5	**0.21**	7.92E-06	7.88E-06	8.25E-06
6	**0.25**	7.74E-06	7.67E-06	8.19E-06
7	**0.29**	7.57E-06	7.48E-06	8.14E-06
8	**0.33**	7.42E-06	7.30E-06	8.10E-06
9	**0.38**	4.76E-06	4.26E-06	7.19E-06
10	**0.42**	4.65E-06	4.12E-06	7.16E-06
12	**0.50**	4.55E-06	3.99E-06	7.13E-06
24	**1.00**	4.46E-06	3.88E-06	7.11E-06
36	**1.50**	4.38E-06	3.78E-06	7.08E-06
48	**2.00**	4.31E-06	3.68E-06	7.05E-06
60	**2.50**	4.25E-06	3.59E-06	7.03E-06
72	**3.00**	4.19E-06	3.51E-06	7.00E-06
84	**3.50**	3.33E-06	3.93E-07	6.96E-06
96	**4.00**	3.28E-06	3.72E-07	6.93E-06
108	**4.50**	1.82E-06	3.54E-07	5.00E-06
120	**5.00**	3.24E-06	3.38E-07	6.91E-06
132	**5.50**	3.20E-06	3.23E-07	6.88E-06
144	**6.00**	2.64E-06	3.09E-07	6.59E-06
156	**6.50**	2.35E-06	2.95E-07	6.31E-06
168	**7.00**	2.22E-06	2.83E-07	6.04E-06
240	**10.00**	1.69E-06	2.16E-07	4.65E-06
360	**15.00**	1.57E-06	1.37E-07	4.33E-06
480	**20.00**	1.46E-06	8.63E-08	4.02E-06
600	**25.00**	1.35E-06	5.43E-08	3.74E-06
720	**30.00**	1.26E-06	3.41E-08	3.48E-06
840	**35.00**	1.17E-06	2.14E-08	3.23E-06
960	**40.00**	9.33E-07	1.34E-08	2.60E-06
1080	**45.00**	5.93E-07	8.39E-09	1.67E-06
1200	**50.00**	3.76E-07	5.25E-09	1.07E-06
1320	**55.00**	2.38E-07	3.29E-09	6.90E-07
