ESTIMATED DOSE RATES FOR PEDIATRIC PATIENT RELEASE CRITERIA FOR ^{131}I THERAPY

A Thesis

by

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ABSTRACT

Radioactive iodine (RAI) therapy using ^{131}I can be used to treat patients with thyroid dysfunction such as hyperthyroidism and differentiated thyroid cancer (DTC). In the case of DTC, cells in the thyroid gland, mainly follicular cells, continue to grow irregularly, forming a mass in one or both lobes of the thyroid that appear microscopically similar to normal thyroid tissue. Hyperthyroidism refers to when the thyroid is overstimulated and produces excess thyroxine hormone (T4) that adversely accelerates the body's metabolism causing many symptoms, including the worsening of a DTC prognosis. While much work has been conducted focused on adult patients and adult members of the public with respect to radiation protection standards and patient release criteria, little has been considered in regard to age-specific pediatric patient cases, both as patients and exposed public. An evaluation of patient bioretention of RAI resulting in estimated exposure rates and effective dose to all members of the public from adult and pediatric patients receiving RAI therapy has been conducted to better inform patient release radiation protection guidelines or patients and exposed family members. The improvements to public protection and patient release criteria account for age-dependent analysis (both patient and public) are proposed in harnessing radiation transport simulations of age-specific phantoms correlated with biokinetics post-administration of RAI therapy. Results demonstrated current patient release regulatory guidelines overestimated dose to patients and members of the public at minimum by a factor of 2 across age groups, indicating that time-dependent age-specific models more accurately determined the time at which release can occur to is potentially sooner than current tools provided in regulatory guidelines to licensees.

DEDICATION

I would like to dedicate my work to all the children out there in the world and especially the ones living with chronic medical conditions. While life can be difficult in many different ways, there is a resilience in children that allows them to persevere beyond our imagination as an adult.

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1. INTRODUCTION

1.1. Nuclear Regulatory Commission Regulatory Guide 8.39 (NRC Reg. Guide)

Although a variety of radioactive materials are used in the medical community for diagnostic, imaging, and therapeutic purposes, radioactive iodine (RAI) poses one of the more significant sources of exposure to the common public. Though RAI is used for therapeutic procedures more frequently, ^{131}I emits gammas with energies between 29.4 and 723 keV that easily escape the patient's body and can penetrate another person who is in close proximity.[1] ^{131}I predominantly emits a 364 keV gamma photon and many of these emissions from the patient expose nearby people in a uniform manner to the whole body of members of the public. While ^{131}I does also emit beta particles with a maximum energy of 606 keV, pure beta particle emitters have a lower tissue penetration and deposit all of their energy locally within the patient.[1] From a radiation safety perspective, while a considerable amount of radiation is emitted, it is confined to the patient, their excreta and body fluids and there is no external irradiation exposure of the public or others. Because of the little concern for beta emission, radioactive material such as ^{131}I regularly administered, limits the external radiation hazard risk to the emitted gamma particles.

A patient who is administered RAI therapy in either inpatient or outpatient care is radiologically monitored until criteria is met for the patient to be released. Patients can be cleared by appropriate guidelines or recommendations listed in US NRC's Reg. Guide 8.39, International Atomic Energy Agency (IAEA) Publication 63, National Council on Radiation Protection and Measurements (NCRP) Report 155 or International Commission on Radiological Protection (ICRP) Publication 94.[2-4] Once a patient is discharged by a

licensee, the radioactive material retained in patient's body or patient's actions are not further radiologically monitored by the licensee. Patients are counseled in behaviors to minimize exposure to others before leaving the medical care, but ultimately, the patient's actions are at their own discretion.[2] Until ^{131}I is fully excreted from the body and physically decayed, the patient continues to emit ^{131}I gamma-rays from their body, potentially exposing members of the public who come in proximity such as on public transit as well as immediate family members of the patient treated.

In April 1997, the U.S. Nuclear Regulatory Commission released Regulatory Guide 8.39 (NRC RG 8.39) which calculated external dose to a member of the general public who was exposed to the patient by assuming them as a point target 1 meter away from a point source, the patient.[2] This method is given in Equation 1.

$$D(t) = \frac{1}{r^2}\ 34.6\ \Gamma\ Q_0\ T_p\ \ (1 -\ e^{-0.693\ t/T_p}) \qquad \text{(Eq. 1)}$$

where:

D(t)	=	accumulated exposure at time t, in Roentgens (R)
34.6	=	Conversion factor of 24 hrs/day times the total integration of decay (1.44),
Γ	=	Specific gamma ray constant for a point source, R/mCi-hr at 1 cm,
Q_0	=	Initial activity of the point source in millicuries, at the time of the release,
T_p	=	Physical half-life in days
r	=	Distance from the point source to the point of interest in centimeters,
T	=	Exposure time in days

The more detailed models described in appendices of NRC RG 8.39 provide more tailored patient-specific flexibility to licensees and is the main advantage of the dose-based

rule.[2] The regulation released in 1997 was based on the maximum effective dose equivalent to an exposed individual to exceed 5 mSv. To facilitate ease of use and compliance with the dose limit, a default table for activity, dose rate, or by performing a dose calculation specific to the patient was given and ultimately allows patients with considerably higher levels of activity to be released. Using the NRC's assumption of a point source and a point target neglects attenuation occurring as radiation exits the patient's body and enters the body of the exposed person.[2] Additionally, using NRC's RG 8.39 methods only accounts for removal by physical decay of iodine but does not factor in a major biological excretion process, urination, or contamination from body fluids such as respiration, saliva, and perspiration estimated.[5-7] Using this method for calculation from NRC RG 8.39 have resulted in a limited estimation of patient release criteria exclusive of state-of the art capabilities in phantom dosimetry and biokinetic excretion. While NRC RG 8.39 provides more specific methods in appendices to partially account for patient-specific data, the NRC acknowledges the approach uses simplified exponential excretion models.[8] The revision of NRC RG 8.39 was released in April 2020 providing more extensive patient instructions and information for release, but no change was made to the method used to determine patient release dose limits, with the release limit continuing to be a potential total effective dose equivalent of 5 millisieverts to any individual.[8] Furthermore, consideration of age-specific patient body burden and age-specific public dosimetry continues to remain a deficiency in radiation protection patient release criteria. The adoption of patient-specific, time-dependent data is important in future development of revisions for radiation protection guidelines to more accurately assess dose and

exposure between a patient and members of the public. Patient type plays an integral role since treatment for hyperthyroidism versus a patient being treated for differentiated thyroid cancer which can be further classified as papillary and follicular, that make up for 95% of thyroid cancers, and several other tumor types that are less common, all have specific treatment plans that affect patient release criteria.[9] Accounting for different patient types can potentially allow for shorter post ^{131}I therapy monitoring periods. An ongoing objective of evaluating the effects of radiation has been to design more accurate models that consider age specificity and improving patient release guidance for pediatric patients and to inform on the risks of radiation dose to pediatric family/members of the public who would come in contact with RAI patients.

2. LITERATURE REVIEW

2.1. International Commission on Radiological Protection (ICRP) [1]

The ICRP defines a protection quantity to quantitatively determine the human body's extent of internal and external exposure to ionizing of radiation.[10] In the Annals of ICRP Publication 103, the adopted method to determine effective dose, a fundamental radiation protection quantity, begins by using absorbed dose, the basic physical quantity for radiological protection used for all types of ionizing radiation and any irradiation geometry.[10] Although absorbed dose is a physical quantity and represents the mean of the distribution of energy deposited in a specific tissue volume in units Gray (Gy), it differs from values such as equivalent dose, H_T, and effective dose, E , that include weighting factors which are based on radiobiological and epidemiological findings.[10] Applying a radiation weighting factor, w_R, to the averaged absorbed dose over specific organ volumes, $D_{T,R}$, accounts for differences in the biological effectiveness of different types of radiations to give the quantity equivalent dose in (Gy), H_T, as defined in Equation 2.

$$H_T = \sum_R w_R D_{T,R} \qquad \text{(Eq. 2)}$$

Table 1 contains the weighting factors for different types of radiation, where in the case of ^{131}I therapy, the focus is only on photons that the radionuclide emits and is capable of penetrating to the exterior of the body.

[1] Table 1 and 2 reprinted with permission from International Commission on Radiological Protection. *The 2007 recommendations of the International Commission on Radiological Protection.* Oxford2007. ICRP Publication 103.

Table 1. Radiation weighting factor values for different radiation types.[10]

Radiation Type	**Radiation weighting factor,** w_R
Photons	1
Electrons and muons	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20

*Neutrons are represented by a continuous function of neutron energy as opposed to a constant.

Values of the equivalent dose to organs can be then weighted for age- and sex-independent radiosensitivity of tissues, w_T, and summed to give the effective dose, in units Sieverts (Sv), as defined by Equation 3. The values of tissue weighting factors used for various organs throughout the human body are listed in Table 2.

$$E = \sum_T w_T H_T \quad \text{(Eq. 3)}$$

Effective dose can be used to assess stochastic health effects from biological reactions and primary physical interactions that occur when human tissues are exposed to radiation. The summation of tissue weights is equal to 1 and uniforms the sex-averaged dose distribution of the whole body. Defining these protection quantities help to determine exposure limit recommendations for regulation where the risk and occurrence of stochastic health effects and tissue reactions are minimized.[10]

Table 2. List of the tissue weighting factors for various human organs.[10]

Tissue	w_T	Σw_T
Bone-marrow (red), Colon, Lung, Stomach, Breast, Remainder tissues*	0.12	0.72
Gonads	0.08	0.08
Bladder, Oesophagus, Liver, Thyroid	0.04	0.16
Bone surface, Brain, Salivary glands, skin	0.01	0.04
	Total	1.00

* A weight of 0.00923 is applied to each of the 12 remainder tissues: adrenals, extrathoracic (ET) region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, small intestine, spleen, thymus; and a weight of 0.00462 is applied to each sex-specific tissue (prostate and uterus)

The ICRP recommends constraints, not limits for patient release, with 1 mSv/y for members of the public, which children fall under this category for ICRP Publication 94 since infants and young children are less likely to give informed consent, are not considered to be essentially involved in patient care or comforting, but are more susceptible to radiation-induced thyroid cancer.[1] ICRP Publication 94 further states, if methods for calculating external dose use activity that is widely distributed in the patient, use of an unattenuated point-source model overestimates external dose to nearby people, compared to a line source where an attenuation correction model is more accurate and can be implemented routinely.[1] The ICRP recommendations listed in Publication 94 for the public are related to effective dose alone and give multiple alternatives for release such as confinement until the residual activity in the patient reaches less than 1100 MBq or the

dose rate at 1 m from the patient was 0.05 mSv/h or less.[1] Another alternative listed was to specify an effective dose limit of 5 mSv for people exposed to the patient.[1]

Meaningful radiation dose reduction and contamination control is achieved by following appropriate procedures, and facility and room design, including shielding where appropriate, as well as education and training to promote awareness and engagement in radiological protection. ICRP Publication 94 recommends that accident prevention and review of safety procedures in radiopharmaceutical therapy are an integral part of the design of facilities, equipment, and administration procedures as well as post therapy.[11] ICRP Publication 94 states that the decision to hospitalize or release a patient after treatment is to be made based on current guidance and regulations, but also needs to account for the individual patient's circumstances such as the residual activity in the patient, the patient's wishes, and family considerations (particularly the presence of children or pregnant family members).[1]

The emphasis of ICRP recommendations, in general, are on the specific needs of patients as well as information to guide radiological protection at home to patients and caregivers, avoiding accidental exposure.[11] ICRP Publication 140 notes reasoning behind lack of biokinetic data is due to the medical community not having adequate resources for the collection of useful biokinetic or dosimetric data for such procedures.[11] Instead, quantitative imaging and dosimetry are recommended for the basis of treatment planning for radiopharmaceutical therapy. For inclusion of biokinetics in regulatory guidance, ICRP Publication 140 indicates more details on the biokinetics of uptake and retention should be readily available in the number of published studies to provide valuable and practical

application.[11] Additionally, for adoption of newer methods to determine patient release criteria, it is beneficial to assess the integrity of data gathered from descriptions of the methods used to acquire the data, meaning that the ICRP is focused on giving regulatory guidance but also paves the path to introduce new guidance in the future and methods for inclusion. Therapeutic radiopharmaceuticals typically exhibit large differences in biokinetics from one patient to another making personalized dosimetry essential to ascertain individual radiopharmaceutical biokinetics to ensure that a therapy administration does not exceed organ or tissue tolerance levels but also helps with the evaluation of patient release criteria.

Guidance for hyperthyroid patients treatment and release should take into account patient-specific factors, along with detailed written guidance for reducing exposure from the patient and their family. Currently no standardized protocols for thyroid disease treatment exist, which reflects a lack of evidence for best practices causing the administration of higher activities than necessary for effective treatment of benign thyroid disease and thus belaboring patient release. Table 3 outlines standard activities at while patients are to be released.[11] The ICRP acknowledges that a personalized approach based on patient-specific measurements can ensure the administration of minimal effective activity, thereby minimizing external exposure and protecting staff, family, and caregivers.

Unlike in cases of hyperthyroid treatment, management guidelines have been published for adult patients with thyroid nodules and differentiated thyroid cancer (DTC) and even for the diagnosis and management of thyroid disease during pregnancy and the

postpartum period. These patients undergoing treatment are recommended hospitalization following administration, but the decision to hospitalize or to release a patient are recommended to be determined on an individual basis according to calculations of potential radiation doses to family and members of the public which differs from Reg. Guide 8.39.

Table 3. Activities in MBq for release of patients dependent on external dose to other people.

Radionuclide	Half-life	MBq for 5 mSv	MBq for 1 mSv
^{131}I	8 days	1200	240

2.2. The National Council on Radiation Protection and Measurements (NCRP)

The NCRP released guidance on the management of radionuclide therapy patients in 2006, which stressed the importance of maintaining as low as reasonably achievable (ALARA) doses to members of the public (receptor). For purposes of limiting radiation doses, members of a patient's family were considered as distinct from members of the public that are limited to 5 mSv, with receptors limited to 1 mSv.[4] Because radiation treatments are considered events not likely to occur more than a few times or once in the course of a lifetime, exposure of patients' families from radionuclide therapy are labeled as "infrequent" exposure with an effective dose limit of 5 mSv. Table 4 gives reference values of activities and their medical use.[4] If patients require hospitalization, they are still allowed to have visitors during the period that radiation precautions are in effect, with the limit to a patient's family member potentially increased to receive up to 50 mSv y^{-1} under

the recommendation of the treating physician.[4] In the event that this occurs, family members are recommended to receive training and individual monitoring as if they were to be occupationally exposed, that is recorded the treating physicians.

The NCRP recommendations are focused on the prevention of the occurrence of clinically significant radiation-induced deterministic effects by adhering to dose limits below the threshold level of such effects, limiting the risk of stochastic effects, cancer and genetic effects, to a reasonable level in relation to societal needs, values, benefits gained, and economic factors.[4] Any procedure that involves radiation exposure have to be justified based on the expected benefits to society exceeding the overall societal cost while maintaining ALARA principles, with economic and societal factors being taken into account and following individual dose limits to ensure people do not exceed levels of acceptable risk. Accordingly, the ALARA principles followed, denote that radiation protection standards for patients' families are not to be as restrictive as those for the public.[4]

Table 4. Activity ranges for types of RAI treatment.[4]

Radionuclide	Typical Activity Used	Medical use
^{131}I	185-740 MBq	Hyperthyroidism (sodium iodide)
	2.59-3.7 GBq	Thyroid ablation (sodium iodide)
	1.11-14.8 GBq	Thyroid cancer (sodium iodide)

Additionally, NCRP specifically noted pediatric patients are a special concern in radiation protection because they have greater radiation sensitivity due to rapid cell division occurring and have a longer period of risk compared to adults for radiogenic sequelae following therapy.[4] Despite the relatively rare use of radiopharmaceutical therapy or brachytherapy in children, these procedures can be critical for pediatric patients

because the biological distribution, metabolism and excretion of radiopharmaceuticals vary widely with age with disparities being most pronounced in infancy and geriatric age. The recommendation made was to develop age-dependent dosimetry models to be used in radiopharmaceutical treatment planning and patient release criteria.[4]

2.3. International Atomic Energy Agency (IAEA)

The IAEA published guidance on release of patients after radionuclide therapy with contributions from the ICRP in 2009. Dose limits similar to other guidance mentioned are for effective dose to not exceed 5 mSv for family member but gives specific limits of 1mSv for children younger than 10 years of age with constraints for children over the age of 10 to 3 mSv per episode.[3] The ICRP does not have recommendations that explicitly require patients to be hospitalized for radionuclide therapy, but guidance from the IAEA in 1992 indicated that in radioiodine therapy of cancer, patients are not recommended to be sent home immediately.[3] Instead, the patient should be hospitalized and monitored for a period of time between hours to several days based on patient circumstances. The IAEA does however document EU members that require treatment of thyroid cancer using radioactive iodine only performed on inpatients. For example, in Germany, all patients who receive RAI therapy are hospitalized for at least 48 hours which highlights how some European countries practice differs from guidelines in ICRP and those described in US radiation protection recommendations.[3] Additionally, Table 5 compares release activity thresholds in patients from different countries, followed by Table 6 which gives guidance on time apart from people in contact once released.[3] The cornerstone of the IAEA position

on patient release are dose limits for the public and dose constraints for the family and caregivers. The ICRP, IAEA and EU propose dose constraints rather than dose limits be applied to comforters and caregivers with primary concern on external dose. For those in contact with a patient's urine, there is concern for contamination, but several studies have shown that the risk of contamination with ^{131}I is generally low but not negligible. Adult relatives, the internal dose due to contamination risk is less than 10% of the external dose.[3] In addition, in a study where skin and thyroid doses were measured, external exposures exceeded the internal thyroid dose equivalent by a factor of over 100.[3]

Much like its counterparts and other regulatory guidance, the IAEA and ICRP draw notice to the shortcomings and many methodological issues that compromise external dose calculations in practice that include: the assumption that the activity in patients behaves as an unattenuated point source, the use of the inverse square law at short distances, issues connected with the uptake and pharmacokinetics of radioiodine, and a tendency to use conservative assumptions.

Table 5. Maximum activity for patient release internationally.[3]

Radionuclide	Retained activity (MBq)					
	US NRC	Germany	Sweden	Finland	Japan	Australia
^{131}I	1200	75	600	800	500	600

Table 6. Recommended time restrictions for contact with others.[3]

Activity (MBq)	Patient Type	Time off work (d)	Time to sleep apart and restrict contact with partner (d)	Time to restrict contact with child <2 years of age (d)	Time to restrict contact with child 2-5 years of age (d)	Time to restrict contact with child 5-11 years of age(d)
200	Hyperthyroid	0	15	15	11	5
400	Hyperthyroid	3	20	21	16	11
600	Hyperthyroid	6	24	24	20	14
800	Hyperthyroid	8	26	27	22	16
1850	Cancer	1,3	3,16	4,16	3,13	2,10
3700	Cancer	2,7	4,20	4,20	4,17	3,13
5550	Cancer	2,10	4,22	5,22	4,19	3,16
7400	Cancer	2,12	5,23	5,24	4,21	4,17

*Under the assumption sleeping 1.0 apart for 8 hours, the first value is for cancer follow ups, the second is for ablation patients.

2.4. Prior Studies

Sparks et al. demonstrated overestimations from NRC Reg. Guide 8.39's point source method by using Monte Carlo radiation transport simulations with anthropomorphic phantoms that measured dose rate at 1 m from an ^{131}I administered patient to calculate the whole-body dose to an exposed individual.[12] Comparing the calculations to 49 ^{131}I radioimmunotherapy patients who received 0.9 to 4.4 MBq and were measured one hour post-administration with a calibrated ionization chamber positioned 1 m medially of the torso, it was concluded that the NRC overestimated about 61% of the actual value because attenuation was not considered in the exposed individual.[12]

In another study, Siegel et. al. made comparisons between NRC point source method and calculations with a line source method to highlight the conservative nature of RG 8.39. The study used several different lengths of line sources to model different age

groups between 20 and 174 cm. Exposure rates were converted to dose rates per unit activity and results indicated similarly to statements in IAEA Publication 63 where the inverse square law approximation was not reliable for shorter distances in point source or line source calculations. Line source estimations for dose rates, however, were within 10% of inverse square law results making the approximation more valid and realistic for certain distances.[13]

King Faisal Hospital and Research Center took another approach at examining the validity of Eq. 1 from RG 8.39 by measuring dose rates at 30 cm and 1 m in patients immediately after RAI treatment with a calibrated Victoreen (Inovision Radiation Measurements, 6045 Cochran Road, Cleveland, OH) model 450P ionization chamber.[14] Mean observed dose rate was typically lower than the theoretical dose rate highlighting the conservative methods of dose calculation in regulatory guidelines such as NRC RG 8.39. The study at King Faisal Hospital and Research Center stated their sample population of patients were grouped based on age and gender, with the overall sample population consisting of 76% females between the age of 21-40.[14] For the 311 patients considered, the computed point source model overestimated the measured dose rates with the average for all females being lower than males.

While the majority of studies described focused on adults, Al-Haj et. al. indicated that 11 children measured in the sample population were under the age of 16, and all had a mean dose rate of 0.034 $\mu Sv\ h^{-1}$ per MBq, higher than adults due to their smaller body structure. With children having a higher dose rate, this can imply that their parents or caregivers too, will likely be exposed much more and was supported by a survey

conducted by the European Union Member States. Jansen and Zoetelief reported of various dose constraints for exposure of individuals helping in the care of patients undergoing medical exposure, the highest reported dose was to parents who assisted their young children after ^{131}I, and for children younger than 1 years old, with an average of 2.3 mSv.[15]

Han et al. presented pediatric phantoms calculations and later, additionally performed ^{131}I source distribution Monte Carlo simulations for position-specific voxel phantoms that were separated by varying distances in two exposure scenarios (standing vs. lying face-to- face) with one scenario modeling a newborn being cared for by a mother that received ^{131}I therapy.[16,17] The Monte Carlo demonstrated effective dose for two facing adult phantoms at 1 m were a factor 1.6 lower than the NRC's point-source method for a hyperthyroid patient.[17] The DTC patient was a factor of 2.2 lower at 1 m distance, but the study overall lacked accounting for time-dependent biological excretion.[17] Similarly, Kochovska et al. estimated effective doses to relatives of 30 hyperthyroid and 30 thyroid cancer patients after providing patients and family members with distancing guidance.[18] The study was for 1 week and resulted with a 0.87 mSv mean value of the effective dose for the relatives of the hyperthyroid patients compared to 0.21 mSv for spouses of thyroid cancer patients which are both below the NRC's dose limits.[18] Family members of hyperthyroid patients who followed appropriate guidance had recorded minimal values with the 1 spouse who did not, receiving the highest measured dose of the study of 6.79 mSv which was over the NRC's limit of 5 mSv.[18] The measured family members of hyperthyroid patients received effective doses between 1 mSv and 3 mSv where thyroid

cancer patient family members received below the recommended dose even for children (1 mSv). The protocol followed included 3 days of hospitalization and continued dose rate measurements using thermo luminescence dosimeters. Written recommendations were given to patients instructing them to sleep in separate rooms from spouses or family members for 7 days and keep a distance of 2 m away to improve radiation protection to family members, general public and environment.[18]

Additionally, Dewji et al. independently verified that the point-source method overestimated the external dose rate of an exposed adult (from an adult patient) between 10 cm to 300 cm of separation distance, regardless of time post ^{131}I administration but the two different methods began to converge beyond 300 cm separation distance, particularly for hyperthyroid subjects.[19] This study employed computational phantom modeling to simulate the body anatomy of an adult patient and member of the public using stylized Phantom with Moving Arms and Limbs (PIMAL). The study concluded that the point-source method overestimates the dose rate for a standing exposed person to a standing hyperthyroid patient by a factor of 1.9 at 8 h post administration at a separation distance of 1 m and by a factor of 3.3 at 8 h for a DTC patient.[19]

2.5. Biokinetic Modeling

As there has been an increase in incidence and concern of thyroid cancer in people, especially younger children, around the world after the accident in Chernobyl, there has been an increase of ^{131}I therapy administered to treat patients.[1] With increasing numbers of patient treatments, the need for more realistic dose calculation and biokinetic modeling

of specific organ targets becomes magnified to develop and be included in patient release criteria that accounts for patient-specific factors such as age and time-dependent excretion patterns. While strides have been taken in absorbed dose estimations due to advancements in developing realistic phantom models, the same cannot be said for biokinetic models to determine real activity distribution retained by patients which can be variable due to prescribed doses, patient weight and other metabolic factors, thus potentially prolonging meeting release criteria by a licensee.