1440	**60.00**	1.51E-07	2.06E-09	4.43E-07
1560	**65.00**	9.51E-08	1.29E-09	2.84E-07
1680	**70.00**	6.00E-08	8.07E-10	1.82E-07
1800	**75.00**	3.79E-08	5.05E-10	1.17E-07
1920	**80.00**	2.39E-08	3.16E-10	7.50E-08
2040	**85.00**	1.51E-08	1.98E-10	4.81E-08
2160	**90.00**	9.52E-09	1.24E-10	3.09E-08

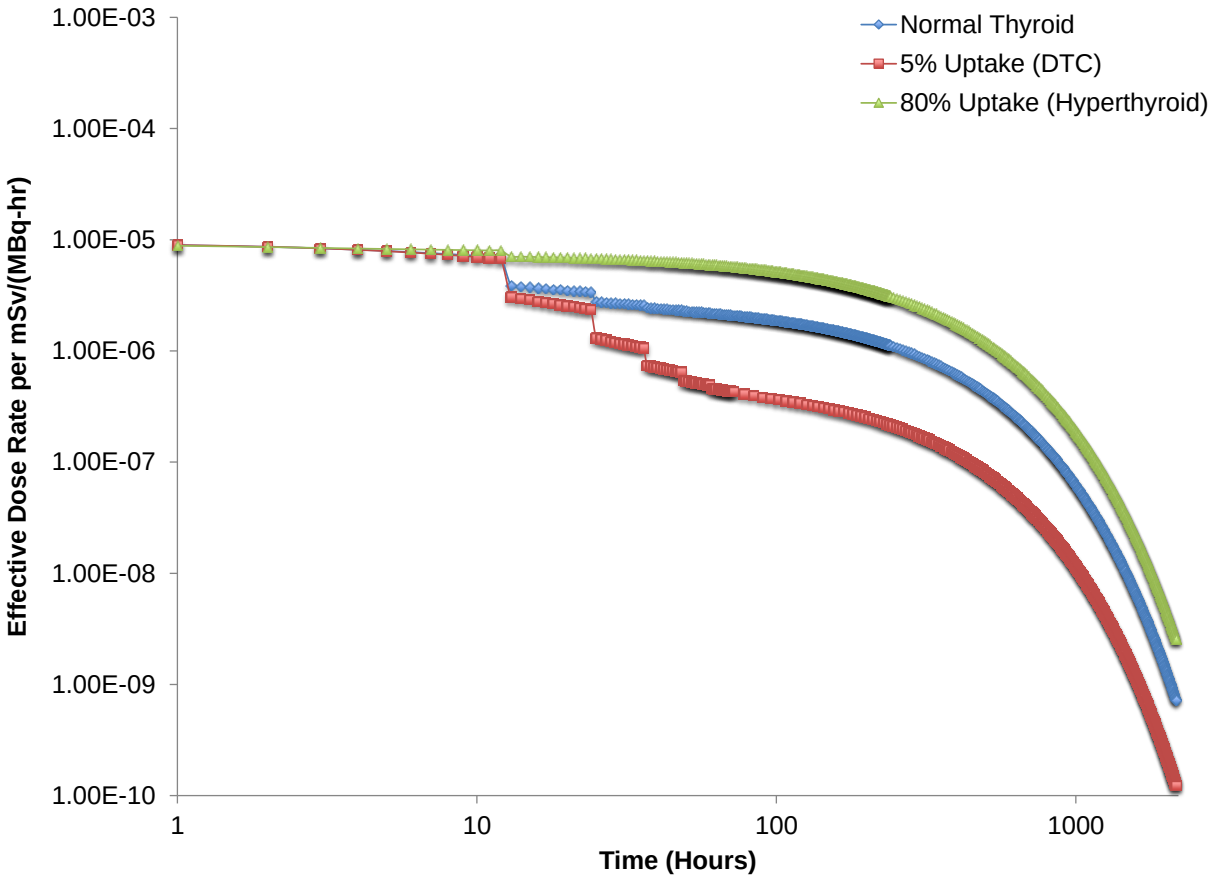


Figure B-59. Effective dose rate as a function of administered activity for hotel room scenario: seated person in adjacent hotel room bed to seated patient (12 hr periodic voiding).

Table B-23. Effective dose rate (mSv/MBq-hr) for hotel room scenario: seated person in adjacent hotel room bed to seated patient (12 hr periodic voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	9.23E-06	9.24E-06	9.13E-06
0.5	**0.02**	9.12E-06	9.13E-06	9.00E-06
1	**0.04**	8.94E-06	8.95E-06	8.82E-06
2	**0.08**	8.63E-06	8.64E-06	8.59E-06
3	**0.13**	8.36E-06	8.36E-06	8.44E-06
4	**0.17**	8.13E-06	8.11E-06	8.33E-06
5	**0.21**	7.92E-06	7.88E-06	8.25E-06
6	**0.25**	7.74E-06	7.67E-06	8.19E-06
7	**0.29**	7.57E-06	7.48E-06	8.14E-06
8	**0.33**	7.42E-06	7.30E-06	8.10E-06
9	**0.38**	7.29E-06	7.14E-06	8.07E-06
10	**0.42**	7.17E-06	7.00E-06	8.03E-06
12	**0.50**	7.06E-06	6.86E-06	8.00E-06
24	**1.00**	6.97E-06	6.73E-06	7.97E-06