With realistic and adaptive metabolic models becoming a powerful tool to determining dose across different patient age ranges and the retained activity, integrating biokinetics in patient release criteria can help better improve regulation guidelines for radiation protection with patient release. ICRP Publication 53 presented a simplified biokinetic pathway of ^{131}I but lacked enough anatomical compartments which led to greater imprecisions.[20] Though years later in ICRP 128, a new model proposed an expansion in detail to compartments, the complexity of the model was deemed difficult by some in adapting to patient specific data.[21] Current ICRP biokinetic models also are not individualized and only consider an "average" metabolism, for example 26% iodine uptake for healthy thyroids, but lack consideration of metabolism due to thyroid dysfunction or illness, e.g. 5% uptake for differentiated thyroid carcinoma (DTC) or 80% uptake for hyperthyroidism.[19,22-24] Furthermore, dose coefficients present in ICRP Publications 106, 128, 53 and 80 – are intended for diagnostic nuclear medicine and not for therapeutic applications.[20,21,25,26]

Leggett proposed an adaptable biokinetic model for iodine that restructured physiological system models by describing three subsystems of the iodine cycle in a human adult: (1) circulating inorganic iodide; (2) thyroidal iodine, and (3) extrathyroidal organic iodine.[24] The model provided a detailed description of the early biokinetics of absorbed iodine to improve radiation dose estimates for short-lived isotopes of iodine compared to the model listed in ICRP Publications 54 and 67.[27,28] By modifying baseline transfer coefficients, Leggett's model becomes applicable to a number of different scenarios in radiation protection. Dewji et al. work highlights the adaptability by using modified transfer coefficients for the thyroid compartment to model hyperthyroid and differentiated thyroid cancer uptake.[19,22] Leggett later expanded his model with more anatomical compartments in the alimentary tract and age-specific transfer coefficients for pediatric patients including excretion rates from ICRP Publication 67 and 100.[23,27,29] A comparison of thyroidal dose coefficients suggested there is little effect on the changes with age in dose coefficients for iodine isotopes, except for short-lived radioiodine which is predicted to have a higher absolute thyroidal dose coefficient.

Guiu-Souto et. al. presented an abbreviated model compared to Leggett's that also expanded alimentary tract compartments to emulate oral administration of ^{131}I in DTC patients.[30] While citing the lack of well-established models and methods for quantifying absorbed doses to specific organs and tumors, Guiu-Souto acknowledged that a certain level of complexity beyond his model is necessary, otherwise there is far too significant degeneration in the validity of their model. Models adopted by the ICRP present for age specific biokinetic patterns but a further use for patient specificity can be regional specific

since reference transfer coefficients were based on typical worldwide dietary intake of stable iodine.[31] ICRP reference thyroidal biokinetics based on Leggett's model showed even further adaptability being modified to use regional data which indicated differences from the global average due to low or high dietary intake of stable.[31] The South Korean population, who generally have a higher dietary iodine intake than the global mean displayed these modifications.[31] In the study, transfer coefficients that were altered for Korean-specific values in thyroidal uptake rate and leakage rate of thyroidal organic iodine as inorganic iodide. The Korean-specific values for these transfers were determined to be 4.48 and 0.0171 d^{-1} compared to 7.26 and 0.0077 d^{-1} typically used.[31] The changes were measured for thyroidal iodine and physiological status of Korean adults. The Korean model using Korean-specific transfer coefficients, predicted lower thyroidal uptake and faster decrease of thyroidal iodine. The predicted cumulative activities of ^{131}I in the thyroid were 40 to 80% lower than those of the ICRP model.[31] Developing a regional-specific model demonstrated how the iodine biokinetics for Koreans (i.e. high-iodine-consuming population) differ from ICRP model predictions and can serve to improve the accuracy of thyroid dose estimation for Koreans and improvements made to radiation protection standards.

2.6. Detector Response

NCRP Report 155 specifically mentioned that for patient release, instrumentation typically used was a scintillation well counter system which has the ability to measure activity in patient samples, such as blood or urine and can be important in developing

biokinetic correlations or determining when to release a patient.[4] While previous studies are discussed below, it is important to note several of the studies utilized in-vivo measurement instrumentation estimations for radiological emergency response scenarios, but the detectors used are also commonly used for nuclear medical procedures.[32-34]

Among instrumentation used, the thyroid uptake system is of particular interest. Measurements for thyroid uptake are determined by the ratio of the radioactive material concentrated in the thyroid gland to the amount administered to the patient. Thyroid uptake measurements are typically used for overactive thyroid dysfunction conditions such as hyperthyroidism, Graves' disease, toxic nodular goiter, and stimulator secreting tumors. Decreased or lower uptake can result from numerous conditions such as with thyroid hormone secretion in ectopic tumors, hormonal release in thyroid injury, after intake of thyroid hormone, or in Jod-Basedow disease. ^{131}I ablation is commonly used during treatment for thyroid cancer, and uptake measurements are used to monitor thyroid activity.

A detector such as the CAPTUS 3000 system has several useful medical applications and functions for thyroid uptake measurements such as storing patient identifiers like demographic and dosage information, count data for both the administered dosage and the patient, decay correcting count data, and calculating thyroid uptake results.[35] One of the predefined regions of interest for library of radionuclides in the system is ^{131}I where a set of "normal" values have been entered and results exceeding these values are flagged. The thyroid uptake software for Captus detectors have been designed for different counting procedures and with either capsules or liquid dosages. When a gamma

or x-ray from a radioactive source reaches the NaI crystal inside the Captus 3000 detector, energy is transferred after collision between electrons in the crystal matrix, primarily through Compton interaction. Excited electrons release energy in the form of visible light directly proportional to the absorbed energy of the electron. A single light pulse is measured by the system from every light emission for each incident ray generated by a Compton scattering event. Pulse intensity is directly proportional to the energy of the incident gamma or x-ray. Light is then directed toward the photomultiplier tube by reflection from the interior side of the aluminum housing. The photomultiplier tube then converts the visible light pulses into amplified electrical energy signals through a series of dynodes that is directly proportional to the intensity of the incident light pulse. In summary, the pulse height generated is directly proportional to the incident gamma or x-ray energy detected.

Several studies have proposed relationships between count rates and radionuclide distributions in the human body to assess dose to patients after an uptake of radioactive materials by using radiation detecting measurement instruments. Kramer et al. constructed a high-purity germanium detector in MCNP to simulate counting efficiencies in two children-aged phantoms.[36] The development of a predictive analytical expression based on a function of photon energy and weight/height ration of an individual assuming a uniform distribution in the whole body, coupled with biokinetic models, estimated intakes and dose of radionuclides to people.

Calibrations factors present another use of measurements made by detectors post treatment, and were developed for five pediatric age groups in a study by Anigstein et al.[37]

Measurements from the detectors were coupled with biokinetic models from Oak Ridge National Laboratory's (ORNL) Dose and Risk Calculation Software (DCAL) to determine the fraction retained of ^{131}I in specific organs and distribution as a function of time.[37] The results of the calibration factors provide estimation of quantities that are used in patient release criteria by a licensee such as committed effective dose and cumulative effective dose as a function of time.

A study conducted by S. Cohen and Associates (SC&A) evaluated many common hospital radiation detectors used for nuclear medical procedures to assess internal contamination from radionuclides following nuclear security events (e.g. dirty bomb involving inhalation of ^{131}I).[32] The SC&A study concluded that the thyroid uptake system, among other detectors, were capable to detect low levels of radiation.[32] In a similar dirty bomb scenario, Scarboro, S. B. also used a thyroid uptake system for the measurements made of various isotopes and concluded one minute to be the minimum necessary counting time for the threshold of one clinical decision level (approximately 0.4 Sv).[34] For measurements of ^{131}I, the probe was placed on the neck where the thyroid was located for the counting time. Analyzing various phantoms showed the count rates to be more similar between various phantom types for the case of ^{131}I, with children showing the lowest count rate per becquerel. Because a child has a smaller thyroid gland than an adult, ^{131}I rapidly saturates a child's thyroid gland before an adult's thyroid gland.

Recently, a study by Li et al. states that there is a deficiency in child thyroidal monitoring with current techniques and instruments being designed and calibrated for monitoring adults following a dirty bomb exposure scenario in which ^{131}I was inhaled.[33]

The study proposed derived age specific calibration factors for thyroid monitoring using four selected detectors, one being the Captus 3000. An example scenario was presented for ^{131}I thyroid uptake in a child. Measuring a count rate with a detector like the Captus 3000 within a post-exposure timeframe, the intake, 30 d thyroid absorbed dose, committed thyroid equivalent dose, and committed effective dose could be estimated directly using the calibration factor.[33]

3. METHODOLOGY

The flow chart in Figure 1 below summarizes the methodology performed in this study. Computational phantoms were used to model members of the public and patients in newborn, 01-year-old (yo), 05yo, 10yo, 15yo and adult age groups. Biokinetics were calculated for each of the age groups by altering age-specific transfer coefficients. The exposure rates, external dose rates, and detector response functions were coupled with biokinetics to estimate radiation protection quantities with time-dependent biological clearance in each age group. Values are integrated to compare with RG 8.39 methods for patient release.

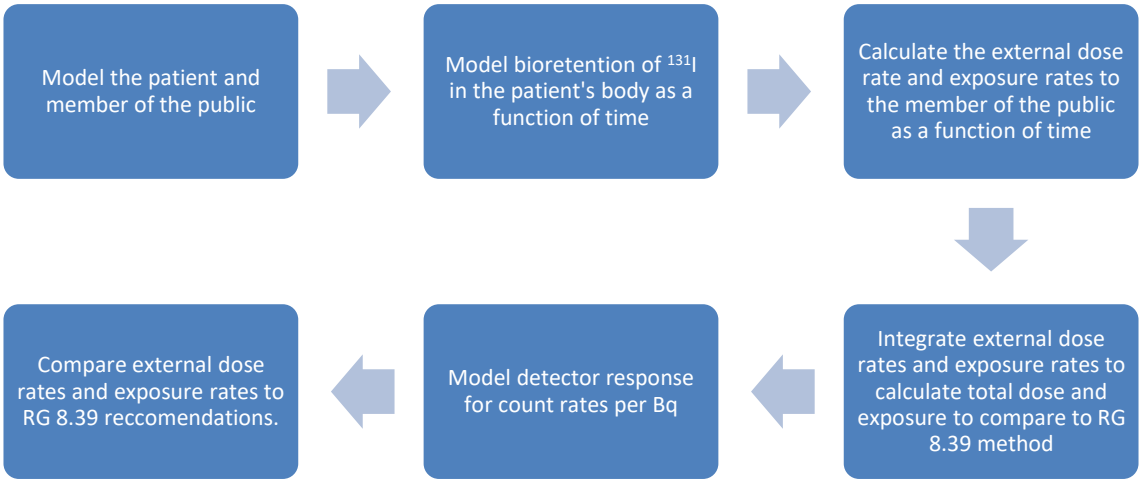

Figure 1. Flow chart of methodology performed throughout this study.

3.1. Biokinetics [2]

The predicted distribution of RAI activity in a patient following therapy for up to 90 days post-administrations was based on the continuous, first-order systemic iodine biokinetic model proposed by Leggett in Figure 2.[23] Modeling was conducted for newborn, 01 year old (yo), 05yo, 10yo, 15yo, and adult age groups. The body was simplified by dividing systemic iodine into three regions: thyroid contents, urinary bladder contents, and soft tissue contents. The soft tissue section represented all other systemic iodide combined where the expanded alimentary tract, liver, kidneys, and other remainder compartments were summed. Three different levels of thyroid uptake of non-decay corrected ^{131}I were considered: a peak thyroid content of 5% for DTC patients, where the 5% represents the remnants of the thyroid following ablation therapy and thyroidectomy; a peak of ~27%, represented normal thyroid activity; and a peak of 80%, represented the overactive hyperthyroid uptake. Leggett defined age specific normal thyroid uptake with baseline parameter values. Peak thyroid uptakes of 5% and 80% were targeted by adjusting the age specific transfer coefficient from iodine in blood to the thyroid iodide compartment on Figure 2, denoted by a red box. The removal of activity from the urinary bladder contents in urine modeled voiding at a constant rate. Voiding and excretory transfer coefficients were adjusted for the alimentary tract based on values listed in ICRP Publications 53 and 100 for age specific parameters.[27,29]

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[2] Figure 2 reprinted with permission from Leggett R. An age-specific biokinetic model for iodine. *J Radiol Prot.* 2017;37(4):864-882.

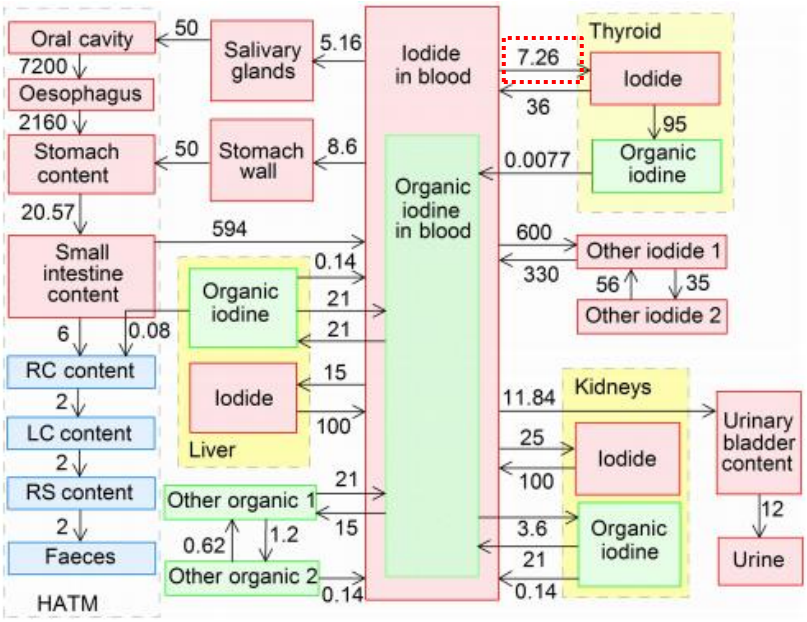

Figure 2. The adult iodine biokinetic model from Leggett used as the starting point for the age-specific model. The numbers correspond to baseline transfer coefficients (d^{-1}). Values shown for urinary bladder and alimentary tract contents are reference values for an adult male (ICRP 1993, 2006); RC = right colon, LC= left colon, RS= rectosigmoid.[23]

To execute the method of multiple compartments in Figure 2, a Python script was created to solve for a first order differential equation matrix system where each element of the matrix represented a positive transfer from one compartment going into another. The diagonal of the matrix system represented the loss of transfer leaving one compartment to another. The first order equations were solved to model continuous excretion. A cubic spline function was used to adjust the discretization of time and corresponding fraction retained of ^{131}I and export Excel file. From the excel file, thyroid, bladder, and soft tissue components of biokinetics were computed. The adult values were compared to values obtained from DCAL comprehensive software system. DCAL calculates the retention of radio-nuclides taken into the body and their distribution among selected anatomical

regions as a function of time following intake of radionuclides which implemented Leggett's model. The age-specific biokinetics produced by the python script was validated against the DCAL software outputted data. Table 7 contains values age-specific transfer coefficients employed in the matrix system.

Table 7. Age-specific transfer coefficients(d^{-1}) altered from Figure 1 compartments.[23]

Pathway	Newborn	01yo	05yo	10yo	15yo	adult
Thyroid 2 to blood organic	6.93E-2	4.62E-2	2.31E-2	1.39E-2	1.07E-2	7.70E-3
Blood organic to Other 3	2.63E1	2.33E1	2.10E1	1.91E1	1.75E1	1.5E1
Other 3 to blood organic	3.68E1	3.27E1	2.94E1	2.67E1	2.45E1	2.10E1
Other 3 to Other 4	2.10E0	1.87E0	1.68E0	1.52E0	1.40E0	1.20E0
Other 4 to Other 3	1.09E0	9.64E-1	8.68E-1	7.89E-1	7.23E-1	6.20E-1
Other 4 to blood iodide	2.45E-1	2.18E-1	1.96E-1	1.78E-1	1.63E-1	1.40E-1
Blood organic to kidneys 2	6.30E0	5.60E0	5.04E0	4.58E0	4.20E0	3.60E0
Kidneys 2 to blood organic	3.68E1	3.27E1	2.94E1	2.67E1	2.45E1	2.10E1
Kidneys 2 to blood iodide	2.45E-1	2.18E-1	1.96E-1	1.78E-1	1.63E-1	1.40E-1
Blood organic to liver 2	3.68E1	3.27E1	2.94E1	2.67E1	2.45E1	2.10E1
Liver 2 to blood organic	3.68E1	3.27E1	2.94E1	2.67E1	2.45E1	2.10E1
Liver 2 to blood iodide	2.45E-1	2.18E-1	1.96E-1	1.78E-1	1.63E-1	1.40E-1
Liver 2 to right colon contents	1.40E-1	1.24E-1	1.12E-1	1.02E-1	9.33E-2	8.00E-2

Other 1 and other 2 represent inorganic iodide in 'other tissue'. Other 3 and other 4 represent organic iodine compartments 1 and 2, respectively. Thyroid 1, kidneys 1, and liver 1 refers to inorganic iodide and thyroid 2, kidneys 2, and liver 2 refers organic iodine pools in the thyroid, kidneys, and liver, respectively.

3.2. Computational Models

Stylized computational hermaphroditic pediatric phantom models were used with the Monte Carlo radiation transport code (MCNP) version 6.2 to estimate time dependent external dose rates at varying distances from each major pediatric milestone temporal phase: newborn, 01yo, 05yo, 10yo, 15yo, and adult for normal (27%) , DTC (5%), hyperthyroid (80%) biokinetics.[38] The pediatric stylized phantoms employed in this study were originally developed at ORNL by Cristy and Eckerman which was later modified by Han et. al. to improve elemental compositions in organs and tissues for ICRP Publication

89.[10,16,39] The modified organs included the head, brain, salivary glands, respiratory tract, extra-pulmonary airways, alimentary tract, rectosigmoid colon, urinary bladder mucosa wall, and kidneys. Additionally, Han et. al. revised radiation transport parameters in the stylized phantoms to include updates to the assigned organ volumes.[39-41] These stylized phantoms contain all organs used for effective dose calculations listed in ICRP Publication 103 except for the extrathoracic region and the lymphatic system which the thymus acts a surrogate.[10] The pediatric stylized phantoms have over 100 mathematical volumes which represent anatomical tissues and organs with 22 distinct material compositions defining the phantom. The tissue masses, compositions, and densities were consistent with ICRP Publication 89 and International Commission on Radiation Units and Measurements Report 46.[42,43] The stylized phantom was determined to be appropriate per the conclusion comparing pediatric external dose coefficients from external gamma-ray exposures with voxel phantoms in Dewji et al.[44] The study compared organ dose rate coefficients at 100, 500, 1000 and 5000 keV energies for all pediatric phantoms, voxel and stylized, for photon assessments. The study concluded that the majority of the sex-averaged organ dose rate coefficients were within 15% of each other over all phantoms, ages and energies. For energies above 500 keV, effective dose rates between the voxel and stylized phantoms were within 5% of each other and for energies above 70 keV the dose rates were within 10% of each other. The primary gamma energy for ^{131}I is 364 keV, making the stylized phantom within 10% of the voxel phantom results. Figure 3 demonstrates a computational phantom employed in this study.

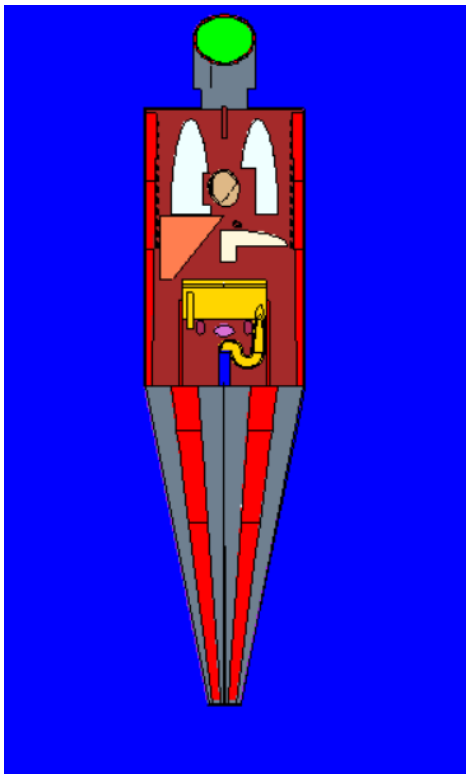

Figure 3. Computational adult phantom visually generated in Visual Editor software and colored for different materials.[45]

3.3. Dose Rates

3.3.1. Exposure Rates

The external dose rate calculations were simplified by dividing the body into three sources: a soft tissue, thyroid and urinary bladder regions. The ^{131}I contents of the thyroid and urinary bladder in patients generally represent the primary contributing organ sources of external dose rates to members of the public (receptors).[24] An example of a soft tissue exposure source generated in Visual Editor software can be seen in Figure 4.[45] For each Monte Carlo calculation in newborn, 01yo, 05yo, 10yo, 15yo, and adult hermaphroditic stylized phantoms, a unit activity of ^{131}I was assigned to one of these three regions, and

three separate Monte Carlo F5 tally calculations. The F5 tally was used to calculate a flux at a point and coupled with age-specific biokinetics at the three different uptakes: Normal (27%), DTC (5%), and hyperthyroidism (80%), to calculate an exposure rate at varying distances from a unit activity distributed throughout the whole body. Exposure rates from the flux tally at a point were estimated by using the air kerma approximation. This approximation is known to be accurate to ~2% for ^{131}I due to the primary photon energy of 364 keV.[17] The results are to be compared to NRC Reg. Guide 8.39 exposure as a point method where the phantom burden with the unit activity of ^{131}I is exposing a receptor at a point.

Figure 4. Adult hermaphroditic phantom with soft tissue distributed source in the presence of air graphically generated by Visual Editor computer software.[45]

3.3.2. Phantom effective dose rates

A phantom with ^{131}I body burden was positioned directly in front, facing towards a second phantom that was the receptor. Permutations of different aged phantom patients and receptors were simulated at various distances between 10 cm to 300cm. Organ dose concentrations and absorbed dose were estimated in the receptor individual using F6 MCNP tally. Dose rates for active marrow and the bone surface were estimated using skeletal response functions reported as cell-averaged flux (particles cm^{-2}) in MCNP (F4 tally) in the skeletal regions specific to the ORNL stylized phantoms. Tallies for receptors were over effective dose organs listed in ICRP Publication 103 except for the extrathoracic region and the lymphatic system which the thymus acts a surrogate.[10] Although the skeletal response functions published in ICRP Publication 116 are specific to the adult voxel reference phantom, these were transposed here due to lack of recent ICRP publication of pediatric skeletal response models at the time of this work.[46] The skeletal response functions employed in the pediatric stylized phantoms were derived from the approximations of the adult phantom from Cristy and Eckerman, which represented the best available data for application in the pediatric phantoms.[39] Anterior dose rates were determined at the surface 1 m from the patient at the level of the patient's umbilicus.[4] Equivalent dose was calculated from absorbed dose results and using tissue weighting factors from Table 2, an effective dose was computed for each of the three sources simulated: thyroid, bladder, and soft tissue. A time dependent effective dose rate was computed by folding in the age specific biokinetics for the three body regions with

effective dose for 5%, 27% and 80% thyroid uptake. Area under the curve was calculated for the effective dose as a function of time and compared to the point source method in NRC RG 8.39.