36	**1.50**	3.87E-06	3.05E-06	7.06E-06
48	**2.00**	3.80E-06	2.96E-06	7.04E-06
60	**2.50**	3.74E-06	2.87E-06	7.01E-06
72	**3.00**	3.68E-06	2.79E-06	6.99E-06
84	**3.50**	3.63E-06	3.95E-07	6.96E-06
96	**4.00**	3.58E-06	3.73E-07	6.93E-06
108	**4.50**	1.82E-06	3.54E-07	5.00E-06
120	**5.00**	3.54E-06	3.38E-07	6.91E-06
132	**5.50**	3.50E-06	3.23E-07	6.88E-06
144	**6.00**	2.64E-06	3.09E-07	6.59E-06
156	**6.50**	2.36E-06	2.95E-07	6.31E-06
168	**7.00**	2.22E-06	2.83E-07	6.04E-06
240	**10.00**	1.69E-06	2.16E-07	4.65E-06
360	**15.00**	1.57E-06	1.37E-07	4.33E-06
480	**20.00**	1.46E-06	8.64E-08	4.02E-06
600	**25.00**	1.35E-06	5.43E-08	3.74E-06
720	**30.00**	1.26E-06	3.41E-08	3.48E-06
840	**35.00**	1.17E-06	2.14E-08	3.23E-06
960	**40.00**	9.33E-07	1.34E-08	2.60E-06
1080	**45.00**	5.94E-07	8.40E-09	1.67E-06
1200	**50.00**	3.76E-07	5.26E-09	1.07E-06
1320	**55.00**	2.38E-07	3.29E-09	6.90E-07
1440	**60.00**	1.51E-07	2.06E-09	4.43E-07
1560	**65.00**	9.51E-08	1.29E-09	2.84E-07
1680	**70.00**	6.00E-08	8.07E-10	1.82E-07
1800	**75.00**	3.79E-08	5.05E-10	1.17E-07
1920	**80.00**	2.39E-08	3.16E-10	7.50E-08
2040	**85.00**	1.51E-08	1.98E-10	4.81E-08
2160	**90.00**	9.52E-09	1.24E-10	3.09E-08

B.3.2 Patient Lying Down in Bed Back-to-Back with Adjacent Room Guest

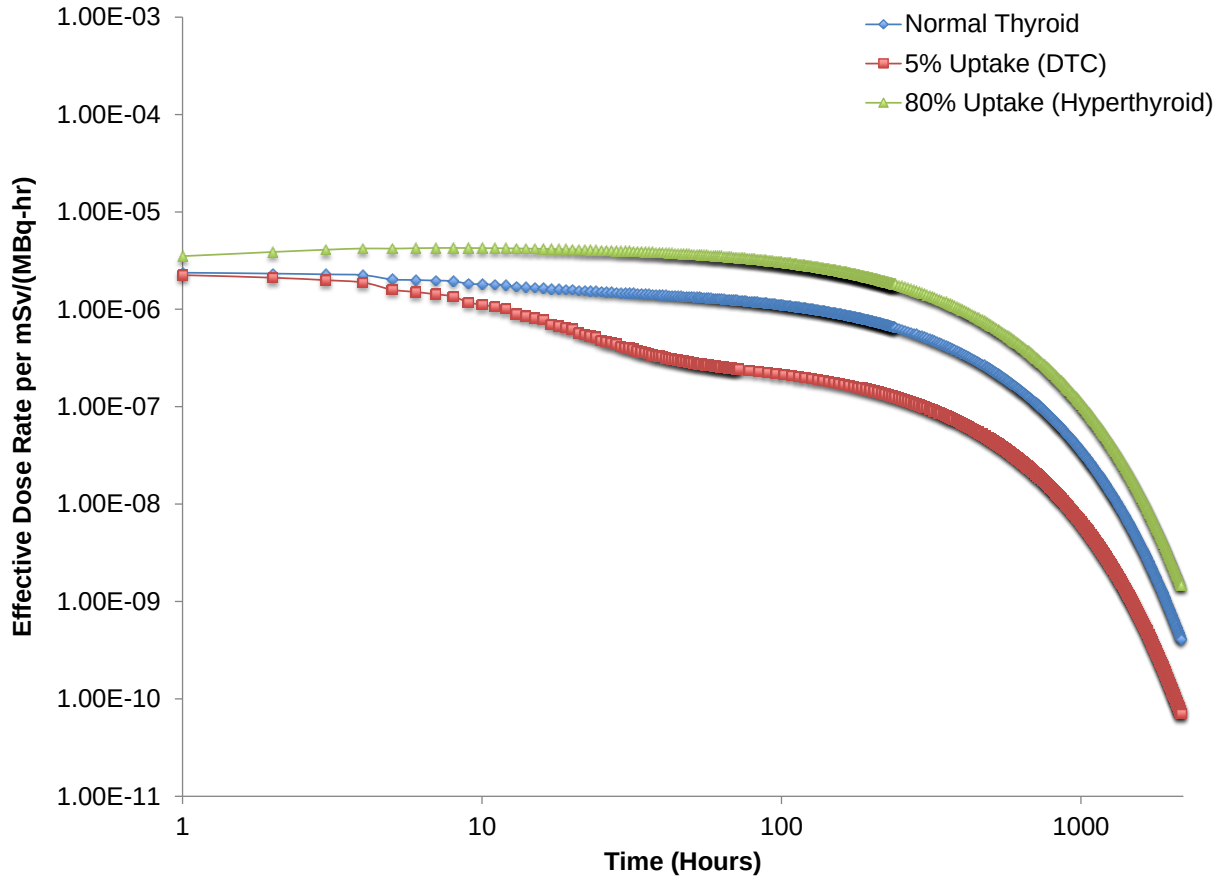


Figure B-60. Effective dose rate as a function of administered activity for hotel room scenario: person lying down in adjacent hotel room bed to patient lying down (4 hr periodic voiding).

Table B-24. Effective dose rate (mSv/MBq-hr) for hotel room scenario: person lying down in adjacent hotel room bed to patient lying down (4r periodic voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	2.42E-06	2.37E-06	3.00E-06
0.5	**0.02**	2.41E-06	2.32E-06	3.22E-06
1	**0.04**	2.38E-06	2.24E-06	3.51E-06
2	**0.08**	2.33E-06	2.11E-06	3.88E-06
3	**0.13**	2.28E-06	1.99E-06	4.09E-06
4	**0.17**	2.25E-06	1.89E-06	4.21E-06
5	**0.21**	2.03E-06	1.59E-06	4.20E-06
6	**0.25**	2.00E-06	1.51E-06	4.24E-06
7	**0.29**	1.97E-06	1.43E-06	4.26E-06
8	**0.33**	1.95E-06	1.36E-06	4.27E-06
9	**0.38**	1.83E-06	1.17E-06	4.26E-06
10	**0.42**	1.81E-06	1.12E-06	4.25E-06
12	**0.50**	1.79E-06	1.06E-06	4.24E-06
24	**1.00**	1.77E-06	1.01E-06	4.23E-06
36	**1.50**	1.70E-06	8.92E-07	4.21E-06
48	**2.00**	1.69E-06	8.52E-07	4.20E-06
60	**2.50**	1.68E-06	8.16E-07	4.18E-06
72	**3.00**	1.66E-06	7.83E-07	4.17E-06
84	**3.50**	1.62E-06	2.30E-07	4.15E-06