Additionally, occupancy factor, is typically set to 0.25, where occupancy factor is the fraction of the time that a patient may be assumed to be close to the exposed member of the public, usually a family member at home. Because occupancy factor can vary depending on practices of patients once released, to build in conservative estimations, this was set to 1. Realistically, as an example, a DTC patient with no family or caregivers once released from the hospital by a licensee after ^{131}I treatment, could have an occupancy factor much lower than the default 0.25, or conservative case of 1. In the US, because there is no standard activity used when treating patients, in some cases, activity is greater than the default 1.11 GBq (30 mCi), while still meeting the primary dose limit of 5 mSv (500 mrem). Adjusting occupancy factor can allow scenarios where the activity at which patients were released, or the activity that was administered on an outpatient basis was greater than 1.11 GBq to be within the 5 mSv dose limit. Figure 5 illustrates an example of the face to face configuration for simulations in different age groups for effective dose calculations.

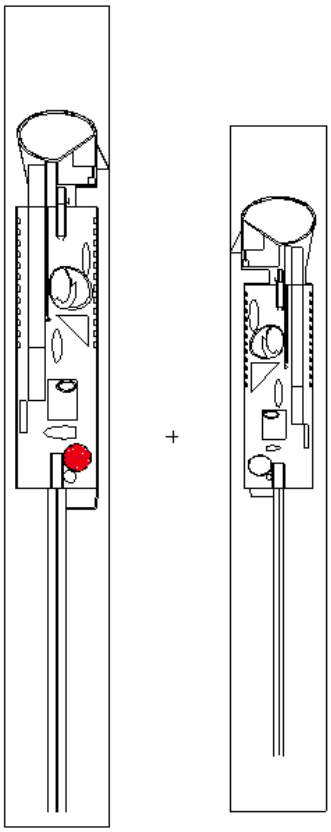

Figure 5. **Adult phantom with bladder source at 30 cm away from a 10 year-old hermaphroditic phantom in the presence of air graphically generated by Visual Editor computer software.**[45]

3.4. Detector Response

Detector responses for the age-specific phantom sources was assessed to propose a relationship between the count rates and radionuclide distributions from pediatric patients using a validated Captus 3000 Monte Carlo simulation that was used by Li et. al. which accounts for different thyroid uptakes associated with normal thyroid function, DTC, and hyperthyroidism.[33] The validated detector model was applied for simulations with their permission. A graphical rendering of a pediatric patient with the Captus 3000

detector is seen in Figure 6. As a common nuclear medicine apparatus, the thyroid uptake system is readily available in hospital nuclear medicine departments and is a functional tool for use in patient release.

A pulse height tally (MCNP F8 tally) was performed over the NaI crystal volume for the photons emitted by the source in the patient and energy deposited in crystal for a count rate. The Captus 3000 Thyroid Uptake System is manufactured by Capintec, Inc, and is a fully automated, PC-based system which is typically used to perform thyroid uptake tests, bioassay tests, and other lab tests. The system includes a 2" Sodium-Iodide (NaI) detector. The detector was collimated with a lead-antimony composite material. The thyroid uptake collimator extends approximately 16 centimeters from the detector face and the bioassay collimator extends only approximately six centimeters from the detector. All Captus 3000 thyroid uptake systems include the thyroid uptake collimator but the bioassay collimator is an optional feature.[34] The focus of this work is on the standard thyroid uptake collimator. The system stores patient information and demographics as well as all collected spectral or counting data. These features are very useful for generating detailed thyroid uptake reports and staff bioassays; reports can be saved and printed as individual reports or as a cumulative history. Specifications from Capintec were used to model the critical components of the detector and collimator.[35] The NaI detector crystal was surrounded by 0.508 mm of Aluminum. The photomultiplier tube is mounted directly against the back of the crystal and was represented by an enclosed cylindrical vacuum in the model. A detector side shield (3.175 mm thick lead) wraps around the detector and connects to the collimator. The 2" x 2" NaI crystal and photomultiplier tube are enclosed

in a lead and antimony collimator that extends approximately 16 cm from the face of the crystal. The entire collimator is housed inside an outer steel layer.

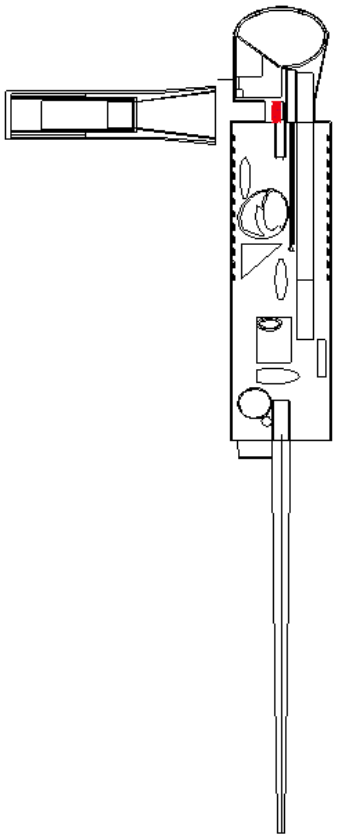

Figure 6. 15year-old hermaphroditic phantom with thyroid source at 10 cm away patient's throat surrounded by air graphically generated by Visual Editor computer software.[45]

4. RESULTS

To summarize, biokinetic data is reported for different age groups to demonstrate which organs and age groups retain or clear activity fastest or slowest. The bladder was responsible for clearing activity in DTC patient, while hyperthyroid patients primarily cleared activity via thyroid. The biokinetics are then coupled with external dose rates, exposure rates and count rates from MCNP for time-dependent and age-specific trends that help with patient release criteria. Results shown are for 10yo, 15yo, and adult patient cases that reflect applicable patients being treated with newborn, 01yo, 05yo, 10yo, 15yo and adult receptors. External dose rates, exposure rates, and count rates per unit of activity indicated typically 10yo patients trended higher than adults.

4.1. Biokinetics

Implementing the method outlined by Leggett and in Figure 2, age-specific biokinetic models were generated using organ-specific transfer coefficients.[23] Altering the transfer between different organs such as blood to thyroid created different uptake schemes that modeled patient's excretion patterns after RAI therapy in normal, DTC, and hyperthyroid patient cases. Table 8 summarizes the numerically derived transfer coefficients altered to reflect 27% uptake for normal thyroid patients, 5% uptake for DTC patients, and 80% for hyperthyroid patients undergoing RAI treatment. The trend for altered thyroid uptakes in pediatric patients results in a higher uptake the younger the patient with newborns having the highest initial uptake.

Table 8. Age-specific transfer coefficients altered for different patient uptakes (d^{-1}).

Age	00yo	01yo	05yo	10yo	15yo	adult
Normal Thyroid	7.26	7.26	7.26	7.26	7.26	7.26
DTC	1.105	1.080	1.055	1.045	1.042	1.040
Hyperthyroid	95.7	92.1	88.7	87.0	86.5	86.0

The plots generated in Figures 7-9 demonstrated the totaled iodide fraction retained of activity over time throughout the entire body post administration of RAI for the three different types of uptakes. Calculating the total iodide fraction refers to the sum of iodide from each compartment in Figure 2 as a function of time. Differences or distinctions in the trends for specific age groups are attributed to the altering of certain organ transfer coefficients to develop age specificity, where 10yo, 15yo, and adult patients trend similarly to each other but differently than newborn, 01yo, and 05yo patients. Newborn models were based on 100-day old infant, but for practical purposes it was denoted as newborn or 00yo, and adult was denoted as 25yo.[23] Transfer coefficients listed in methods were determined to have less influence on trends, however, alimentary tract, voiding, and thyroid transfer coefficients were the cause of change in uptake trends. The importance of groupings ages is based on growth milestones achieved by a person throughout their lifetime, namely how the body functions in pre-pubescence and the onset of puberty to adulthood.

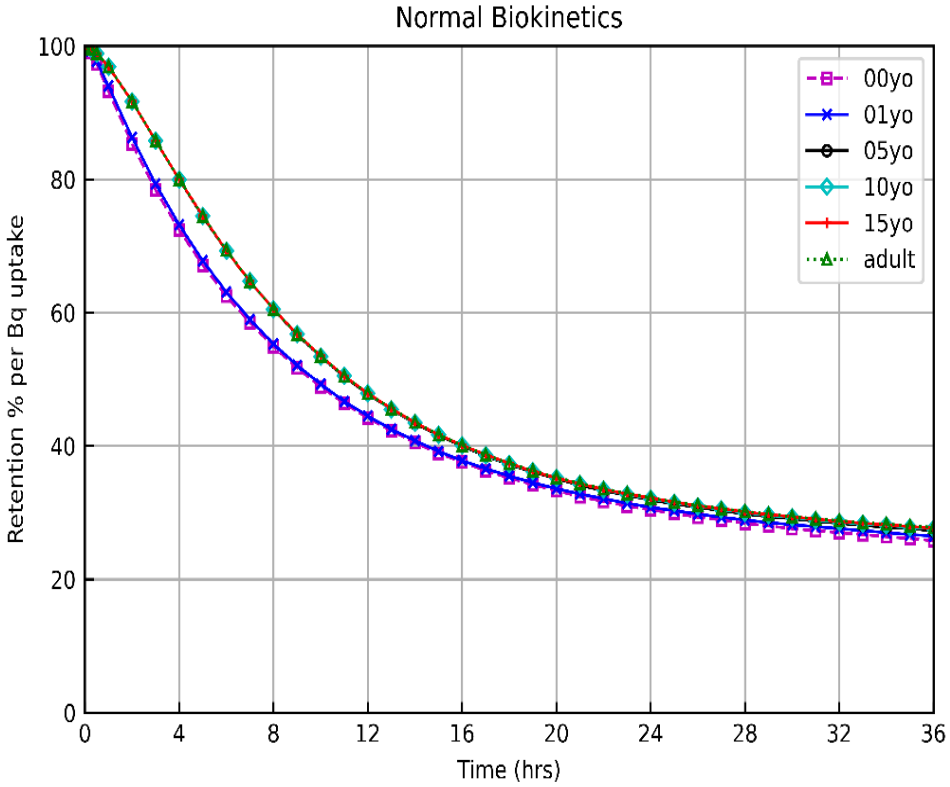

Figure 7. Normal (27%) total uptake of biokinetics for different age groups.

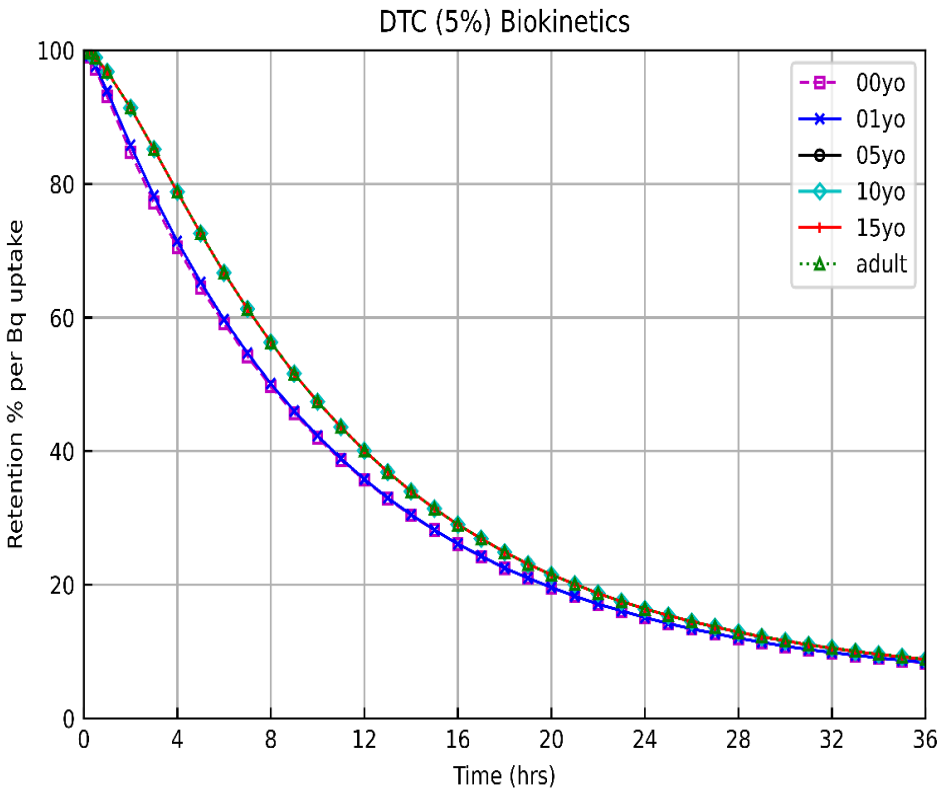

Figure 8. Total biokinetics for DTC (5%) patients among different age groups.

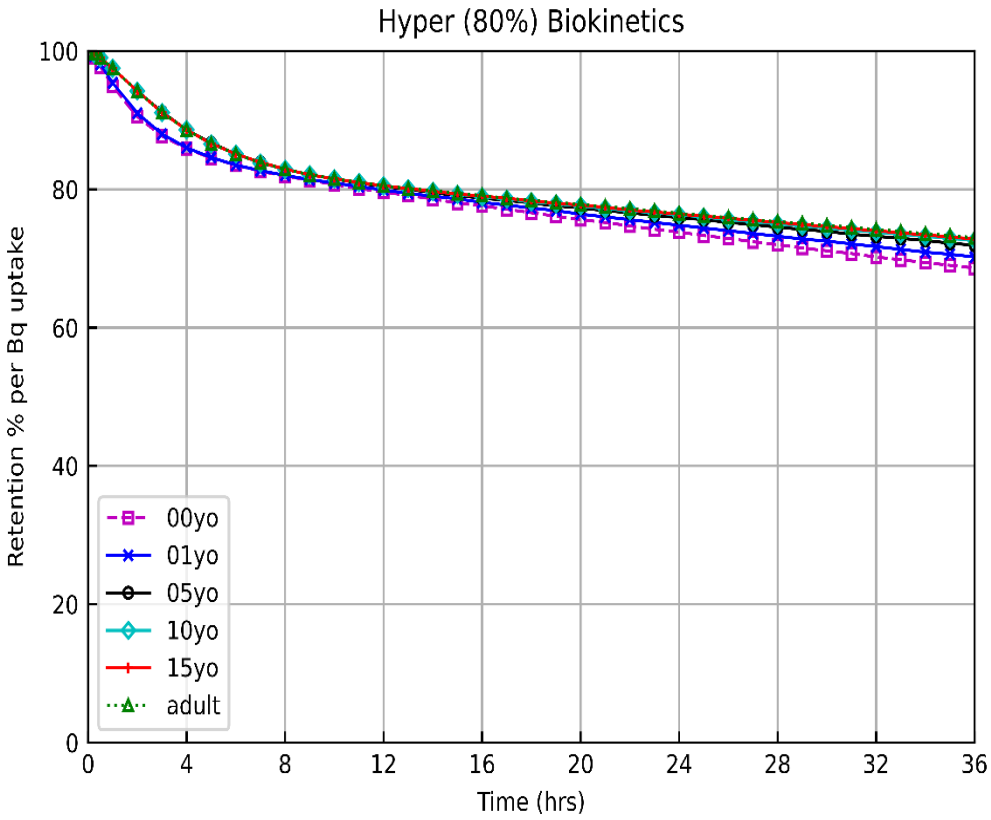

Figure 9. Total biokinetics for hyperthyroid (80%) patients in different age groups.

While trends in age groups compared among the same uptake pattern do not vary drastically and carry generally the same curve shape, Figure 10 makes the comparison in a 10yo patient between the three uptake schemes that highlights the distinctions between patients. Hyperthyroid patients retained activity for a longer period of time while DTC patients removed activity at a much more rapid rate comparatively among the three uptakes plotted for 36 hours.

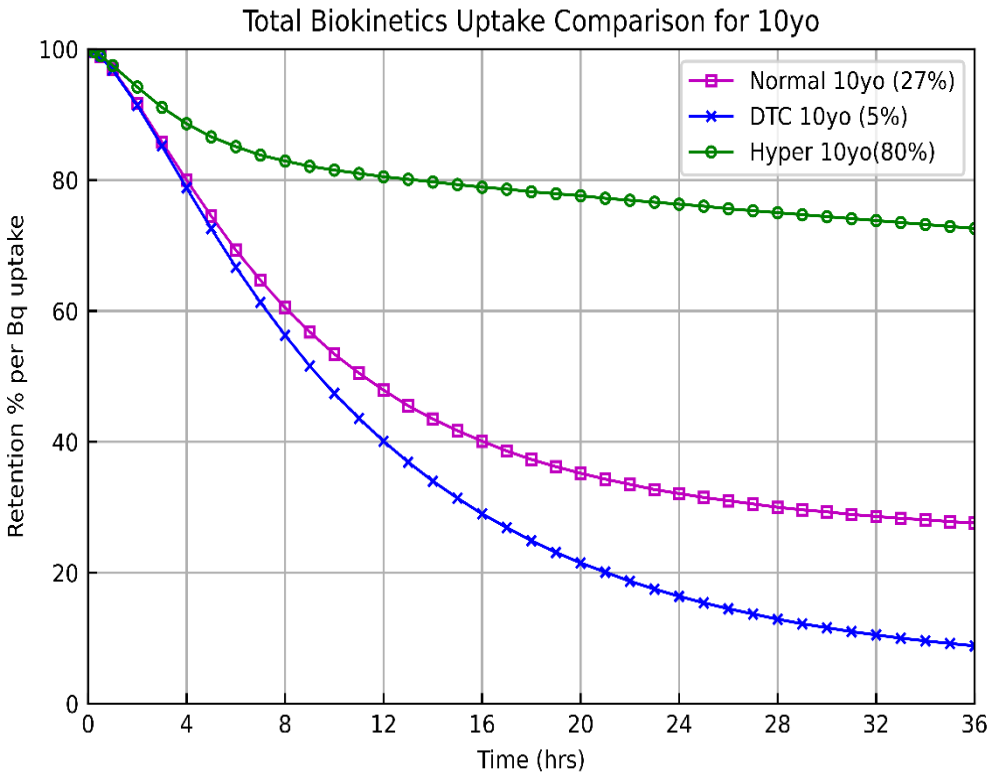

Figure 10. Total biokinetics for different uptakes in 10yo patient.

Because a DTC patient typically undergoes a thyroidectomy, the partial or total removal of the thyroid, RAI redistributes throughout the body differently because a smaller amount of RAI is absorbed into the leftover remnants of the thyroid. Figure 11 illustrates the main driving mechanism of clearing RAI in a DTC patient is voiding with the bladder peaking higher and helps further explain why in Figures 8 and 10 the total DTC trend depresses much more rapidly than hyperthyroid and normal patients across age groups shown in Figures 7-9. Bladder transfer coefficients are adjusted based on age groups to reflect the difference of rates a specific age group voids at and clearance of RAI from the bladder.

The younger a patient, because the volume of the bladder is smaller than an adult, they have a higher rate of clearance due to voiding more frequently.

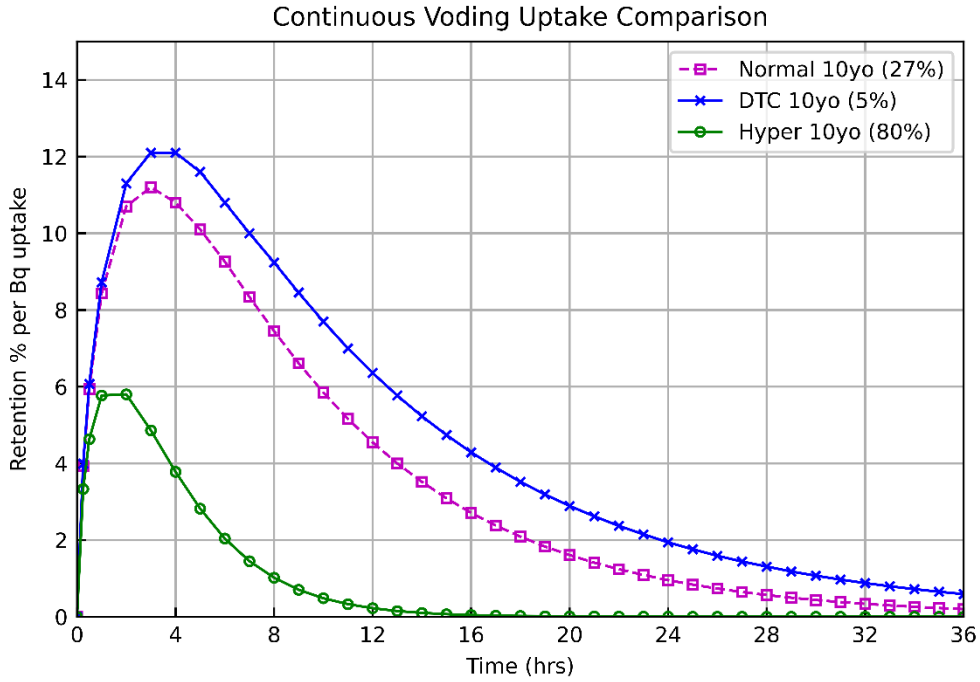

Figure 11. Voiding comparison of uptakes in 10yo patient as function of percentage (%) retention over time.

Figures 12-14 divide the total biokinetics into three main compartments, thyroid, soft tissue, and the urinary bladder to help depict why hyperthyroid patients require more time to clear RAI. Comparing the trends between each uptake scheme, Figure 14 demonstrates that the thyroid retains a higher fraction of RAI for a longer period of time because of the higher uptake by the thyroid due to hyperthyroidism, reflective of an overactive thyroid and the higher transfer coefficient defined in Table 8. Because less RAI is being cleared through voiding in hyperthyroid patients, physical decay plays a larger role than biological

clearance compared in DTC patients who are more bladder dependent. In other words, DTC patients, clearance was driven by voiding while thyroid metabolism drives hyperthyroid patients.