96	**4.00**	1.61E-06	2.18E-07	4.14E-06
108	**4.50**	1.07E-06	2.08E-07	2.95E-06
120	**5.00**	1.60E-06	1.99E-07	4.12E-06
132	**5.50**	1.59E-06	1.90E-07	4.11E-06
144	**6.00**	1.46E-06	1.81E-07	3.92E-06
156	**6.50**	1.38E-06	1.73E-07	3.75E-06
168	**7.00**	1.31E-06	1.65E-07	3.58E-06
240	**10.00**	9.94E-07	1.25E-07	2.74E-06
360	**15.00**	9.21E-07	7.89E-08	2.54E-06
480	**20.00**	8.54E-07	4.96E-08	2.36E-06
600	**25.00**	7.91E-07	3.11E-08	2.19E-06
720	**30.00**	7.33E-07	1.95E-08	2.03E-06
840	**35.00**	6.79E-07	1.22E-08	1.88E-06
960	**40.00**	5.40E-07	7.64E-09	1.51E-06
1080	**45.00**	3.42E-07	4.78E-09	9.64E-07
1200	**50.00**	2.16E-07	2.99E-09	6.18E-07
1320	**55.00**	1.36E-07	1.87E-09	3.96E-07
1440	**60.00**	8.61E-08	1.17E-09	2.54E-07
1560	**65.00**	5.43E-08	7.34E-10	1.63E-07
1680	**70.00**	3.43E-08	4.60E-10	1.04E-07
1800	**75.00**	2.16E-08	2.88E-10	6.70E-08
1920	**80.00**	1.36E-08	1.80E-10	4.29E-08
2040	**85.00**	8.61E-09	1.13E-10	2.75E-08
2160	**90.00**	5.43E-09	7.05E-11	1.77E-08

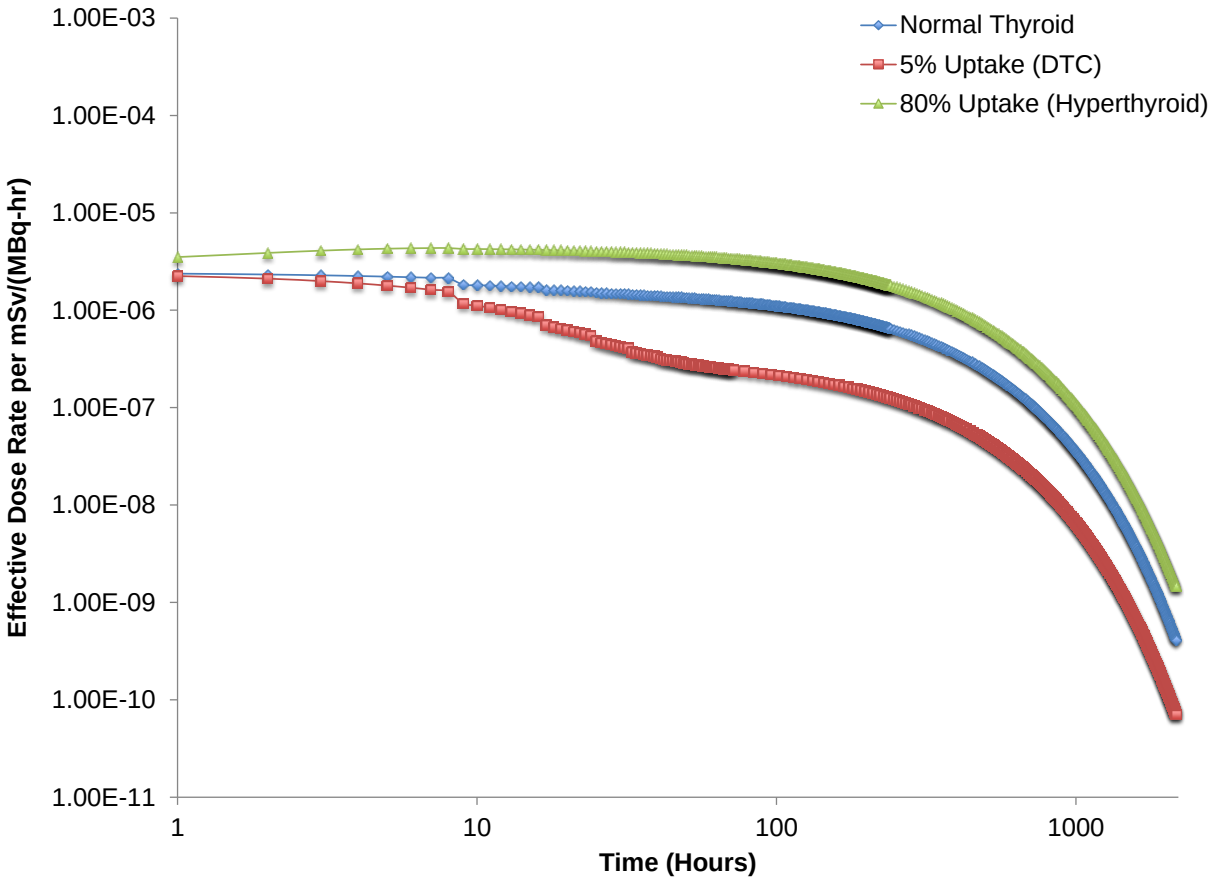


Figure B-61. Effective dose rate as a function of administered activity for hotel room scenario: person lying down in adjacent hotel room bed to patient lying down (8 hr periodic voiding).

Table B-25. Effective dose rate (mSv/MBq-hr) for hotel room scenario: person lying down in adjacent hotel room bed to patient lying down (8 hr periodic voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	2.42E-06	2.37E-06	3.00E-06
0.5	**0.02**	2.41E-06	2.32E-06	3.22E-06
1	**0.04**	2.38E-06	2.24E-06	3.51E-06
2	**0.08**	2.33E-06	2.11E-06	3.88E-06
3	**0.13**	2.28E-06	1.99E-06	4.09E-06
4	**0.17**	2.25E-06	1.89E-06	4.21E-06
5	**0.21**	2.21E-06	1.79E-06	4.28E-06
6	**0.25**	2.18E-06	1.70E-06	4.32E-06
7	**0.29**	2.15E-06	1.62E-06	4.34E-06
8	**0.33**	2.13E-06	1.55E-06	4.35E-06
9	**0.38**	1.83E-06	1.17E-06	4.26E-06
10	**0.42**	1.81E-06	1.12E-06	4.25E-06
12	**0.50**	1.79E-06	1.06E-06	4.24E-06
24	**1.00**	1.77E-06	1.01E-06	4.23E-06
36	**1.50**	1.76E-06	9.71E-07	4.21E-06
48	**2.00**	1.74E-06	9.30E-07	4.20E-06
60	**2.50**	1.73E-06	8.94E-07	4.19E-06
72	**3.00**	1.72E-06	8.61E-07	4.17E-06
84	**3.50**	1.62E-06	2.30E-07	4.15E-06
96	**4.00**	1.61E-06	2.19E-07	4.14E-06
108	**4.50**	1.07E-06	2.08E-07	2.95E-06
120	**5.00**	1.60E-06	1.99E-07	4.12E-06
132	**5.50**	1.59E-06	1.90E-07	4.11E-06