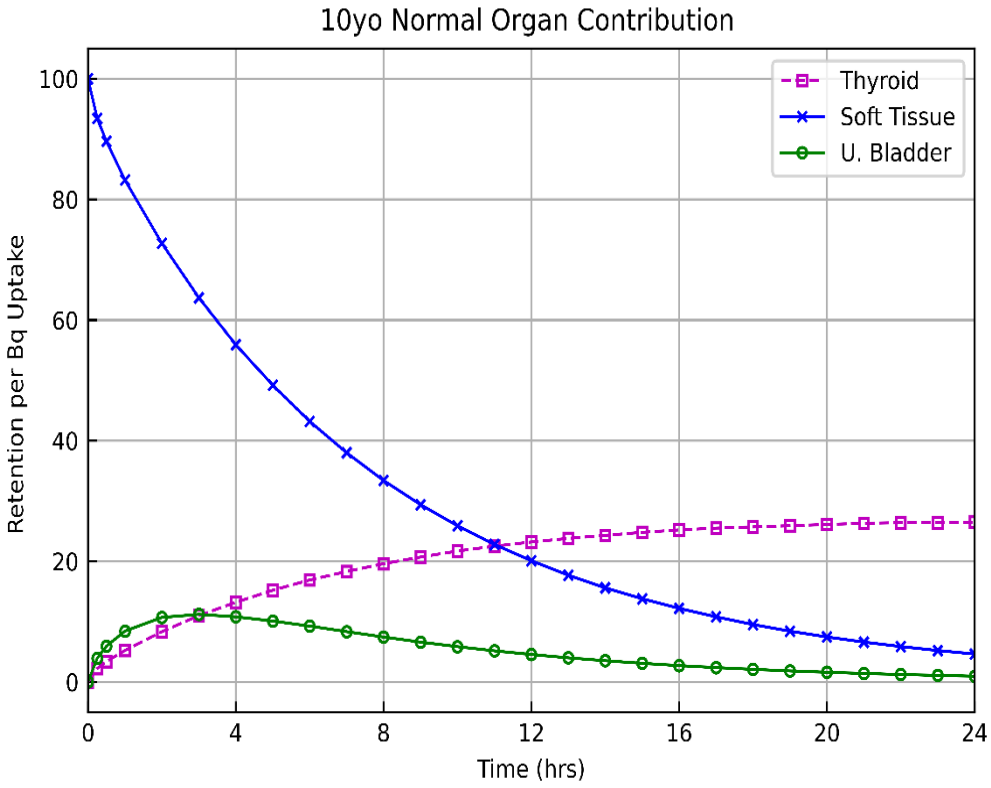

Figure 12. Organ contributions to a normal uptake (27%) 10yo patient.

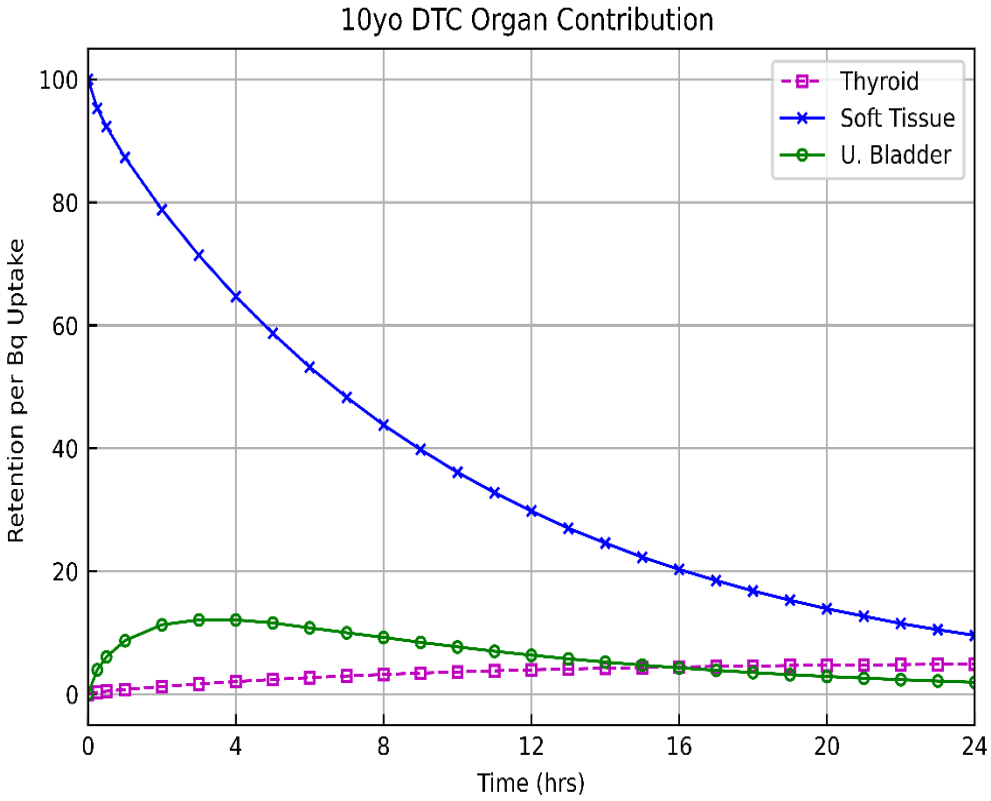

Figure 13. Fraction retained in organs for 10yo DTC uptake (5%) patient.

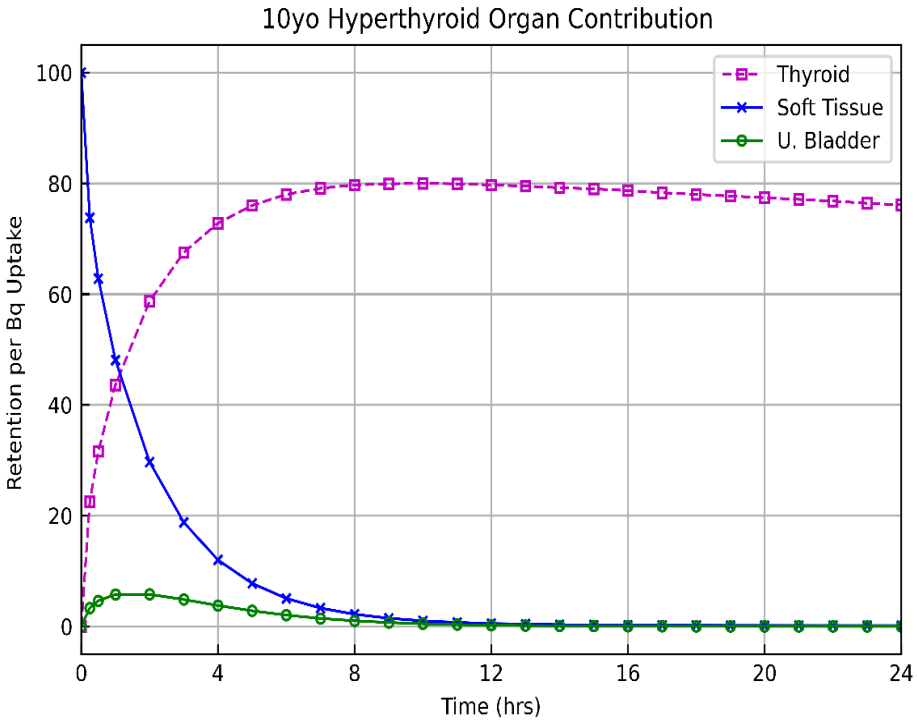

Figure 14. Hyperthyroid uptake (80%) 10yo patient's organ contributions.

4.2. Exposure Rates

Previously outlining the different biokinetic uptakes was to further explain the role in calculations in determining radiation protection quantities and their limits placed by entities such as the NRC RG 8.39. An F5 tally was used to simulate a flux at a point and using the air kerma approximation, an exposure rate in μR/(Bq-hr) was calculated for 10yo, 15yo, and adult patients at each of the three different uptakes. Figures 15-17 demonstrate similar trends as those in Figures 7-9 while Figures 10 and 18 also share similarities due to the underlying role that biokinetics play with clearance of RAI. Of the varying age groups, 10yo patients resulted in a higher peak exposure rate that also occurred

faster than in adults. Exposure rate scenarios were calculated for 10yo, 15yo, and adult patients representing the patient demographics.[47] The increased incidence of pediatric patients with thyroid dysfunction, and thus need for RAI treatment, occurs parallel to the onset of puberty which on average starts at the age of ten. Because the body is not yet fully developed, establishing radiation protection quantities for pediatric patients because more imperative as complications have a longer lifespan to arise than in adults.

Exposure in μR can be determined mathematically after integrating exposure rate over time and defining the activity used for RAI treatment that can be then compared to the method defined by Equation 1 from NRC RG 8.39. Distances of 1m were used as comparison to the approximation established by NRC RG 8.39. Additionally, a comparison between the method established here and NRC's point source method in Equation 1 will be further examined in discussion for determining whether current regulation defines a conservative estimation that is not applicable to children. Monte Carlo calculations converged with a standard error of less than 5% in all results of exposure rates and calculated exposure rates for all age groups can be referred to in Appendix A to F.

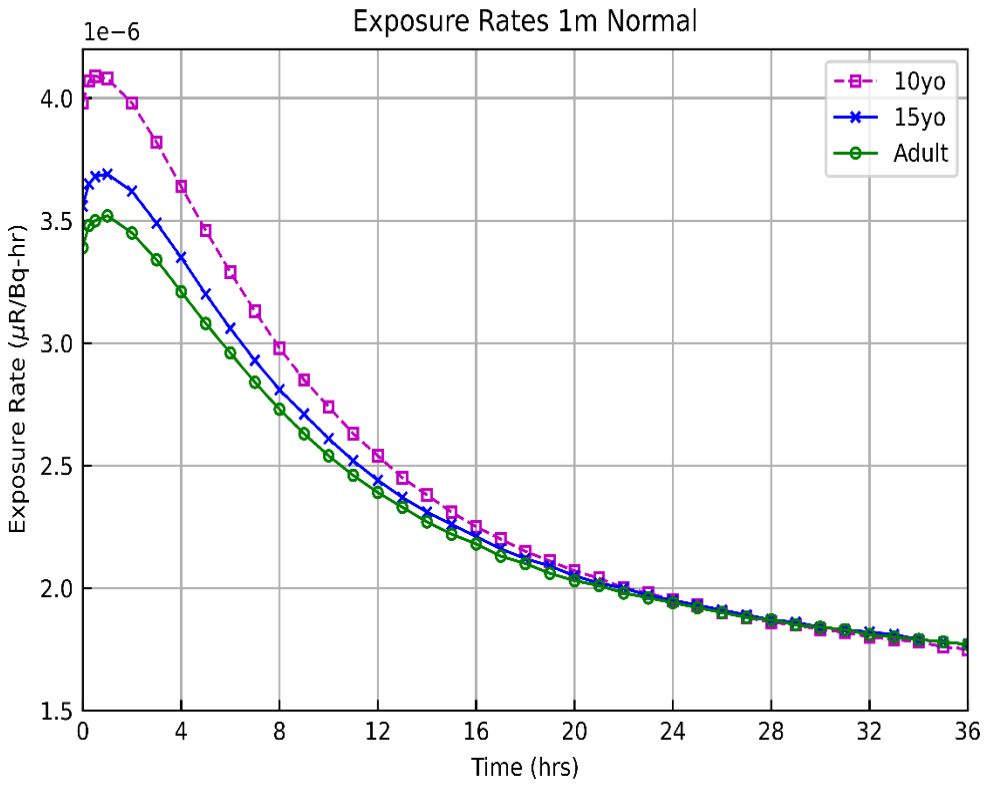

Figure 15. Exposure rates at 1m for Normal uptake (27%) patients.

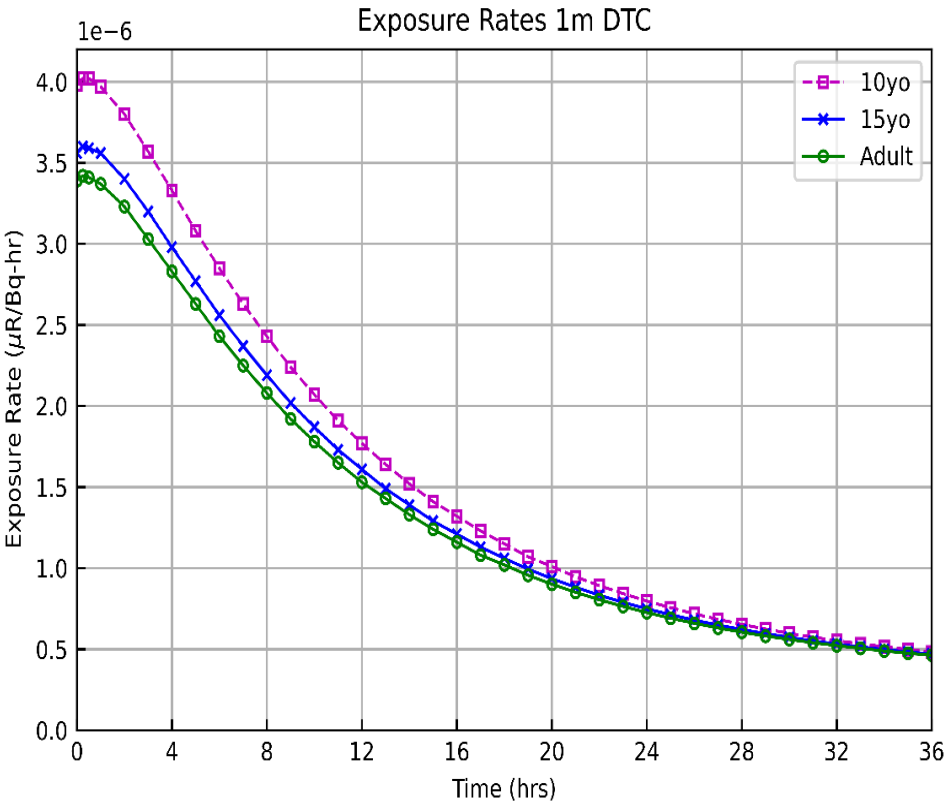

Figure 16. Exposure rates for DTC uptake (5%) patients at 1m.

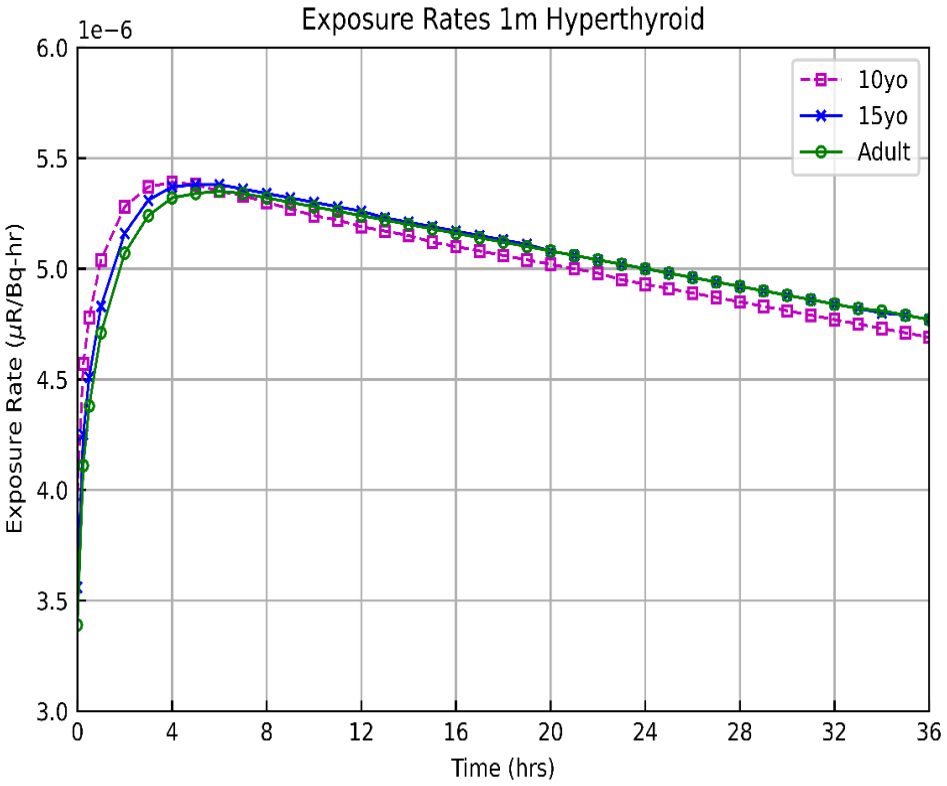

Figure 17. Exposure rates in Hyperthyroid uptake (80%) patients at 1m.

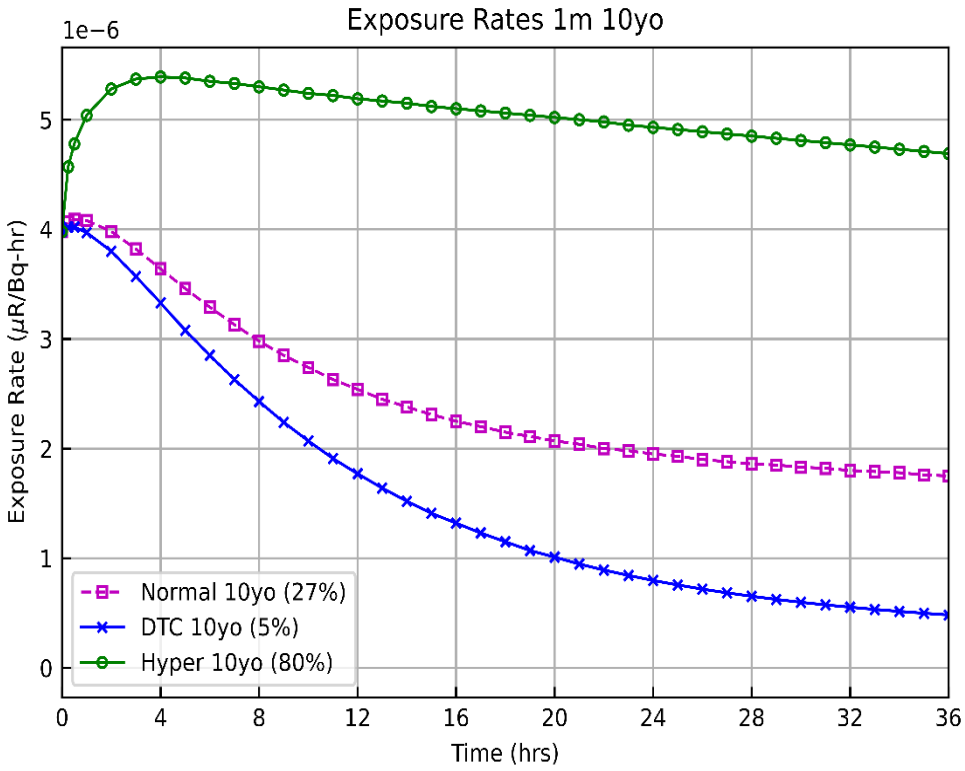

Figure 18. Comparison of exposure rates in 10yo for three different uptakes.

4.3. Effective Dose

Permutations of different aged pediatric patients with different aged targets were simulated in MCNP with an F4 and F6 tally over the major organs in the body to determine an absorbed dose, then an effective dose rate in units of mSv/(MBq-hour) was calculated using tissue weighting factors and iodide biokinetics. Figures 19-21 demonstrate the effective dose rates which resulted similarly in trends to exposure rates from the previous

section, where 10yo patients have effective dose rates that peak higher than older age group counterparts. A 10yo target was used which is more reflective to occur in real life with RAI treatment more likely to occur in older patients who may come into contact with younger targets.

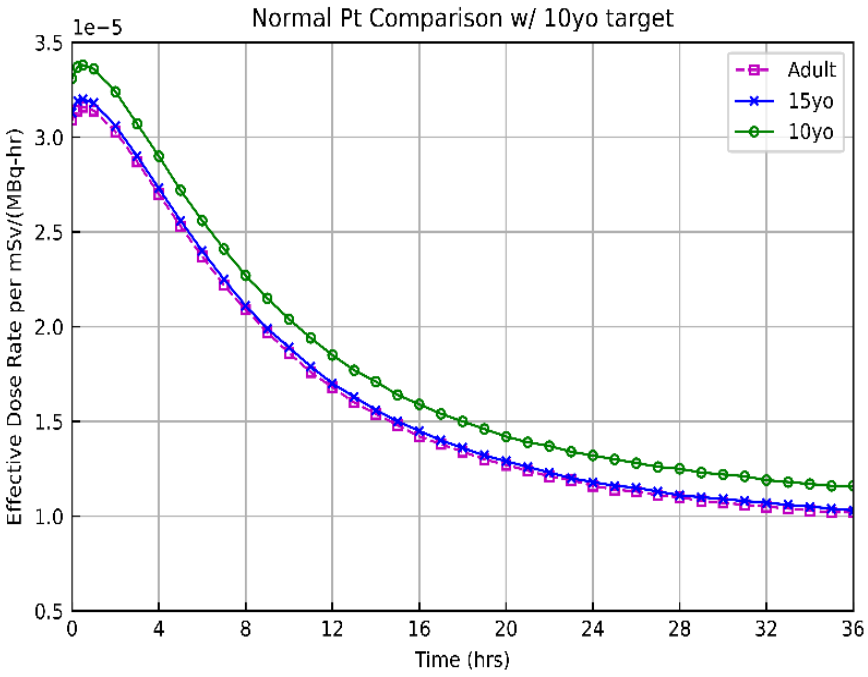

Figure 19. Normal patient comparison 1 m of effective dose rates to 10yo target.

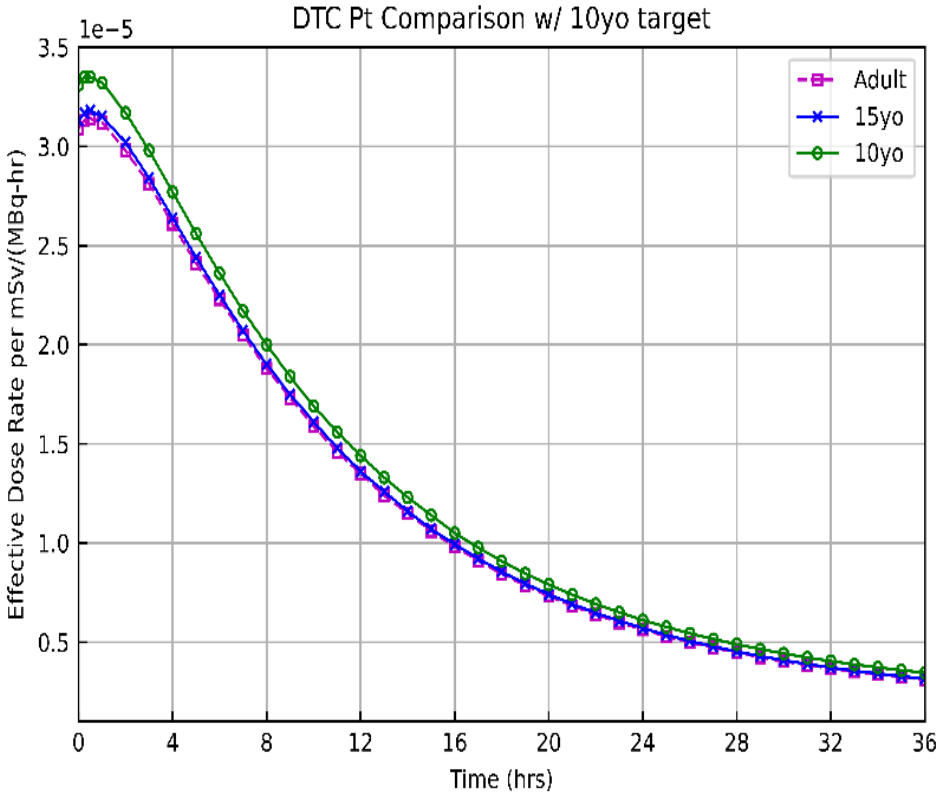

Figure 20. DTC patient comparison 1 m of effective dose rates to 10yo target

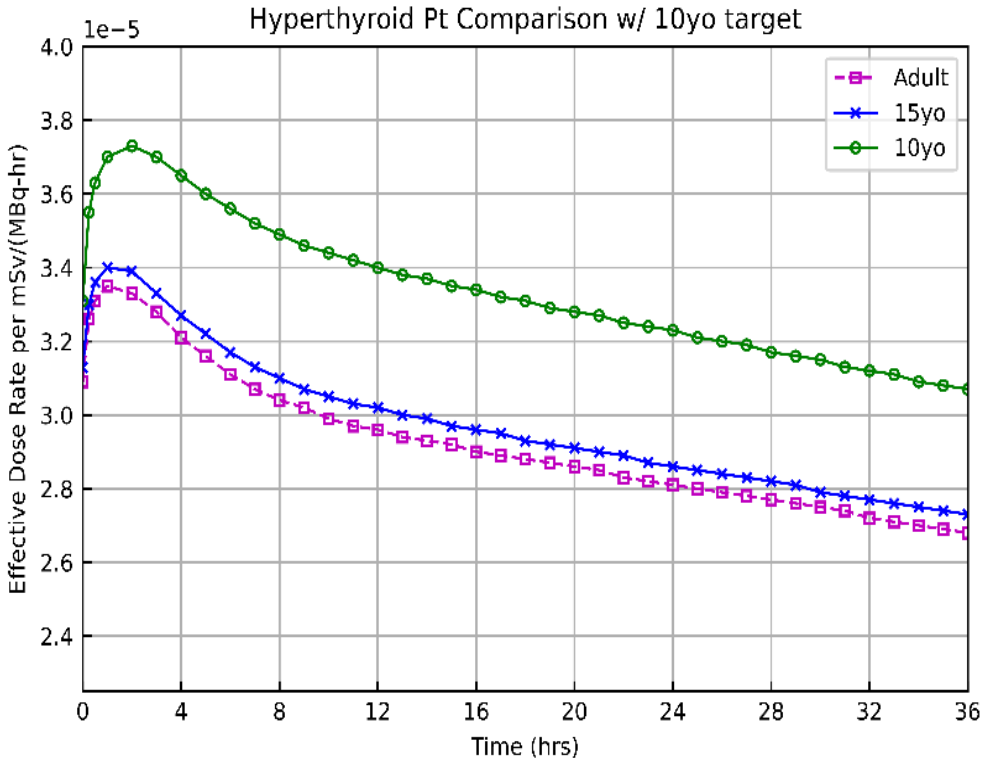

Figure 21. Hyperthyroid patient comparison at 1 m distance for effective dose rates to 10yo target.

Table 9 and 10 were calculated from the effective dose rate by integration and using a 7400 MBq source of RAI for DTC patients and 1100 MBq source of RAI for hyperthyroid patients similarly to examples done in the appendix of RG 8.39.[2] The results for effective doses indicated that younger targets exceeded the 1mSv dose limits set by NRC RG 8.39 than older targets when a 10yo patient was treated for thyroid dysfunction with RAI. Monte Carlo calculations performed had a standard error of less than 10% in all data presented for effective dose rates estimated, different target age groups can be referred to in Appendix I to L at varying distances.

Table 9. The time at which dose limits are exceeded for 10yo DTC patient.

Time to exceed dose at 1 m		
Target	**1 mSv**	**5 mSv**
10yo	< 5 hours	< 186 hours
15yo	< 6 hours	< 222 hours
25yo	< 6 hours	<234 hours

Table 10. The time at which it takes to exceed dose limits for hyperthyroid 10yo patient

Time to exceed dose at 1 m		
Target	**1 mSv**	**5 mSv**
10yo	< 27 hours	< 180 hours
15yo	< 28 hours	< 192 hours
25yo	<28 hours	< 192 hours

Across distances in Figure 22, the further away a target was from the patient, the lower the effective dose rate and more applicable the point source method. Additionally, the further away a target was from the patient, the more applicable the inverse square law became but statistically, MCNP had greater relative error in larger distance simulations.

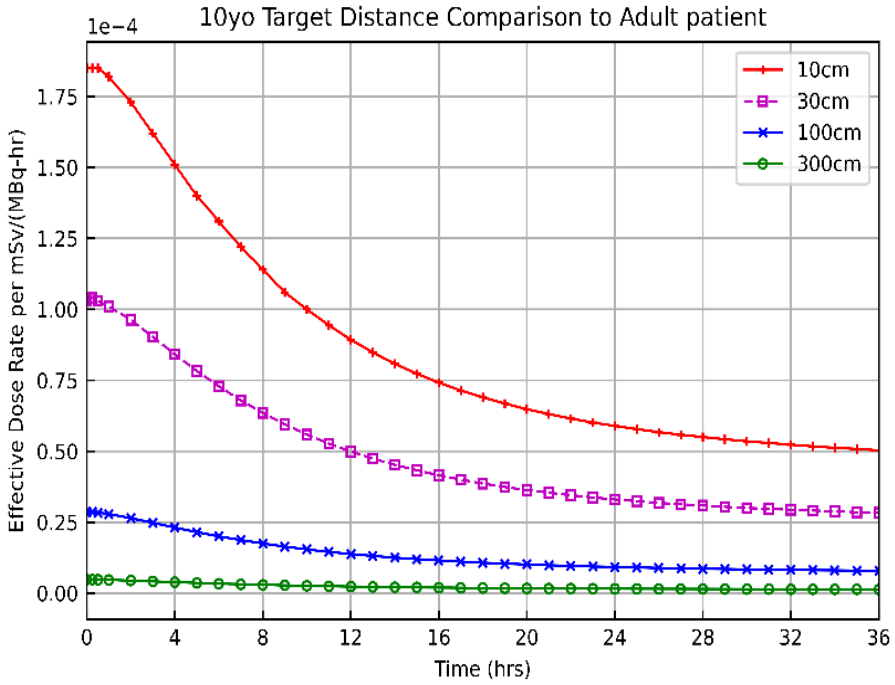

Figure 22. Comparison of effective dose rate at varying distances.

4.4. Detector Response

Using a validated Captus 3000 detector in a Monte Carlo simulation produced Figures 23-25 that display count rates per Bq of administered activity over a period of time. In DTC patients, with little thyroid remnants, the whole body contributed to the higher count rate where the smaller 10yo patient peaks highest among the three age groups because the distribution of activity is spread throughout a shorter body. Unlike DTC patients, hyperthyroid and normal patients had adult patients with the highest count rates. Among the three uptakes per unit Bq, hyperthyroid adult patients had the highest count rates per Bq, likely due to 80% uptake occurring in the thyroid which is physically largest in the

adult age group and 20% distributed in the rest of the body. Count rates per Bq for all age groups compared together can be viewed in Appendix H.

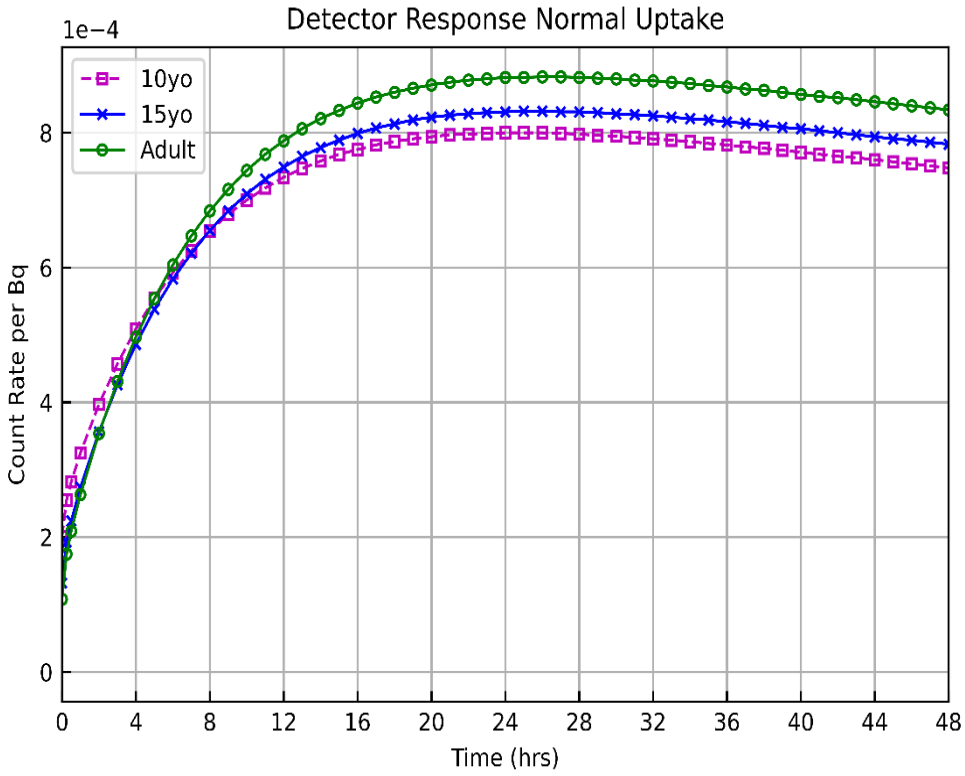

Figure 23. Count rate per Bq ^{131}I administered for normal patient uptake.

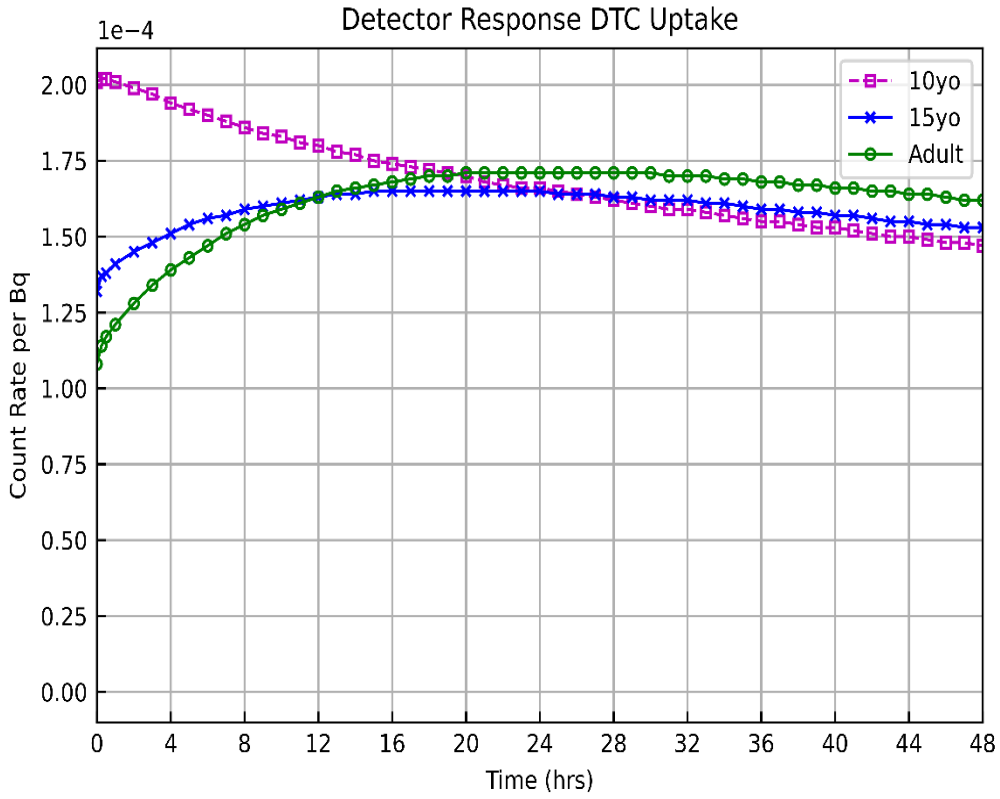

Figure 24. Count rate per Bq ^{131}I administered for DTC patient uptake.

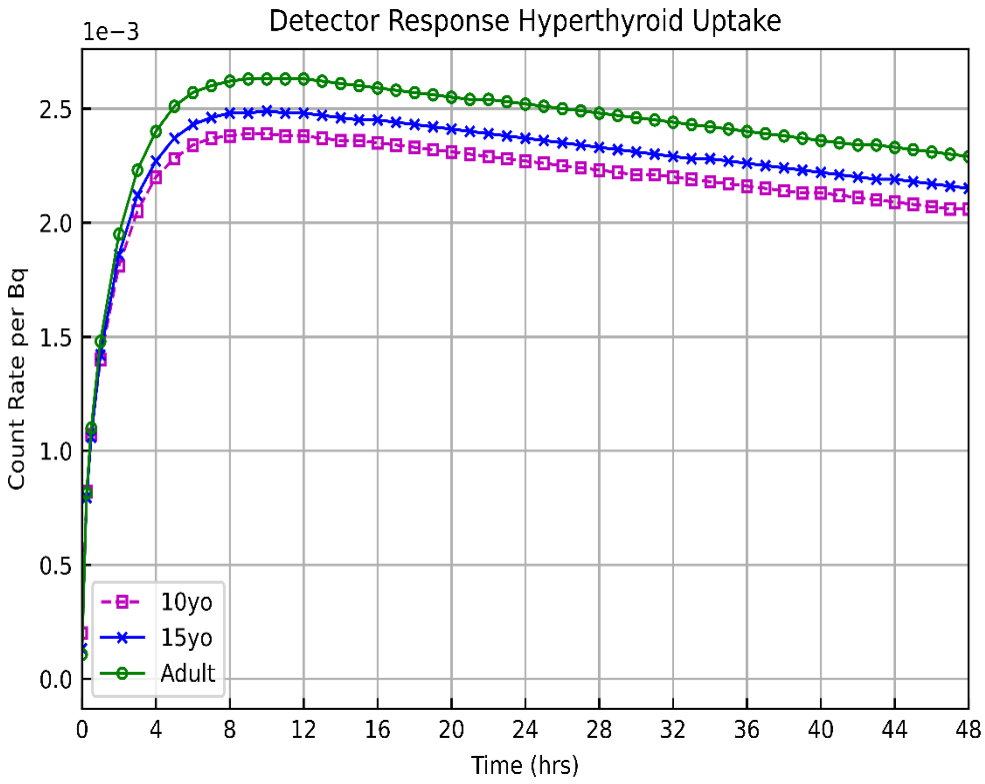

Figure 25. Count rate per Bq ^{131}I administered for hyperthyroid patient uptake.

5. DISCUSSION

5.1. Exposure Rates

Calculated exposure rates in Figures 15-17 for the three different uptake schemes in 10yo, 15yo, and adult hermaphroditic phantoms were integrated to obtain exposure for each age group. Using Eq. 1, exposure was calculated with the point source method outlined under current NRC regulations in RG 8.39. Tables 12-14 below represents the ratio between the point source method outlined in NRC current regulation and exposures calculated using MCNP modeled 10yo, 15yo, and adult phantoms that account for biokinetic movement of iodine from compartments in Figure 2. The emphasis on 1 meter quantities is due to that clinically and under radiation protection recommendations, patients in hospitals base measurements or estimations 1 m from the surface of the patient and 1 m above the ground While calculations were done for 10 cm, they serve as the maximum overestimation possible compared to the point source method.

Across different age groups, the ratios greater than 1 in Tables 11-13 indicate that there is overestimation using the point source method. Contributing factors that lead to the overestimation from point source method include that it does not consider attenuation by a patient's tissues such as skin or the time-dependent fluctuations of the distribution of systemic ^{131}I in a patient's body.[19] Values calculated for Table 11-13 are normalized to 1 GBq for normal patients, with DTC patients administered 7.4 GBq and hyperthyroid patients administered 1.11 GBq, similarly done in examples in Appendix B of RG 8.39.[2]

Typically, therapeutic radiopharmaceuticals are administered at standard fixed activities (in GBq or mCi), standard fixed activities per unit body mass (MBq kg $^{-1}$or mCi

kg $^{-1}$) or standard fixed activities per unit body surface area (MBq m^{-2} or mCi m^{-2}) as determined empirically from clinical trials to yield an acceptable maximal frequency or severity of toxicity and an acceptable minimal frequency or extent of therapeutic response.[4]

For hyperthyroid patients, the point-source method overestimated to exposure to a member of the public by a factor of ~1.2 from 8 hour post administration to 48 hours at a separation distance of 1 m, with no appreciable difference between age groups. As time progresses there is little significant change between ratios due to hyperthyroid patients reliance on physical decay of ^{131}I and less clearance from voiding. Results from pediatric hyperthyroid patients show less overestimation with de Carvalho et. al. similarly using voxel phantoms and asserting that because most of the activity is distributed to a patients thyroid in these patients, at distance at 1 m and farther the point source approximation becomes more reasonable resulting in a ratio close to 1.[48] Carvalho et. al. further states that the difference between patients with hyperthyroidism in a realistic phantom model versus simplified point or line source models appear to be conservative by a factor of 2 to 4 in their non-time-dependent scenarios.[48] While a point source model may be more appropriate in further distances, expressing systemic activity of ^{131}I in the body as a point in closer distances than 1 m is not as realistic since several structures in the body would be further away from the thyroid than the separation distance of an exposed person leading to over approximation for estimating exposure from therapy patients. Color legends in Tables 11-13 coordinate with the three different uptake datasets presented in appendices

A-F and I-T. Orange denotes normal uptake, blue denotes DTC, and green denotes hyperthyroid.

Table 11. Ratio of RG 8.39 point source exposure to MCNP phantom exposure for 10yo at separation distances for different ^{131}I uptake modes. Exposure was normalized to 1 GBq for normal patients, with DTC patients administered 7.4 GBq and hyperthyroid patients administered 1.11 GBq.

		Separation Distance	
Time post-administration	Uptake mode	10 cm	100 cm
8 h	Normal	5.89	1.91
	DTC	13.88	2.31
	Hyperthyroid	2.01	1.21
24 h	Normal	5.19	2.90
	DTC	21.82	6.93
	Hyperthyroid	2.04	1.26
48 h	Normal	5.39	3.31
	DTC	26.85	14.62
	Hyperthyroid	2.16	1.34

Table 12. Ratio of Reg. Guide. 8.39 point source exposure to MCNP phantom exposure for 15yo at separation distances for ^{131}I uptake modes. Exposure was normalized to 1 GBq for normal patients, with DTC patients administered 7.4 GBq and hyperthyroid patients administered 1.11 GBq.

		Separation Distance	
Time post-administration	Uptake mode	10 cm	100 cm
8 h	Normal	5.79	2.04
	DTC	16.74	2.57
	Hyperthyroid	1.81	1.20
24 h	Normal	4.72	2.90
	DTC	21.61	7.39
	Hyperthyroid	1.84	1.25
48 h	Normal	4.84	3.26
	DTC	24.50	14.69
	Hyperthyroid	1.94	1.32

Table 13. Ratio of Reg. Guide. 8.39 point source exposure to MCNP phantom exposure for adult at separation distances for ^{131}I uptake modes. Exposure was normalized to 1 GBq for normal patients, with DTC patients administered 7.4 GBq and hyperthyroid patients administered 1.11 GBq.

		Separation Distance	
Time post-administration	Uptake mode	10 cm	100 cm
8 h	Normal	5.30	2.10
	DTC	17.48	2.70
	Hyperthyroid	1.59	1.21
24 h	Normal	4.15	2.92
	DTC	19.86	7.63
	Hyperthyroid	1.61	1.25
48 h	Normal	4.23	3.26
	DTC	21.56	14.76
	Hyperthyroid	1.69	1.32

However, for a standing 10yo DTC patient at 1 m, analysis indicated that the point-source method overestimated exposure to the public by a minimum factor of 2.31 at 8 h post administration for a separation distance of 1 m and the overestimation continued to widen as time progressed to 48 h, with the maximum overestimation by a factor of 14. A difference in the patient types and overestimations is a direct result of the inclusion of time-dependence and biokinetic modeling that demonstrated the bladder-driven excretion in DTC patients. The findings from Tables 11-13 are similar to those of others who have also indicated a significant overestimation of exposure rates modeled with the use of an unshielded point source.[48,49] For a cancer patient for whom nearly all thyroid tissue is removed surgically, the effective half-life for the administered ^{131}I is usually of the order

of a day or less, leading to a much smaller integrated dose for the exposed person compared to using the 8-day radiological half-life in the screening calculation.[4] Yi et. al. reported that for ^{131}I cancer patients with remnants of their thyroid, activity administered absorbed is generally distributed uniformly throughout the patient's body and the exposure rates are concluded to be overestimations by a factor about 2 at 1 m after taking measurements with a regularly calibrated sodium iodide scintillation survey meter.[49] The minimum reported by the study of all patients measured was ~0.8, with a maximum factor of ~9. While data analyzed for pubescent pediatric patients to adulthood were higher using realistic phantoms than the data Yi reported, the difference came from the inclusion of biokinetics and time-dependence of ^{131}I systemic distribution as more is removed.[49] The same author further assessed that the unshielded line source method resulted in less overapproximated factors to the measurements taken with exposure being overestimated by factors of about 1.3 to 1.5 at 1 m.

While patient release NRC guidelines using the point source method were originally released in 1997, many studies, not limited to the ones listed, were quick to report the differences between measurements made for adult family members of patients exposed to radiation after release and the point source model estimates where removal of activity from the body only accounts for radioactive decay. Most of studies, however, lacked in pediatric guidance or recommendations as there has been an increase in use of ^{131}I therapy and with greater risk posed to younger patients who are developing and will live for longer periods. Use of more realistic modeling techniques demonstrated here, especially for patient specific factors such as pediatric patients versus adult patients should

be used to develop future recommendations for the release of patients after radionuclides therapy to more accurately estimated quantities. Inclusion of patient specific data is of great importance because revised guidelines are likely to reduce patient monitoring times and hospital stays which are a larger factor in pediatric patients cases since they typically are accompanied by caregivers or parents. The benefit of new calculation methods greatly reduces any unnecessary burden to families in reduction hospitalization.

5.2. Effective Dose

Figures 19-21 display the results of pubescent pediatric patients and adult patients effective dose rates in a 10yo target. The results indicated similarly to those of Figures 26-28 where the younger patient and the younger targets such as a 10yo have higher effective dose rates. A comparison was made to Dewji et. al. in adult patients with an adult target as reference towards the pediatric models and methods used where the adult stylized phantom produced little difference between the results from their study, but both the adult patient and Dewji's study result in a lower effective dose rate than a 10yo patient with an adult target.[19,22] Tables 14-16 generate ratios between point-source method and effective dose calculations with adult targets that indicate the point source method overestimates dose received in 10yo patients with adult targets less than 15yo and adult patients but nevertheless are over approximations by at least a factor of ~2 in all uptake modes. The inclusion of time-dependence and biological excretion in calculations further increases the over approximation as time post administration of ^{131}I progressed.