144	**6.00**	1.46E-06	1.81E-07	3.92E-06
156	**6.50**	1.38E-06	1.73E-07	3.75E-06
168	**7.00**	1.31E-06	1.65E-07	3.58E-06
240	**10.00**	9.94E-07	1.25E-07	2.74E-06
360	**15.00**	9.21E-07	7.89E-08	2.54E-06
480	**20.00**	8.54E-07	4.96E-08	2.36E-06
600	**25.00**	7.91E-07	3.11E-08	2.19E-06
720	**30.00**	7.33E-07	1.95E-08	2.03E-06
840	**35.00**	6.79E-07	1.22E-08	1.88E-06
960	**40.00**	5.40E-07	7.64E-09	1.51E-06
1080	**45.00**	3.42E-07	4.78E-09	9.64E-07
1200	**50.00**	2.16E-07	2.99E-09	6.18E-07
1320	**55.00**	1.36E-07	1.87E-09	3.96E-07
1440	**60.00**	8.61E-08	1.17E-09	2.54E-07
1560	**65.00**	5.43E-08	7.34E-10	1.63E-07
1680	**70.00**	3.43E-08	4.60E-10	1.04E-07
1800	**75.00**	2.16E-08	2.88E-10	6.70E-08
1920	**80.00**	1.36E-08	1.80E-10	4.29E-08
2040	**85.00**	8.61E-09	1.13E-10	2.75E-08
2160	**90.00**	5.43E-09	7.05E-11	1.77E-08

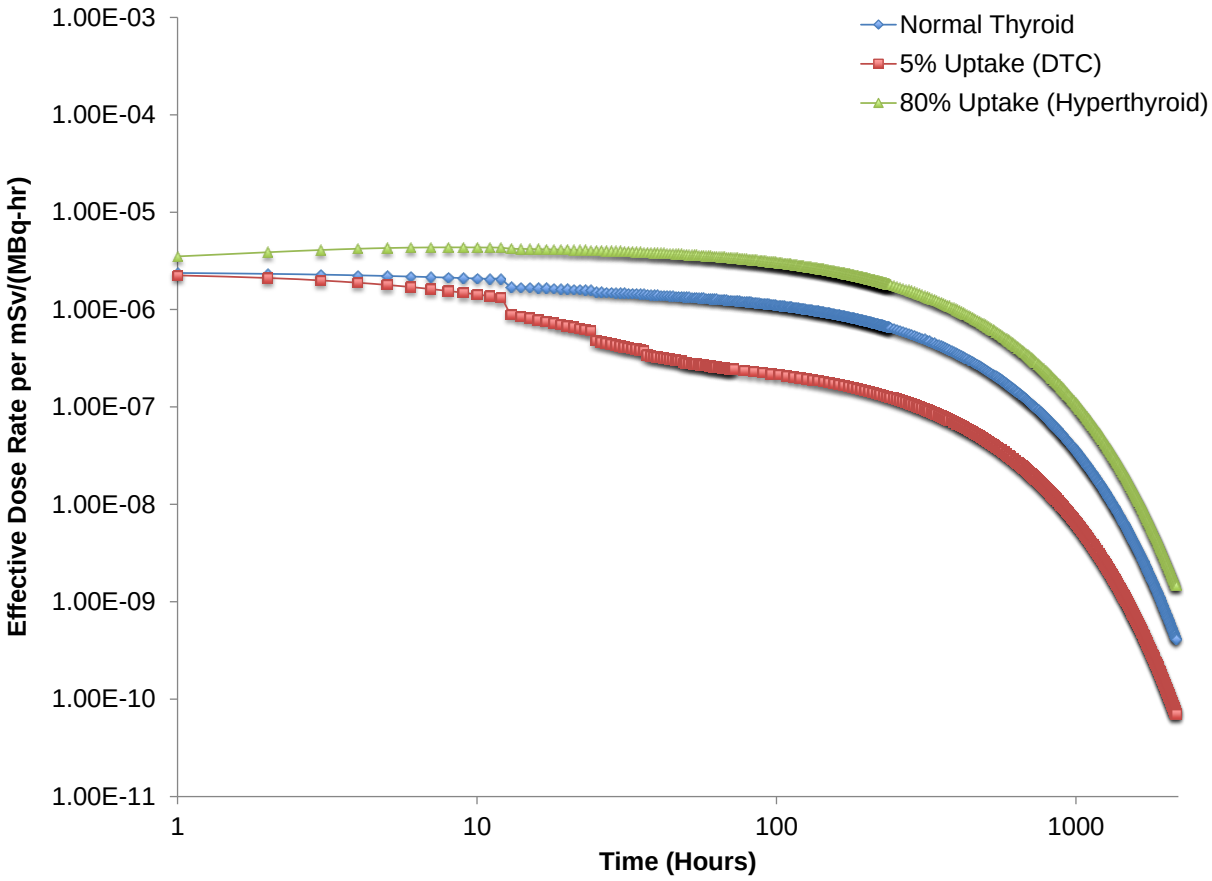


Figure B-62. Effective dose rate as a function of administered activity for hotel room scenario: person lying down in adjacent hotel room bed to patient lying down (12 hr periodic voiding).