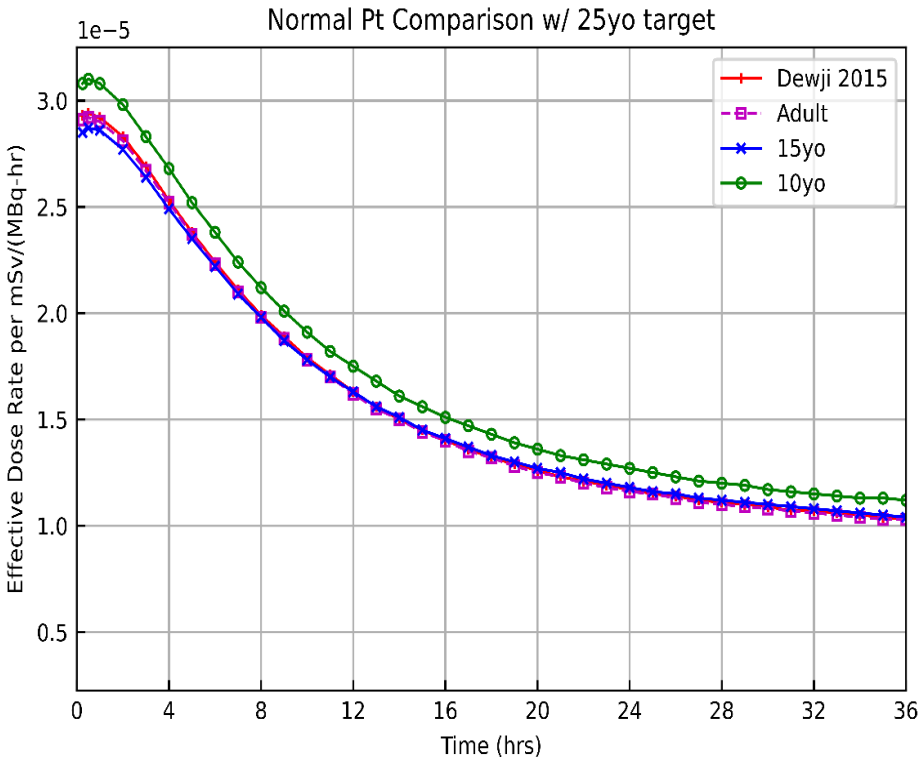

Figure 26. Effective dose rate comparison for normal uptake mode between different age groups and Dewji.[19]

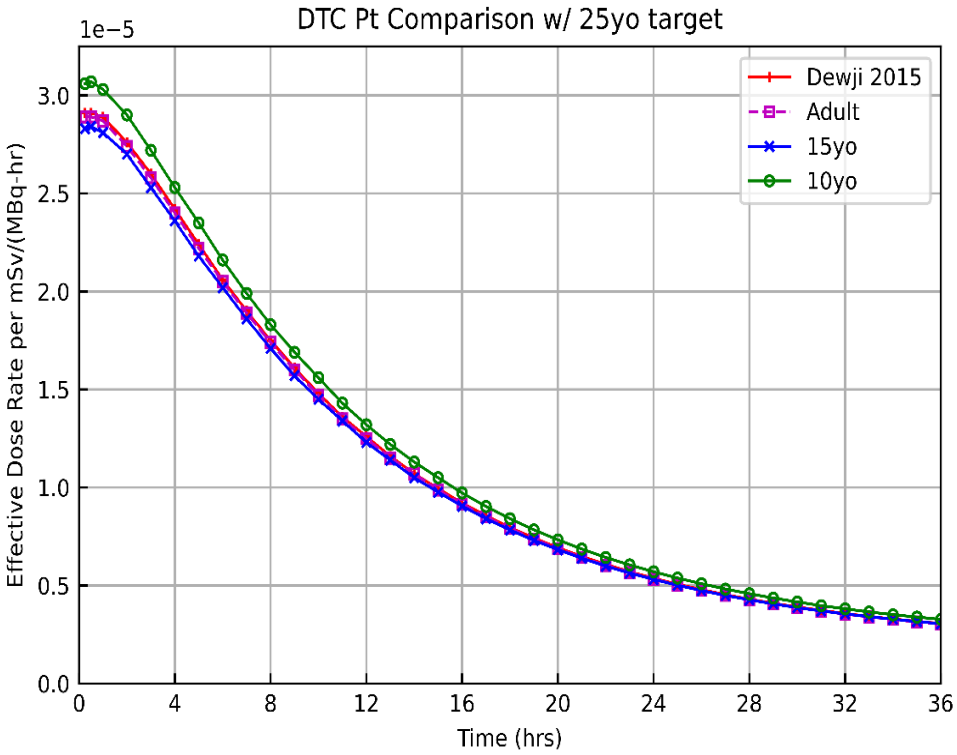

Figure 27. Effective dose rate comparison for DTC uptake mode between different age groups and Dewji.[19]

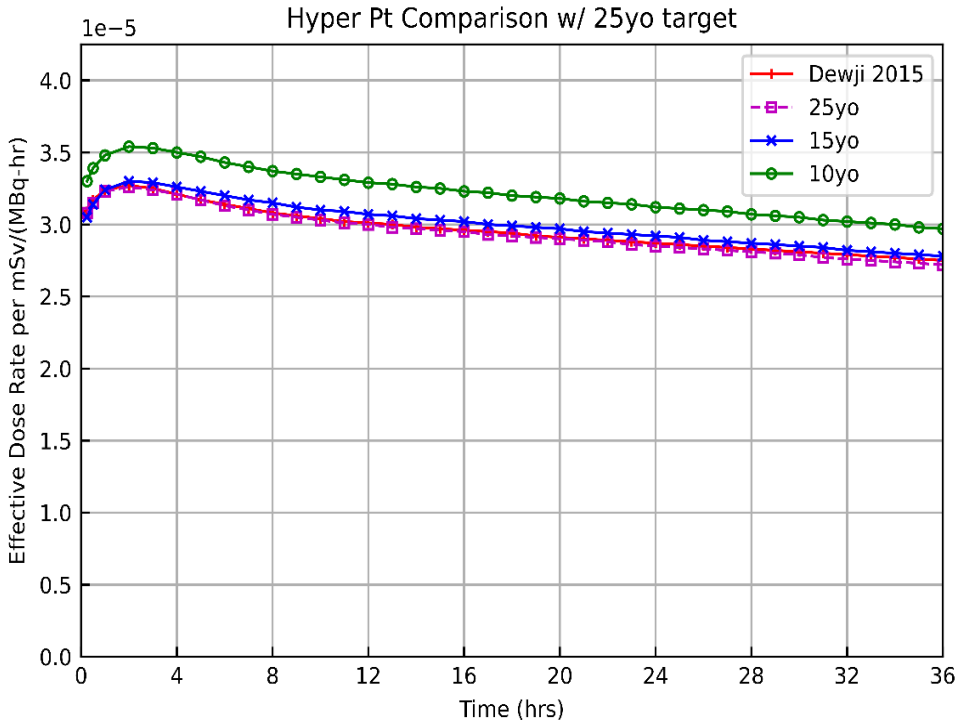

Figure 28. Effective dose rate comparison for normal uptake mode between different age groups and Dewji.[19]

The Monte Carlo simulations with realistic phantoms such as the ones used here provide more accurate dose rate estimates near patients treated with radionuclides such as ^{131}I, including the distribution to specific organs in different irradiation geometries. De Carvalho et al. presented a comparison of point, line, and phantom dose rate estimates around patients treated with radionuclides.[48] The study evaluated hyperthyroid, thyroid cancer, and non-Hodgkin's lymphoma patient therapy types. In the point source model, results were overestimated compared to the phantom dose rate source model by factors of 1.45 to 2.10 at 1 m which are similar to the lower end results to the methods outlined for pediatric patients. The line source model was reported to have closer approximations with

20 to 70% overestimated dose rates at 1 m. Another comparison to Han et al. can be made where the study reported that the point-source method overestimated the dose rate by a factor of ~1.6 for 1 m separation distance based on Monte Carlo simulations using a stylized phantom in hyperthyroid patients. [17] Han et al. also estimated that the point-source method overestimates by a factor of 2.2 at 100 cm for a DTC patient. While factors in Han's study, she found similar results among the pediatric ages groups and cited the need for implementation of biokinetic modeling that improves approximations.[17]

Table 14. Ratio of RG 8.39 point source to MCNP phantom dose for 10yo at 1 m separation distances for ^{131}I uptake modes.

Time post-administration	Uptake mode	100 cm
8 h	Normal	2.68
	DTC	3.06
	Hyperthyroid	1.92
24 h	Normal	4.44
	DTC	9.68
	Hyperthyroid	2.02
48 h	Normal	5.22
	DTC	22.38
	Hyperthyroid	2.13

Table 15. Ratio of RG. 8.39 point source to MCNP phantom dose for 15yo at 1 m separation distances for ^{131}I uptake modes.

Time post-administration	Uptake mode	100 cm
8 h	Normal	2.87
	DTC	3.28
	Hyperthyroid	2.05
24 h	Normal	4.78
	DTC	10.39
	Hyperthyroid	2.16
48 h	Normal	5.57
	DTC	23.96
	Hyperthyroid	2.28

Table 16. Ratio of RG 8.39 point source to MCNP phantom dose for adult at 1 m separation distances for ^{131}I uptake modes.

Time post-administration	Uptake mode	100 cm
8 h	Normal	2.87
	DTC	3.22
	Hyperthyroid	2.10
24 h	Normal	4.86
	DTC	10.35
	Hyperthyroid	2.21
48 h	Normal	5.68
	DTC	24.22
	Hyperthyroid	2.32

Despite offering more specific examples in which decay is included from the initial 8 hours post administration and inclusion of an extrathyroidal component, the NRC does not account for biological voiding in guidelines released in 1997 and lacked guidance or discussion in release criteria for pediatric patients.[2]

While most patients receiving radiopharmaceuticals are compared with simplified line or point sources, other studies try to compare volume sources as alternative to phantom methods under the assumption the activities administered to patients are dispersed quickly in the blood and there is no loss occurred through excretion. Similarly, to the effective dose rates obtained by stylized pediatric phantoms, Liu et. al. stated MCNP-calculated results for organ-dependent activity distributions had the most realistic values that were selected for reference due to the accuracy comparatively with simplified models evaluated. Liu indicated that the activity distribution in the patient had limited impact on the external dose estimations unlike previous studies.[48,50] Three simplified source models (i.e., point, line, and cylinder) were reported alongside the phantom models for radioactive patients that all overestimated the dose rates to varying degrees when compared to the phantom results. The dose rates calculated using the unshielded point source model however were reported to have exceeded the reference values by approximately 30–40% at 1m from the patient, far less than the dose rates calculated for pediatric patients. The unshielded line source model was the closest model with dose rates approximately 9 to 18% overestimated at 1 m distances.[50] While results varied drastically compared to the dose rates from pediatric patient results, Liu indicated that inclusion of derived biological half-lives for ^{131}I cause discrepancies because they can range from 2 h

to 23 h[50]. Biological half-lives are another area that has lacked guidance of inclusion in NRC recommendations because calculations are patient dependent and impacted by numerous factors such as the patient's gender and the administration of thyroid-stimulating hormones. When taking measurements for comparison, Liu additionally discussed that the scattered radiation monitored room decreased 27.5% of the total dose rate at a distance of 1 m which can cause systematic underestimation of the simplified models but does not improve with lead shielding due to photoelectric absorption.[50]

5.3. Detector Response

Following analysis of the various phantom age groups, results indicated that in general, the highest count rate is found in the adults, likely due to the difference in size among different age groups from 10yo to adult. Children are expected to have the least amount of tissue, or attenuating material, between the radionuclide and the detector resulting in potentially higher count rates, from less absorption of the gamma ray photons before they reach the detector crystal, but the specific radionuclide used has equal impact on the count rates detected.

Results from Figures 23-25 are of comparable magnitude to those of Scarboro where she used a similar validated Captus 3000 detector model positioned at the neck in Monte Carlo simulations with ^{131}I in different phantom types.[34] The count rates trend similarly between the phantom types, with the child showing the lowest count rate per becquerel. Because ^{131}I gets rapidly absorbed systemically by the thyroid gland, a child with smaller thyroid gland than an adult, reaches saturation before an adult's thyroid. The

count rates from phantom models can be coupled with exposure rates and kinetics for validation purposes of measurements in patient release criteria. An evaluation of a patient being monitored that results in similar count rates can be likely equated to have the correlating exposure rate listed in Figures 13, 14, and 15. The exposure rate data was tabulated for calibration of any instrument that provides exposure rate which allows for flexibility in the medical setting. Studies monitoring members of the public outside the immediate family for radiation exposure poses considerable logistical, ethical and legal issues that in most situations would be overtly difficult as well as expensive, and potentially unethical, which has led to a limited number of studies done on this matter.

5.4. Significance

Extended hospitalization reduces exposure to the public and relatives, but often unnecessarily increases overall cost to the family which can be more burdening than the actual treatment and thus also may increase exposure to hospital staff. The decision to hospitalize patients is weighed heavily in several of the regulatory guides reviewed earlier because hospitalization often involves a significant psychological burden for patients and families due to isolation, as well as monetary and other costs that should be analyzed and justified. Cost should be considered in terms of both justification and optimization of any radiation practice because it tends to be a threshold for patients being treated early versus late staged. Few studies have attempted to determine the costs associated with the various methodologies related to release of patients after therapy with unsealed radionuclides. To be realistic, ‘costs’ should include both the immediate monetary considerations and the consequences in terms of psychological impact and health outcome. A U.S. study was

performed, but, while there was general interest, its applicability in many countries is limited due to different circumstances in each country.[3,51] The study indicated that a single day of being hospitalized in 1990 was $687 and based on an 8% per year increase by 1993 the estimate was $800, then factoring in each patient being treated with radiopharmaceuticals must be contained in a private room, the cost was $1000 per day.[51] Extrapolating this estimate to the current year 2021, at the 8% increase per year, 28 years later the estimate for one day of being hospitalized is $8,700. Considering the cost of this estimate that may be mandatory due to current guidelines provides a significant reason to have more accurate guidelines, especially if hospitalization is weighed against lost wages from work in the process. Lack of available data to inform recommendations for pediatric patients, under current criteria, may result in utilization of adult data and in increased hospital stays and unnecessary family burden.

5.5. Future Work

With the ever-evolving world of science, there continues to be a need for updating regulation that is current to matters being researched. Because Monte Carlo calculations tend to be computationally intensive depending on the simulation complexity with realistic phantoms, they are not as practical using this method for an individual per patient release basis. However, much like in the current NRC RG 8.39, a number of precalculated values could be provided from simulations previously executed to make more realistic guidelines that could be easily looked up or have a simple software algorithm developed that contains a library of results. Additionally, computational models and data continue to be updated,

for example, after completion of the work, ICRP released Publication 143 which contains reference pediatric voxel phantoms and can be implemented in future computational phantom studies.[52] Using instruments like the Captus 3000 provides the foundation for measurements and data to be benchmarked and capable of producing individualized biokinetics included in said library from patient monitoring. Using sophisticated imaging enables better biokinetics modeling of a radiopharmaceutical, but the benefits should be weighed against what is practically achievable. Multiple SPECT/computed tomography (CT) or PET/CT sessions for example, can be helpful for determining the biokinetics of novel therapeutic radiopharmaceuticals.[4] The type and number of imaging sessions needed for a particular patient undergoing radiopharmaceutical therapy should be optimized. Considerations should include the availability of personnel, equipment, financial and logistical costs, as well as expected validity.[4] The Captus 3000 count rates can also similarly be used to develop calibration factors much like those presented in Li.[33] Planar imaging with a gamma camera for dosimetric purposes also can be useful for determining organ uptake and clearance biokinetics, and individual organ overlap to accurately assess, taking into account attenuation, scatter, and background correction.[53] The number of data points needed depends on the biokinetics in the respective organ or tissue. Biokinetics can be further improved to solved in a non-continuous pattern by coupling excretion with multiple organs. The non-continuous voiding pattern would be to represent a patient periodic excretion rather than continuous. The versatility of biokinetics allows for different metabolic considerations to account for flushing of the thyroid with non-radioactive iodine in hyperthyroid patients or modeling patients with multiple

comorbidities that present unique challenges such as a patient with end stage renal disease because clearance and buildup occurs with hemodialysis causing an increase dose to bone marrow. Applications of these patients types can be benchmarked through personal monitoring devices such as wearable devices or home monitoring systems that are provided upon release with instructions much like those of Gallicchio.[54]

Additionally, NRC published new revisions and updates in April 2020 to RG 8.39 that expanded patient instructions given during discharge.[8] The NRC further announced that it had plans to review the point source method as they became aware of the conservative estimations and aims to review alternative methods with an intent to have a second revision published within the next 2-3 years. With the results presented, it is concluded that current guidelines are too conservative in pediatric cases who have different considerations and should be specifically included in future iterations of guidelines. Future work analysis of resources and how overtly conservative protocols in 8.39 propagate in various aspects of healthcare, patient safety, public radiation protection.

6. CONCLUSION

Monte Carlo methods simulating realistic phantoms to calculate exposure and external dose rates provide more realistic approximations that account for physical processes of scattering and attenuation. Because RG 8.39 lacks patient-specific guidance and the inclusion of pediatric patient release recommendations, an assessment to determine the relevance of RG 8.29 to pediatric patients undergoing RAI therapy was necessary to be performed. Using computational phantoms, time-dependent biokinetic data, and Monte Carlo simulations, it was determined that RG 8.39 was overtly conservative in pediatric patient and that specific guidance should be included in any upcoming revision. Phantom models allow flexibility for simulations at varied separation distances, age groups, and even in different geometries such as standing or sitting situations that occur scenarios involving buses or airlines, and others. The differences between the various methods published and studied can significantly impact the time before patients are released, as well as the time for them to be monitored, as current guidelines exercise conservatism. Use of more realistic calculations, with phantoms, Monte Carlo methods, and time-dependent excretion, should be used to develop new criteria for patient release as they provide more accurate results that are necessary for pediatric patients being treated and monitored. Considerations of these models avoids unnecessary hospital confinement of pediatric patients and the development of more accurate can lead to more meaningful instructions for patients with likely shorter restriction times.

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APPENDIX A

EXPOSURE RATES FOR NEWBORN

	Normal			DTC			Hyper		
Time (h)	10cm	100cm	300cm	10cm	100cm	300cm	10cm	100cm	300cm
0.00	1.78E-04	4.91E-06	5.77E-07	1.78E-04	4.91E-06	5.77E-07	1.78E-04	4.91E-06	5.77E-07
0.25	1.78E-04	4.92E-06	5.78E-07	1.74E-04	4.89E-06	5.75E-07	2.25E-04	5.23E-06	6.12E-07
0.50	1.76E-04	4.86E-06	5.70E-07	1.70E-04	4.81E-06	5.66E-07	2.42E-04	5.30E-06	6.19E-07
1.00	1.73E-04	4.69E-06	5.50E-07	1.63E-04	4.62E-06	5.43E-07	2.63E-04	5.33E-06	6.21E-07
2.00	1.65E-04	4.34E-06	5.09E-07	1.50E-04	4.21E-06	4.95E-07	2.88E-04	5.32E-06	6.18E-07
3.00	1.59E-04	4.03E-06	4.72E-07	1.38E-04	3.85E-06	4.52E-07	3.01E-04	5.29E-06	6.14E-07
4.00	1.53E-04	3.76E-06	4.40E-07	1.27E-04	3.52E-06	4.13E-07	3.08E-04	5.26E-06	6.10E-07
5.00	1.49E-04	3.53E-06	4.13E-07	1.17E-04	3.23E-06	3.79E-07	3.12E-04	5.23E-06	6.06E-07
6.00	1.44E-04	3.32E-06	3.89E-07	1.08E-04	2.96E-06	3.48E-07	3.14E-04	5.20E-06	6.03E-07
7.00	1.40E-04	3.14E-06	3.67E-07	1.01E-04	2.72E-06	3.20E-07	3.14E-04	5.17E-06	5.99E-07
8.00	1.37E-04	2.98E-06	3.48E-07	9.34E-05	2.51E-06	2.94E-07	3.13E-04	5.14E-06	5.95E-07
9.00	1.33E-04	2.84E-06	3.31E-07	8.68E-05	2.31E-06	2.71E-07	3.12E-04	5.11E-06	5.91E-07
10.00	1.30E-04	2.71E-06	3.16E-07	8.09E-05	2.13E-06	2.50E-07	3.11E-04	5.08E-06	5.88E-07
11.00	1.28E-04	2.60E-06	3.03E-07	7.55E-05	1.97E-06	2.31E-07	3.09E-04	5.05E-06	5.84E-07
12.00	1.25E-04	2.50E-06	2.91E-07	7.06E-05	1.82E-06	2.13E-07	3.07E-04	5.02E-06	5.80E-07
13.00	1.23E-04	2.41E-06	2.80E-07	6.62E-05	1.69E-06	1.98E-07	3.06E-04	4.98E-06	5.77E-07
14.00	1.21E-04	2.33E-06	2.71E-07	6.21E-05	1.56E-06	1.83E-07	3.04E-04	4.95E-06	5.73E-07
15.00	1.19E-04	2.26E-06	2.62E-07	5.84E-05	1.45E-06	1.70E-07	3.02E-04	4.92E-06	5.69E-07
16.00	1.18E-04	2.19E-06	2.55E-07	5.50E-05	1.35E-06	1.59E-07	3.00E-04	4.89E-06	5.66E-07
17.00	1.16E-04	2.13E-06	2.48E-07	5.20E-05	1.26E-06	1.48E-07	2.98E-04	4.86E-06	5.62E-07
18.00	1.14E-04	2.08E-06	2.42E-07	4.92E-05	1.18E-06	1.38E-07	2.96E-04	4.83E-06	5.59E-07
19.00	1.13E-04	2.03E-06	2.36E-07	4.66E-05	1.10E-06	1.29E-07	2.94E-04	4.80E-06	5.55E-07
20.00	1.12E-04	1.99E-06	2.31E-07	4.43E-05	1.03E-06	1.21E-07	2.93E-04	4.77E-06	5.52E-07
21.00	1.11E-04	1.95E-06	2.26E-07	4.22E-05	9.72E-07	1.14E-07	2.91E-04	4.74E-06	5.48E-07
22.00	1.09E-04	1.91E-06	2.22E-07	4.02E-05	9.14E-07	1.07E-07	2.89E-04	4.71E-06	5.45E-07
23.00	1.08E-04	1.88E-06	2.18E-07	3.84E-05	8.62E-07	1.01E-07	2.87E-04	4.68E-06	5.42E-07
24.00	1.07E-04	1.85E-06	2.15E-07	3.68E-05	8.15E-07	9.52E-08	2.85E-04	4.65E-06	5.38E-07
25.00	1.06E-04	1.82E-06	2.11E-07	3.53E-05	7.71E-07	9.01E-08	2.84E-04	4.62E-06	5.35E-07
26.00	1.05E-04	1.80E-06	2.08E-07	3.40E-05	7.31E-07	8.54E-08	2.82E-04	4.59E-06	5.32E-07
27.00	1.04E-04	1.77E-06	2.05E-07	3.27E-05	6.95E-07	8.11E-08	2.80E-04	4.57E-06	5.28E-07
28.00	1.03E-04	1.75E-06	2.03E-07	3.15E-05	6.62E-07	7.72E-08	2.78E-04	4.54E-06	5.25E-07
29.00	1.03E-04	1.73E-06	2.00E-07	3.05E-05	6.31E-07	7.36E-08	2.77E-04	4.51E-06	5.22E-07
30.00	1.02E-04	1.71E-06	1.98E-07	2.95E-05	6.04E-07	7.04E-08	2.75E-04	4.48E-06	5.19E-07

	Normal			DTC			Hyper		
Time (h)	10cm	100cm	300cm	10cm	100cm	300cm	10cm	100cm	300cm
31.00	1.01E-04	1.69E-06	1.96E-07	2.86E-05	5.78E-07	6.74E-08	2.73E-04	4.46E-06	5.15E-07
32.00	1.00E-04	1.67E-06	1.94E-07	2.78E-05	5.55E-07	6.46E-08	2.72E-04	4.43E-06	5.12E-07
33.00	9.94E-05	1.66E-06	1.92E-07	2.70E-05	5.33E-07	6.21E-08	2.70E-04	4.40E-06	5.09E-07
34.00	9.86E-05	1.64E-06	1.90E-07	2.63E-05	5.13E-07	5.98E-08	2.68E-04	4.38E-06	5.06E-07
35.00	9.79E-05	1.63E-06	1.88E-07	2.56E-05	4.95E-07	5.76E-08	2.67E-04	4.35E-06	5.03E-07
36.00	9.72E-05	1.61E-06	1.87E-07	2.50E-05	4.79E-07	5.57E-08	2.65E-04	4.32E-06	5.00E-07

APPENDIX B

EXPOSURE RATES FOR 01YO

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
0.00	1.30E-04	4.63E-06	5.59E-07	1.30E-04	4.63E-06	5.59E-07	1.30E-04	4.63E-06	5.59E-07
0.25	1.31E-04	4.66E-06	5.62E-07	1.27E-04	4.63E-06	5.59E-07	1.87E-04	5.02E-06	5.99E-07
0.50	1.31E-04	4.63E-06	5.57E-07	1.24E-04	4.58E-06	5.52E-07	2.08E-04	5.13E-06	6.09E-07
1.00	1.31E-04	4.50E-06	5.41E-07	1.19E-04	4.42E-06	5.33E-07	2.36E-04	5.22E-06	6.15E-07
2.00	1.29E-04	4.19E-06	5.03E-07	1.10E-04	4.05E-06	4.88E-07	2.70E-04	5.26E-06	6.15E-07
3.00	1.27E-04	3.90E-06	4.68E-07	1.02E-04	3.70E-06	4.46E-07	2.89E-04	5.26E-06	6.12E-07
4.00	1.25E-04	3.65E-06	4.37E-07	9.41E-05	3.39E-06	4.08E-07	3.00E-04	5.24E-06	6.09E-07
5.00	1.24E-04	3.43E-06	4.09E-07	8.74E-05	3.11E-06	3.74E-07	3.06E-04	5.22E-06	6.06E-07
6.00	1.22E-04	3.24E-06	3.85E-07	8.13E-05	2.85E-06	3.43E-07	3.09E-04	5.20E-06	6.03E-07
7.00	1.21E-04	3.07E-06	3.64E-07	7.58E-05	2.62E-06	3.15E-07	3.10E-04	5.18E-06	5.99E-07
8.00	1.20E-04	2.92E-06	3.46E-07	7.08E-05	2.41E-06	2.90E-07	3.11E-04	5.15E-06	5.96E-07
9.00	1.18E-04	2.78E-06	3.29E-07	6.63E-05	2.22E-06	2.67E-07	3.10E-04	5.12E-06	5.93E-07
10.00	1.17E-04	2.66E-06	3.15E-07	6.22E-05	2.05E-06	2.46E-07	3.09E-04	5.10E-06	5.90E-07
11.00	1.16E-04	2.56E-06	3.02E-07	5.85E-05	1.89E-06	2.27E-07	3.08E-04	5.07E-06	5.87E-07
12.00	1.15E-04	2.46E-06	2.90E-07	5.51E-05	1.75E-06	2.10E-07	3.07E-04	5.04E-06	5.83E-07
13.00	1.14E-04	2.38E-06	2.80E-07	5.20E-05	1.62E-06	1.94E-07	3.05E-04	5.02E-06	5.80E-07
14.00	1.13E-04	2.31E-06	2.71E-07	4.92E-05	1.50E-06	1.80E-07	3.04E-04	4.99E-06	5.77E-07
15.00	1.13E-04	2.24E-06	2.62E-07	4.66E-05	1.40E-06	1.67E-07	3.02E-04	4.96E-06	5.74E-07
16.00	1.12E-04	2.18E-06	2.55E-07	4.43E-05	1.30E-06	1.56E-07	3.01E-04	4.93E-06	5.71E-07
17.00	1.11E-04	2.13E-06	2.49E-07	4.22E-05	1.21E-06	1.45E-07	2.99E-04	4.91E-06	5.68E-07
18.00	1.10E-04	2.08E-06	2.43E-07	4.02E-05	1.13E-06	1.35E-07	2.97E-04	4.88E-06	5.65E-07
19.00	1.09E-04	2.03E-06	2.37E-07	3.85E-05	1.06E-06	1.27E-07	2.96E-04	4.86E-06	5.62E-07
20.00	1.09E-04	1.99E-06	2.33E-07	3.68E-05	9.97E-07	1.19E-07	2.94E-04	4.83E-06	5.59E-07
21.00	1.08E-04	1.96E-06	2.28E-07	3.54E-05	9.37E-07	1.12E-07	2.93E-04	4.80E-06	5.56E-07
22.00	1.07E-04	1.93E-06	2.24E-07	3.40E-05	8.83E-07	1.05E-07	2.91E-04	4.78E-06	5.53E-07
23.00	1.07E-04	1.90E-06	2.21E-07	3.28E-05	8.34E-07	9.90E-08	2.89E-04	4.75E-06	5.50E-07
24.00	1.06E-04	1.87E-06	2.17E-07	3.17E-05	7.89E-07	9.36E-08	2.88E-04	4.73E-06	5.47E-07
25.00	1.05E-04	1.84E-06	2.14E-07	3.06E-05	7.47E-07	8.86E-08	2.86E-04	4.70E-06	5.44E-07
26.00	1.05E-04	1.82E-06	2.11E-07	2.97E-05	7.10E-07	8.41E-08	2.85E-04	4.68E-06	5.41E-07
27.00	1.04E-04	1.80E-06	2.09E-07	2.88E-05	6.76E-07	8.00E-08	2.83E-04	4.65E-06	5.38E-07
28.00	1.03E-04	1.78E-06	2.06E-07	2.80E-05	6.45E-07	7.62E-08	2.82E-04	4.63E-06	5.35E-07
29.00	1.03E-04	1.76E-06	2.04E-07	2.72E-05	6.16E-07	7.27E-08	2.80E-04	4.60E-06	5.32E-07
30.00	1.02E-04	1.74E-06	2.02E-07	2.66E-05	5.90E-07	6.96E-08	2.79E-04	4.58E-06	5.29E-07

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
31.00	1.02E-04	1.72E-06	2.00E-07	2.59E-05	5.66E-07	6.67E-08	2.77E-04	4.55E-06	5.27E-07
32.00	1.01E-04	1.71E-06	1.98E-07	2.53E-05	5.44E-07	6.41E-08	2.76E-04	4.53E-06	5.24E-07
33.00	1.00E-04	1.69E-06	1.96E-07	2.48E-05	5.24E-07	6.16E-08	2.74E-04	4.50E-06	5.21E-07
34.00	9.98E-05	1.68E-06	1.95E-07	2.43E-05	5.06E-07	5.94E-08	2.73E-04	4.48E-06	5.18E-07
35.00	9.92E-05	1.67E-06	1.93E-07	2.38E-05	4.89E-07	5.74E-08	2.71E-04	4.46E-06	5.16E-07
36.00	9.86E-05	1.65E-06	1.91E-07	2.34E-05	4.73E-07	5.55E-08	2.70E-04	4.43E-06	5.13E-07

APPENDIX C

EXPOSURE RATES FOR 05YO

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
0.00	8.98E-05	4.33E-06	5.52E-07	8.98E-05	4.33E-06	5.52E-07	8.98E-05	4.33E-06	5.52E-07
0.25	9.26E-05	4.40E-06	5.59E-07	8.74E-05	4.36E-06	5.56E-07	1.49E-04	4.78E-06	5.94E-07
0.50	9.36E-05	4.41E-06	5.60E-07	8.57E-05	4.36E-06	5.55E-07	1.72E-04	4.95E-06	6.08E-07
1.00	9.50E-05	4.39E-06	5.55E-07	8.27E-05	4.30E-06	5.47E-07	2.03E-04	5.12E-06	6.22E-07
2.00	9.70E-05	4.24E-06	5.34E-07	7.73E-05	4.10E-06	5.21E-07	2.41E-04	5.26E-06	6.29E-07
3.00	9.85E-05	4.04E-06	5.07E-07	7.22E-05	3.85E-06	4.89E-07	2.62E-04	5.29E-06	6.26E-07
4.00	9.96E-05	3.83E-06	4.78E-07	6.76E-05	3.58E-06	4.54E-07	2.75E-04	5.27E-06	6.20E-07
5.00	1.00E-04	3.62E-06	4.50E-07	6.33E-05	3.31E-06	4.20E-07	2.82E-04	5.23E-06	6.13E-07
6.00	1.01E-04	3.42E-06	4.24E-07	5.94E-05	3.06E-06	3.87E-07	2.86E-04	5.19E-06	6.06E-07
7.00	1.01E-04	3.24E-06	3.99E-07	5.58E-05	2.82E-06	3.57E-07	2.88E-04	5.15E-06	6.01E-07
8.00	1.02E-04	3.07E-06	3.77E-07	5.25E-05	2.60E-06	3.28E-07	2.89E-04	5.11E-06	5.96E-07
9.00	1.02E-04	2.92E-06	3.57E-07	4.96E-05	2.39E-06	3.02E-07	2.89E-04	5.08E-06	5.91E-07
10.00	1.02E-04	2.79E-06	3.39E-07	4.69E-05	2.21E-06	2.78E-07	2.89E-04	5.05E-06	5.87E-07
11.00	1.02E-04	2.67E-06	3.24E-07	4.44E-05	2.04E-06	2.56E-07	2.88E-04	5.02E-06	5.84E-07
12.00	1.02E-04	2.56E-06	3.09E-07	4.21E-05	1.88E-06	2.36E-07	2.87E-04	4.99E-06	5.81E-07
13.00	1.02E-04	2.46E-06	2.97E-07	4.01E-05	1.74E-06	2.18E-07	2.86E-04	4.97E-06	5.78E-07
14.00	1.02E-04	2.38E-06	2.86E-07	3.82E-05	1.61E-06	2.02E-07	2.85E-04	4.95E-06	5.75E-07
15.00	1.02E-04	2.30E-06	2.76E-07	3.65E-05	1.49E-06	1.87E-07	2.84E-04	4.92E-06	5.72E-07
16.00	1.02E-04	2.23E-06	2.67E-07	3.50E-05	1.39E-06	1.73E-07	2.83E-04	4.90E-06	5.69E-07
17.00	1.01E-04	2.17E-06	2.59E-07	3.36E-05	1.29E-06	1.61E-07	2.81E-04	4.88E-06	5.67E-07
18.00	1.01E-04	2.12E-06	2.52E-07	3.23E-05	1.20E-06	1.50E-07	2.80E-04	4.85E-06	5.64E-07
19.00	1.01E-04	2.07E-06	2.46E-07	3.11E-05	1.13E-06	1.40E-07	2.79E-04	4.83E-06	5.61E-07
20.00	1.01E-04	2.03E-06	2.40E-07	3.00E-05	1.05E-06	1.31E-07	2.78E-04	4.81E-06	5.59E-07
21.00	1.00E-04	1.99E-06	2.35E-07	2.91E-05	9.88E-07	1.22E-07	2.77E-04	4.79E-06	5.56E-07
22.00	9.98E-05	1.95E-06	2.30E-07	2.82E-05	9.28E-07	1.15E-07	2.75E-04	4.77E-06	5.54E-07
23.00	9.95E-05	1.92E-06	2.26E-07	2.73E-05	8.74E-07	1.08E-07	2.74E-04	4.74E-06	5.51E-07
24.00	9.91E-05	1.89E-06	2.23E-07	2.66E-05	8.24E-07	1.02E-07	2.73E-04	4.72E-06	5.49E-07
25.00	9.87E-05	1.87E-06	2.19E-07	2.59E-05	7.80E-07	9.58E-08	2.72E-04	4.70E-06	5.46E-07
26.00	9.83E-05	1.84E-06	2.16E-07	2.52E-05	7.39E-07	9.06E-08	2.70E-04	4.68E-06	5.44E-07
27.00	9.80E-05	1.82E-06	2.13E-07	2.46E-05	7.01E-07	8.58E-08	2.69E-04	4.66E-06	5.41E-07
28.00	9.75E-05	1.80E-06	2.11E-07	2.41E-05	6.67E-07	8.15E-08	2.68E-04	4.64E-06	5.39E-07
29.00	9.71E-05	1.78E-06	2.08E-07	2.36E-05	6.36E-07	7.75E-08	2.67E-04	4.62E-06	5.36E-07
30.00	9.67E-05	1.76E-06	2.06E-07	2.31E-05	6.08E-07	7.39E-08	2.66E-04	4.60E-06	5.34E-07

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
31.00	9.63E-05	1.74E-06	2.04E-07	2.27E-05	5.82E-07	7.06E-08	2.64E-04	4.58E-06	5.32E-07
32.00	9.59E-05	1.73E-06	2.02E-07	2.23E-05	5.59E-07	6.76E-08	2.63E-04	4.56E-06	5.29E-07
33.00	9.55E-05	1.71E-06	2.00E-07	2.19E-05	5.37E-07	6.49E-08	2.62E-04	4.54E-06	5.27E-07
34.00	9.51E-05	1.70E-06	1.98E-07	2.16E-05	5.17E-07	6.24E-08	2.61E-04	4.51E-06	5.25E-07
35.00	9.46E-05	1.69E-06	1.97E-07	2.13E-05	4.99E-07	6.01E-08	2.60E-04	4.49E-06	5.22E-07
36.00	9.42E-05	1.68E-06	1.95E-07	2.10E-05	4.83E-07	5.80E-08	2.59E-04	4.47E-06	5.20E-07

APPENDIX D

EXPOSURE RATES FOR 10YO

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
0.00	6.31E-05	3.98E-06	5.43E-07	6.31E-05	3.98E-06	5.43E-07	6.31E-05	3.98E-06	5.43E-07
0.25	6.82E-05	4.07E-06	5.51E-07	6.17E-05	4.02E-06	5.47E-07	1.37E-04	4.57E-06	5.91E-07
0.50	7.05E-05	4.09E-06	5.52E-07	6.07E-05	4.02E-06	5.46E-07	1.67E-04	4.78E-06	6.08E-07
1.00	7.41E-05	4.08E-06	5.48E-07	5.88E-05	3.97E-06	5.39E-07	2.06E-04	5.04E-06	6.26E-07
2.00	8.01E-05	3.98E-06	5.30E-07	5.56E-05	3.80E-06	5.14E-07	2.55E-04	5.28E-06	6.39E-07
3.00	8.50E-05	3.82E-06	5.04E-07	5.26E-05	3.57E-06	4.83E-07	2.83E-04	5.37E-06	6.39E-07
4.00	8.91E-05	3.64E-06	4.76E-07	4.99E-05	3.33E-06	4.49E-07	3.00E-04	5.39E-06	6.35E-07
5.00	9.27E-05	3.46E-06	4.49E-07	4.74E-05	3.08E-06	4.15E-07	3.11E-04	5.38E-06	6.29E-07
6.00	9.57E-05	3.29E-06	4.24E-07	4.52E-05	2.85E-06	3.83E-07	3.17E-04	5.35E-06	6.23E-07
7.00	9.83E-05	3.13E-06	4.00E-07	4.31E-05	2.63E-06	3.53E-07	3.20E-04	5.33E-06	6.18E-07
8.00	1.00E-04	2.98E-06	3.79E-07	4.12E-05	2.43E-06	3.25E-07	3.22E-04	5.30E-06	6.14E-07
9.00	1.02E-04	2.85E-06	3.60E-07	3.95E-05	2.24E-06	2.99E-07	3.22E-04	5.27E-06	6.10E-07
10.00	1.04E-04	2.74E-06	3.43E-07	3.79E-05	2.07E-06	2.76E-07	3.22E-04	5.24E-06	6.06E-07
11.00	1.05E-04	2.63E-06	3.27E-07	3.64E-05	1.91E-06	2.54E-07	3.22E-04	5.22E-06	6.03E-07
12.00	1.06E-04	2.54E-06	3.14E-07	3.51E-05	1.77E-06	2.35E-07	3.21E-04	5.19E-06	6.00E-07
13.00	1.07E-04	2.45E-06	3.01E-07	3.39E-05	1.64E-06	2.17E-07	3.20E-04	5.17E-06	5.97E-07
14.00	1.08E-04	2.38E-06	2.91E-07	3.28E-05	1.52E-06	2.01E-07	3.19E-04	5.15E-06	5.94E-07
15.00	1.09E-04	2.31E-06	2.81E-07	3.18E-05	1.41E-06	1.86E-07	3.17E-04	5.12E-06	5.91E-07
16.00	1.09E-04	2.25E-06	2.73E-07	3.09E-05	1.32E-06	1.73E-07	3.16E-04	5.10E-06	5.89E-07
17.00	1.09E-04	2.20E-06	2.65E-07	3.01E-05	1.23E-06	1.61E-07	3.15E-04	5.08E-06	5.86E-07
18.00	1.10E-04	2.15E-06	2.58E-07	2.93E-05	1.15E-06	1.50E-07	3.14E-04	5.06E-06	5.84E-07
19.00	1.10E-04	2.11E-06	2.52E-07	2.86E-05	1.07E-06	1.40E-07	3.12E-04	5.04E-06	5.81E-07
20.00	1.10E-04	2.07E-06	2.47E-07	2.80E-05	1.01E-06	1.31E-07	3.11E-04	5.02E-06	5.79E-07
21.00	1.10E-04	2.04E-06	2.42E-07	2.74E-05	9.47E-07	1.22E-07	3.10E-04	5.00E-06	5.76E-07
22.00	1.10E-04	2.00E-06	2.37E-07	2.68E-05	8.92E-07	1.15E-07	3.09E-04	4.98E-06	5.74E-07
23.00	1.10E-04	1.98E-06	2.33E-07	2.63E-05	8.43E-07	1.08E-07	3.07E-04	4.95E-06	5.72E-07
24.00	1.10E-04	1.95E-06	2.30E-07	2.58E-05	7.97E-07	1.02E-07	3.06E-04	4.93E-06	5.69E-07
25.00	1.09E-04	1.93E-06	2.26E-07	2.54E-05	7.56E-07	9.61E-08	3.05E-04	4.91E-06	5.67E-07
26.00	1.09E-04	1.90E-06	2.23E-07	2.50E-05	7.18E-07	9.10E-08	3.03E-04	4.89E-06	5.64E-07
27.00	1.09E-04	1.88E-06	2.21E-07	2.46E-05	6.84E-07	8.63E-08	3.02E-04	4.87E-06	5.62E-07
28.00	1.09E-04	1.86E-06	2.18E-07	2.43E-05	6.53E-07	8.20E-08	3.01E-04	4.85E-06	5.60E-07
29.00	1.08E-04	1.85E-06	2.16E-07	2.39E-05	6.24E-07	7.82E-08	3.00E-04	4.83E-06	5.57E-07
30.00	1.08E-04	1.83E-06	2.14E-07	2.36E-05	5.98E-07	7.46E-08	2.99E-04	4.81E-06	5.55E-07

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
31.00	1.08E-04	1.82E-06	2.12E-07	2.33E-05	5.74E-07	7.14E-08	2.97E-04	4.79E-06	5.53E-07
32.00	1.07E-04	1.80E-06	2.10E-07	2.31E-05	5.53E-07	6.84E-08	2.96E-04	4.77E-06	5.51E-07
33.00	1.07E-04	1.79E-06	2.08E-07	2.28E-05	5.33E-07	6.57E-08	2.95E-04	4.75E-06	5.48E-07
34.00	1.07E-04	1.78E-06	2.06E-07	2.26E-05	5.15E-07	6.32E-08	2.94E-04	4.73E-06	5.46E-07
35.00	1.06E-04	1.76E-06	2.05E-07	2.24E-05	4.98E-07	6.10E-08	2.92E-04	4.71E-06	5.44E-07
36.00	1.06E-04	1.75E-06	2.03E-07	2.21E-05	4.82E-07	5.89E-08	2.91E-04	4.69E-06	5.41E-07

APPENDIX E

EXPOSURE RATES FOR 15YO

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
0.00	4.57E-05	3.56E-06	5.18E-07	4.57E-05	3.56E-06	5.18E-07	4.57E-05	3.56E-06	5.18E-07
0.25	5.27E-05	3.65E-06	5.27E-07	4.50E-05	3.60E-06	5.23E-07	1.34E-04	4.25E-06	5.73E-07
0.50	5.60E-05	3.68E-06	5.29E-07	4.45E-05	3.59E-06	5.23E-07	1.69E-04	4.51E-06	5.92E-07
1.00	6.14E-05	3.69E-06	5.27E-07	4.35E-05	3.56E-06	5.17E-07	2.16E-04	4.83E-06	6.14E-07
2.00	7.05E-05	3.62E-06	5.10E-07	4.18E-05	3.40E-06	4.93E-07	2.74E-04	5.16E-06	6.31E-07
3.00	7.81E-05	3.49E-06	4.87E-07	4.03E-05	3.20E-06	4.63E-07	3.09E-04	5.31E-06	6.34E-07
4.00	8.46E-05	3.35E-06	4.61E-07	3.89E-05	2.98E-06	4.31E-07	3.29E-04	5.37E-06	6.32E-07
5.00	9.02E-05	3.20E-06	4.36E-07	3.76E-05	2.77E-06	3.99E-07	3.42E-04	5.38E-06	6.28E-07
6.00	9.51E-05	3.06E-06	4.12E-07	3.65E-05	2.56E-06	3.68E-07	3.49E-04	5.38E-06	6.23E-07
7.00	9.92E-05	2.93E-06	3.90E-07	3.54E-05	2.37E-06	3.40E-07	3.54E-04	5.36E-06	6.18E-07
8.00	1.03E-04	2.81E-06	3.70E-07	3.45E-05	2.19E-06	3.13E-07	3.56E-04	5.34E-06	6.14E-07
9.00	1.06E-04	2.71E-06	3.52E-07	3.36E-05	2.02E-06	2.88E-07	3.57E-04	5.32E-06	6.10E-07
10.00	1.09E-04	2.61E-06	3.36E-07	3.28E-05	1.87E-06	2.66E-07	3.57E-04	5.30E-06	6.07E-07
11.00	1.11E-04	2.52E-06	3.21E-07	3.20E-05	1.73E-06	2.45E-07	3.56E-04	5.28E-06	6.04E-07
12.00	1.13E-04	2.44E-06	3.08E-07	3.13E-05	1.61E-06	2.26E-07	3.56E-04	5.26E-06	6.01E-07
13.00	1.14E-04	2.37E-06	2.97E-07	3.07E-05	1.49E-06	2.09E-07	3.54E-04	5.23E-06	5.98E-07
14.00	1.16E-04	2.31E-06	2.87E-07	3.01E-05	1.39E-06	1.94E-07	3.53E-04	5.21E-06	5.95E-07
15.00	1.17E-04	2.26E-06	2.78E-07	2.96E-05	1.29E-06	1.80E-07	3.52E-04	5.19E-06	5.93E-07
16.00	1.18E-04	2.21E-06	2.70E-07	2.91E-05	1.21E-06	1.67E-07	3.51E-04	5.17E-06	5.90E-07
17.00	1.19E-04	2.16E-06	2.63E-07	2.86E-05	1.13E-06	1.55E-07	3.49E-04	5.15E-06	5.88E-07
18.00	1.19E-04	2.12E-06	2.56E-07	2.82E-05	1.06E-06	1.45E-07	3.48E-04	5.13E-06	5.85E-07
19.00	1.20E-04	2.09E-06	2.50E-07	2.78E-05	9.94E-07	1.35E-07	3.47E-04	5.11E-06	5.83E-07
20.00	1.20E-04	2.05E-06	2.45E-07	2.74E-05	9.35E-07	1.27E-07	3.45E-04	5.08E-06	5.81E-07
21.00	1.20E-04	2.02E-06	2.41E-07	2.71E-05	8.82E-07	1.19E-07	3.44E-04	5.06E-06	5.78E-07
22.00	1.20E-04	2.00E-06	2.36E-07	2.68E-05	8.33E-07	1.12E-07	3.43E-04	5.04E-06	5.76E-07
23.00	1.20E-04	1.97E-06	2.33E-07	2.65E-05	7.89E-07	1.05E-07	3.41E-04	5.02E-06	5.74E-07
24.00	1.20E-04	1.95E-06	2.29E-07	2.62E-05	7.49E-07	9.92E-08	3.40E-04	5.00E-06	5.71E-07
25.00	1.20E-04	1.93E-06	2.26E-07	2.59E-05	7.13E-07	9.38E-08	3.38E-04	4.98E-06	5.69E-07
26.00	1.20E-04	1.91E-06	2.23E-07	2.57E-05	6.79E-07	8.89E-08	3.37E-04	4.96E-06	5.67E-07
27.00	1.20E-04	1.89E-06	2.21E-07	2.54E-05	6.49E-07	8.44E-08	3.36E-04	4.94E-06	5.64E-07
28.00	1.20E-04	1.87E-06	2.18E-07	2.52E-05	6.21E-07	8.03E-08	3.34E-04	4.92E-06	5.62E-07
29.00	1.20E-04	1.86E-06	2.16E-07	2.50E-05	5.96E-07	7.66E-08	3.33E-04	4.90E-06	5.60E-07
30.00	1.19E-04	1.84E-06	2.14E-07	2.48E-05	5.73E-07	7.32E-08	3.32E-04	4.88E-06	5.58E-07