Table B-26. Effective dose rate (mSv/MBq-hr) for hotel room scenario: person lying down in adjacent hotel room bed to patient lying down (12 hour periodic voiding)

Time After Administration		Normal Thyroid	5% Uptake (DTC)	80% Uptake (Hyperthyroid)
(Hours)	(Days)			
0.25	**0.01**	2.42E-06	2.37E-06	3.00E-06
0.5	**0.02**	2.41E-06	2.32E-06	3.22E-06
1	**0.04**	2.38E-06	2.24E-06	3.51E-06
2	**0.08**	2.33E-06	2.11E-06	3.88E-06
3	**0.13**	2.28E-06	1.99E-06	4.09E-06
4	**0.17**	2.25E-06	1.89E-06	4.21E-06
5	**0.21**	2.21E-06	1.79E-06	4.28E-06
6	**0.25**	2.18E-06	1.70E-06	4.32E-06
7	**0.29**	2.15E-06	1.62E-06	4.34E-06
8	**0.33**	2.13E-06	1.55E-06	4.35E-06
9	**0.38**	2.11E-06	1.49E-06	4.35E-06
10	**0.42**	2.08E-06	1.43E-06	4.34E-06
12	**0.50**	2.07E-06	1.37E-06	4.33E-06
24	**1.00**	2.05E-06	1.32E-06	4.32E-06
36	**1.50**	1.70E-06	8.92E-07	4.21E-06
48	**2.00**	1.69E-06	8.52E-07	4.20E-06
60	**2.50**	1.68E-06	8.16E-07	4.18E-06
72	**3.00**	1.66E-06	7.83E-07	4.17E-06
84	**3.50**	1.65E-06	2.30E-07	4.15E-06
96	**4.00**	1.64E-06	2.19E-07	4.14E-06
108	**4.50**	1.07E-06	2.08E-07	2.95E-06
120	**5.00**	1.63E-06	1.99E-07	4.12E-06
132	**5.50**	1.62E-06	1.90E-07	4.11E-06
144	**6.00**	1.46E-06	1.81E-07	3.92E-06
156	**6.50**	1.38E-06	1.73E-07	3.75E-06
168	**7.00**	1.31E-06	1.65E-07	3.58E-06
240	**10.00**	9.94E-07	1.25E-07	2.74E-06
360	**15.00**	9.21E-07	7.89E-08	2.54E-06
480	**20.00**	8.54E-07	4.96E-08	2.36E-06
600	**25.00**	7.91E-07	3.11E-08	2.19E-06
720	**30.00**	7.33E-07	1.95E-08	2.03E-06
840	**35.00**	6.79E-07	1.22E-08	1.88E-06
960	**40.00**	5.40E-07	7.64E-09	1.51E-06
1080	**45.00**	3.42E-07	4.78E-09	9.64E-07
1200	**50.00**	2.16E-07	2.99E-09	6.18E-07
1320	**55.00**	1.36E-07	1.87E-09	3.96E-07
1440	**60.00**	8.61E-08	1.17E-09	2.54E-07
1560	**65.00**	5.43E-08	7.34E-10	1.63E-07
1680	**70.00**	3.43E-08	4.60E-10	1.04E-07
1800	**75.00**	2.16E-08	2.88E-10	6.70E-08
1920	**80.00**	1.36E-08	1.80E-10	4.29E-08
2040	**85.00**	8.61E-09	1.13E-10	2.75E-08
2160	**90.00**	5.43E-09	7.05E-11	1.77E-08