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
31.00	1.19E-04	1.83E-06	2.12E-07	2.46E-05	5.51E-07	7.01E-08	3.30E-04	4.86E-06	5.55E-07
32.00	1.19E-04	1.82E-06	2.10E-07	2.44E-05	5.32E-07	6.72E-08	3.29E-04	4.84E-06	5.53E-07
33.00	1.18E-04	1.81E-06	2.08E-07	2.42E-05	5.14E-07	6.47E-08	3.28E-04	4.82E-06	5.51E-07
34.00	1.18E-04	1.79E-06	2.07E-07	2.41E-05	4.98E-07	6.23E-08	3.26E-04	4.80E-06	5.49E-07
35.00	1.18E-04	1.78E-06	2.05E-07	2.39E-05	4.83E-07	6.01E-08	3.25E-04	4.79E-06	5.46E-07
36.00	1.17E-04	1.77E-06	2.04E-07	2.37E-05	4.70E-07	5.81E-08	3.24E-04	4.77E-06	5.44E-07

APPENDIX F

EXPOSURE RATES FOR ADULT

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
0.00	3.84E-05	3.39E-06	5.11E-07	3.84E-05	3.39E-06	5.11E-07	3.84E-05	3.39E-06	5.11E-07
0.25	4.73E-05	3.48E-06	5.20E-07	3.83E-05	3.42E-06	5.16E-07	1.42E-04	4.11E-06	5.64E-07
0.50	5.16E-05	3.50E-06	5.22E-07	3.81E-05	3.41E-06	5.16E-07	1.83E-04	4.38E-06	5.83E-07
1.00	5.86E-05	3.52E-06	5.20E-07	3.76E-05	3.37E-06	5.10E-07	2.39E-04	4.71E-06	6.04E-07
2.00	7.04E-05	3.45E-06	5.03E-07	3.68E-05	3.23E-06	4.87E-07	3.08E-04	5.07E-06	6.20E-07
3.00	8.02E-05	3.34E-06	4.80E-07	3.61E-05	3.03E-06	4.57E-07	3.49E-04	5.24E-06	6.22E-07
4.00	8.87E-05	3.21E-06	4.55E-07	3.54E-05	2.83E-06	4.26E-07	3.73E-04	5.32E-06	6.20E-07
5.00	9.61E-05	3.08E-06	4.30E-07	3.48E-05	2.63E-06	3.94E-07	3.88E-04	5.34E-06	6.15E-07
6.00	1.02E-04	2.96E-06	4.06E-07	3.42E-05	2.43E-06	3.64E-07	3.97E-04	5.35E-06	6.11E-07
7.00	1.08E-04	2.84E-06	3.84E-07	3.37E-05	2.25E-06	3.35E-07	4.02E-04	5.34E-06	6.06E-07
8.00	1.13E-04	2.73E-06	3.64E-07	3.32E-05	2.08E-06	3.09E-07	4.05E-04	5.32E-06	6.02E-07
9.00	1.17E-04	2.63E-06	3.46E-07	3.28E-05	1.92E-06	2.84E-07	4.06E-04	5.30E-06	5.98E-07
10.00	1.20E-04	2.54E-06	3.30E-07	3.23E-05	1.78E-06	2.62E-07	4.07E-04	5.28E-06	5.95E-07
11.00	1.23E-04	2.46E-06	3.16E-07	3.19E-05	1.65E-06	2.42E-07	4.06E-04	5.26E-06	5.92E-07
12.00	1.26E-04	2.39E-06	3.03E-07	3.16E-05	1.53E-06	2.23E-07	4.05E-04	5.24E-06	5.89E-07
13.00	1.28E-04	2.33E-06	2.92E-07	3.12E-05	1.43E-06	2.06E-07	4.04E-04	5.22E-06	5.87E-07
14.00	1.30E-04	2.27E-06	2.82E-07	3.09E-05	1.33E-06	1.91E-07	4.03E-04	5.20E-06	5.84E-07
15.00	1.32E-04	2.22E-06	2.73E-07	3.06E-05	1.24E-06	1.77E-07	4.02E-04	5.18E-06	5.82E-07
16.00	1.33E-04	2.18E-06	2.65E-07	3.03E-05	1.16E-06	1.65E-07	4.00E-04	5.16E-06	5.79E-07
17.00	1.34E-04	2.13E-06	2.58E-07	3.01E-05	1.08E-06	1.53E-07	3.99E-04	5.14E-06	5.77E-07
18.00	1.35E-04	2.10E-06	2.52E-07	2.98E-05	1.02E-06	1.43E-07	3.97E-04	5.12E-06	5.74E-07
19.00	1.35E-04	2.06E-06	2.46E-07	2.96E-05	9.56E-07	1.33E-07	3.96E-04	5.10E-06	5.72E-07
20.00	1.36E-04	2.03E-06	2.41E-07	2.93E-05	9.01E-07	1.25E-07	3.94E-04	5.08E-06	5.70E-07
21.00	1.36E-04	2.01E-06	2.36E-07	2.91E-05	8.51E-07	1.17E-07	3.93E-04	5.06E-06	5.68E-07
22.00	1.37E-04	1.98E-06	2.32E-07	2.89E-05	8.05E-07	1.10E-07	3.91E-04	5.04E-06	5.65E-07
23.00	1.37E-04	1.96E-06	2.29E-07	2.87E-05	7.64E-07	1.04E-07	3.90E-04	5.02E-06	5.63E-07
24.00	1.37E-04	1.94E-06	2.25E-07	2.85E-05	7.26E-07	9.78E-08	3.88E-04	5.00E-06	5.61E-07
25.00	1.37E-04	1.92E-06	2.22E-07	2.83E-05	6.91E-07	9.24E-08	3.87E-04	4.98E-06	5.59E-07
26.00	1.37E-04	1.90E-06	2.19E-07	2.82E-05	6.60E-07	8.76E-08	3.85E-04	4.96E-06	5.57E-07
27.00	1.37E-04	1.88E-06	2.17E-07	2.80E-05	6.31E-07	8.32E-08	3.84E-04	4.94E-06	5.54E-07
28.00	1.37E-04	1.87E-06	2.15E-07	2.78E-05	6.05E-07	7.92E-08	3.82E-04	4.92E-06	5.52E-07
29.00	1.36E-04	1.85E-06	2.12E-07	2.77E-05	5.81E-07	7.55E-08	3.81E-04	4.90E-06	5.50E-07
30.00	1.36E-04	1.84E-06	2.10E-07	2.75E-05	5.60E-07	7.21E-08	3.79E-04	4.88E-06	5.48E-07

	Normal			DTC			Hyper		
Time (h)	10 cm	100cm	300cm	10 cm	100cm	300cm	10cm	100cm	300cm
31.00	1.36E-04	1.83E-06	2.09E-07	2.74E-05	5.40E-07	6.91E-08	3.78E-04	4.86E-06	5.46E-07
32.00	1.36E-04	1.81E-06	2.07E-07	2.72E-05	5.22E-07	6.63E-08	3.76E-04	4.84E-06	5.44E-07
33.00	1.35E-04	1.80E-06	2.05E-07	2.71E-05	5.05E-07	6.38E-08	3.75E-04	4.82E-06	5.41E-07
34.00	1.35E-04	1.79E-06	2.04E-07	2.69E-05	4.89E-07	6.14E-08	3.73E-04	4.81E-06	5.39E-07
35.00	1.35E-04	1.78E-06	2.02E-07	2.68E-05	4.75E-07	5.93E-08	3.72E-04	4.79E-06	5.37E-07
36.00	1.34E-04	1.77E-06	2.01E-07	2.67E-05	4.63E-07	5.73E-08	3.70E-04	4.77E-06	5.35E-07

APPENDIX H

DETECTOR RESPONSE ALL AGE GROUPS

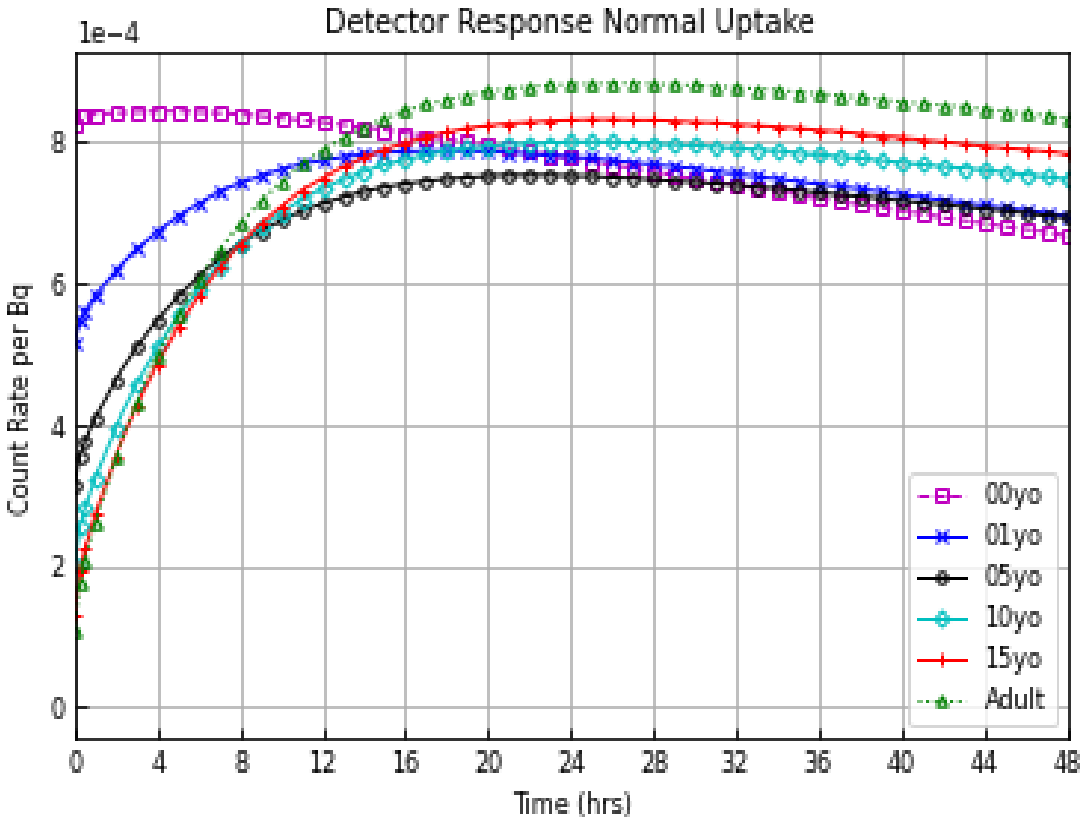

Figure 29. Detector Response for all age groups for normal uptake.

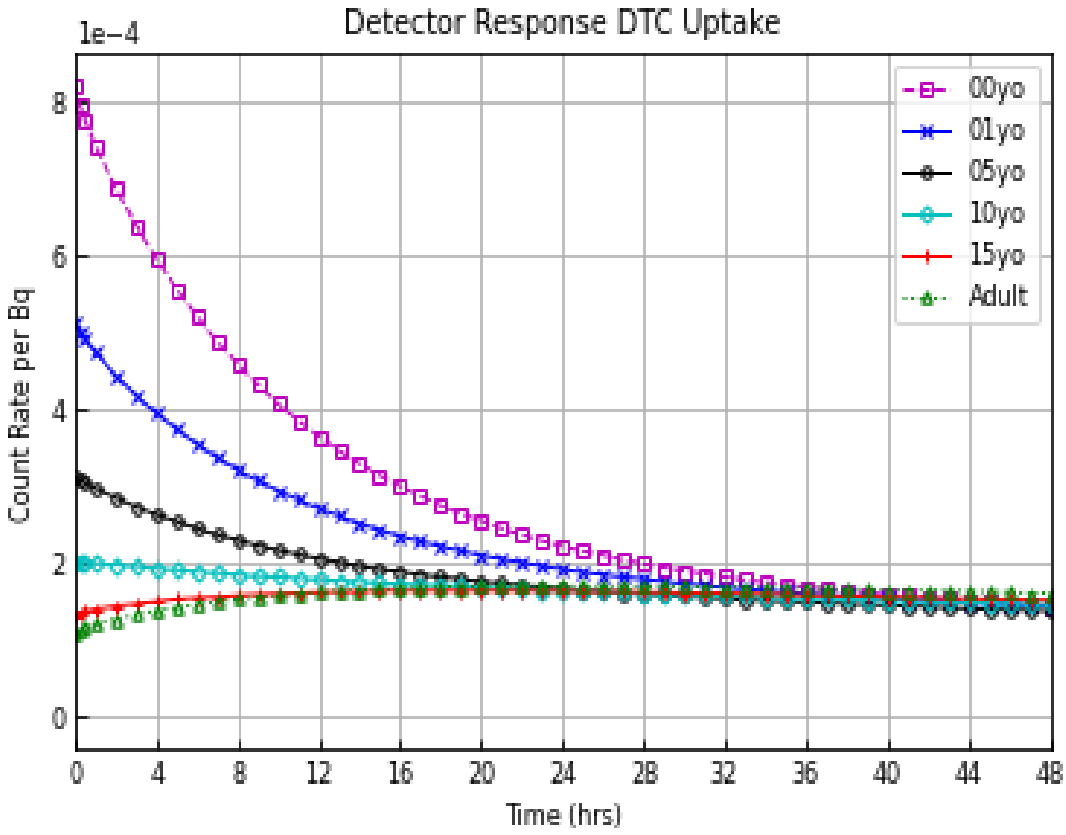

Figure 30. Detector Response for all age groups for DTC uptake.

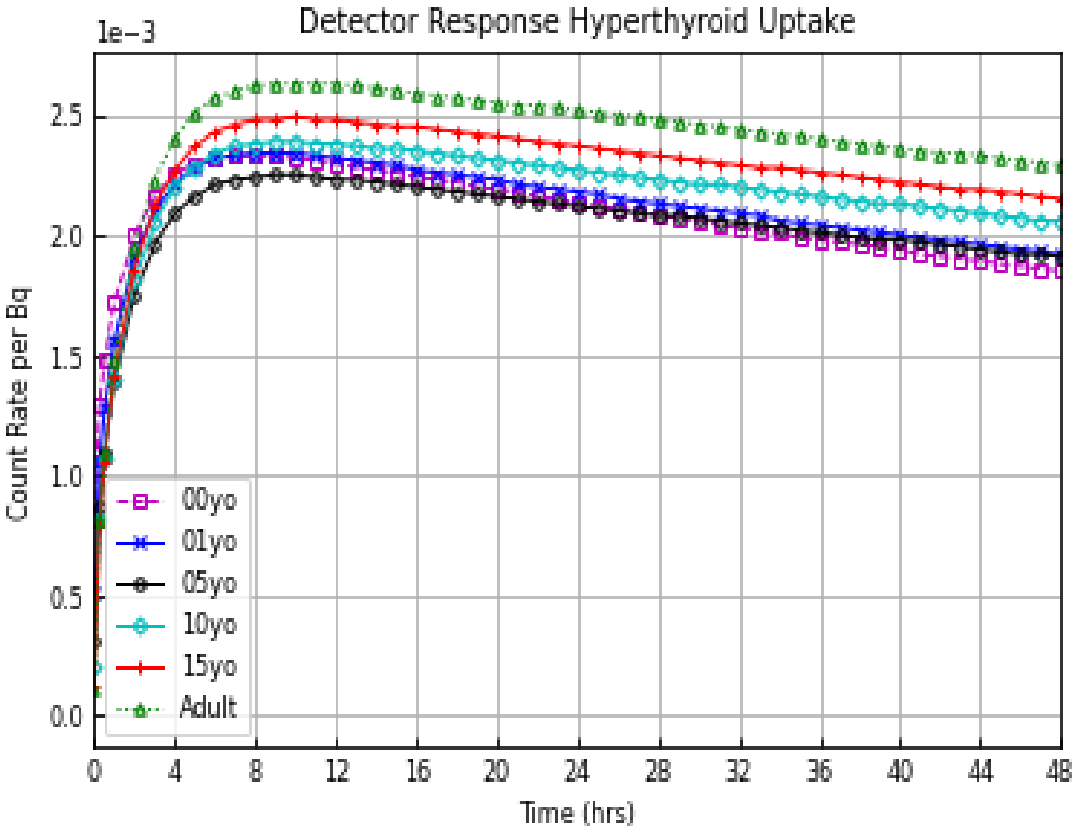

Figure 31. Detector Response for all age groups for hyperthyroid uptake.

APPENDIX I

EFFECTIVE DOSE RATE 10 CM FOR ADULT PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.82E-04	1.82E-04	1.82E-04	1.85E-04	1.85E-04	1.85E-04	2.18E-04	2.18E-04	2.18E-04
0.25	1.86E-04	1.85E-04	2.00E-04	1.89E-04	1.89E-04	1.96E-04	2.23E-04	2.24E-04	2.12E-04
0.50	1.87E-04	1.86E-04	2.06E-04	1.90E-04	1.89E-04	2.00E-04	2.25E-04	2.27E-04	2.09E-04
1.00	1.87E-04	1.84E-04	2.12E-04	1.90E-04	1.89E-04	2.03E-04	2.24E-04	2.27E-04	2.02E-04
2.00	1.82E-04	1.77E-04	2.17E-04	1.84E-04	1.82E-04	2.03E-04	2.16E-04	2.20E-04	1.87E-04
3.00	1.74E-04	1.67E-04	2.16E-04	1.75E-04	1.71E-04	2.00E-04	2.03E-04	2.08E-04	1.74E-04
4.00	1.64E-04	1.55E-04	2.14E-04	1.65E-04	1.59E-04	1.96E-04	1.88E-04	1.93E-04	1.64E-04
5.00	1.55E-04	1.44E-04	2.12E-04	1.54E-04	1.48E-04	1.93E-04	1.74E-04	1.79E-04	1.56E-04
6.00	1.46E-04	1.33E-04	2.10E-04	1.45E-04	1.36E-04	1.90E-04	1.60E-04	1.65E-04	1.50E-04
7.00	1.38E-04	1.22E-04	2.08E-04	1.36E-04	1.25E-04	1.87E-04	1.47E-04	1.51E-04	1.45E-04
8.00	1.30E-04	1.13E-04	2.06E-04	1.28E-04	1.15E-04	1.85E-04	1.36E-04	1.38E-04	1.42E-04
9.00	1.23E-04	1.04E-04	2.05E-04	1.20E-04	1.06E-04	1.84E-04	1.26E-04	1.27E-04	1.40E-04
10.00	1.17E-04	9.56E-05	2.04E-04	1.14E-04	9.73E-05	1.82E-04	1.17E-04	1.16E-04	1.38E-04
11.00	1.12E-04	8.81E-05	2.03E-04	1.08E-04	8.96E-05	1.81E-04	1.08E-04	1.06E-04	1.37E-04
12.00	1.07E-04	8.13E-05	2.02E-04	1.03E-04	8.25E-05	1.80E-04	1.01E-04	9.74E-05	1.36E-04
13.00	1.03E-04	7.51E-05	2.01E-04	9.79E-05	7.60E-05	1.79E-04	9.49E-05	8.93E-05	1.35E-04
14.00	9.91E-05	6.94E-05	2.00E-04	9.38E-05	7.02E-05	1.78E-04	8.92E-05	8.19E-05	1.34E-04
15.00	9.57E-05	6.43E-05	1.99E-04	9.02E-05	6.48E-05	1.78E-04	8.42E-05	7.52E-05	1.33E-04
16.00	9.27E-05	5.97E-05	1.98E-04	8.69E-05	6.00E-05	1.77E-04	7.98E-05	6.92E-05	1.32E-04
17.00	9.01E-05	5.54E-05	1.97E-04	8.41E-05	5.56E-05	1.76E-04	7.59E-05	6.37E-05	1.32E-04
18.00	8.77E-05	5.16E-05	1.96E-04	8.15E-05	5.16E-05	1.75E-04	7.24E-05	5.87E-05	1.31E-04
19.00	8.56E-05	4.81E-05	1.96E-04	7.92E-05	4.80E-05	1.75E-04	6.94E-05	5.41E-05	1.31E-04
20.00	8.36E-05	4.50E-05	1.95E-04	7.72E-05	4.47E-05	1.74E-04	6.67E-05	5.00E-05	1.30E-04
21.00	8.19E-05	4.21E-05	1.94E-04	7.54E-05	4.18E-05	1.73E-04	6.43E-05	4.63E-05	1.30E-04
22.00	8.04E-05	3.95E-05	1.93E-04	7.37E-05	3.91E-05	1.73E-04	6.21E-05	4.29E-05	1.29E-04
23.00	7.90E-05	3.71E-05	1.93E-04	7.23E-05	3.66E-05	1.72E-04	6.02E-05	3.98E-05	1.29E-04
24.00	7.78E-05	3.50E-05	1.92E-04	7.10E-05	3.44E-05	1.71E-04	5.85E-05	3.70E-05	1.28E-04
25.00	7.66E-05	3.30E-05	1.91E-04	6.98E-05	3.23E-05	1.71E-04	5.70E-05	3.45E-05	1.28E-04
26.00	7.56E-05	3.12E-05	1.90E-04	6.87E-05	3.05E-05	1.70E-04	5.57E-05	3.22E-05	1.27E-04
27.00	7.47E-05	2.96E-05	1.90E-04	6.77E-05	2.88E-05	1.69E-04	5.45E-05	3.01E-05	1.27E-04
28.00	7.38E-05	2.81E-05	1.89E-04	6.69E-05	2.73E-05	1.69E-04	5.34E-05	2.82E-05	1.26E-04
29.00	7.30E-05	2.68E-05	1.88E-04	6.60E-05	2.59E-05	1.68E-04	5.24E-05	2.64E-05	1.26E-04
30.00	7.23E-05	2.55E-05	1.87E-04	6.53E-05	2.46E-05	1.67E-04	5.15E-05	2.48E-05	1.25E-04

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	7.16E-05	2.44E-05	1.87E-04	6.46E-05	2.34E-05	1.67E-04	5.07E-05	2.34E-05	1.25E-04
32.00	7.10E-05	2.34E-05	1.86E-04	6.40E-05	2.24E-05	1.66E-04	5.00E-05	2.21E-05	1.24E-04
33.00	7.04E-05	2.24E-05	1.85E-04	6.34E-05	2.14E-05	1.65E-04	4.93E-05	2.09E-05	1.24E-04
34.00	6.98E-05	2.16E-05	1.84E-04	6.28E-05	2.05E-05	1.65E-04	4.87E-05	1.98E-05	1.23E-04
35.00	6.93E-05	2.08E-05	1.84E-04	6.23E-05	1.97E-05	1.64E-04	4.81E-05	1.88E-05	1.23E-04
36.00	6.88E-05	2.01E-05	1.83E-04	6.19E-05	1.90E-05	1.63E-04	4.76E-05	1.79E-05	1.22E-04

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	2.22E-04	2.22E-04	2.22E-04	2.37E-04	2.37E-04	2.37E-04	2.67E-04	2.67E-04	2.67E-04
0.25	2.29E-04	2.31E-04	2.04E-04	2.47E-04	2.51E-04	2.11E-04	2.86E-04	2.90E-04	2.37E-04
0.50	2.31E-04	2.35E-04	1.96E-04	2.51E-04	2.57E-04	1.99E-04	2.94E-04	3.01E-04	2.24E-04
1.00	2.31E-04	2.37E-04	1.81E-04	2.53E-04	2.61E-04	1.80E-04	3.00E-04	3.11E-04	2.01E-04
2.00	2.22E-04	2.31E-04	1.56E-04	2.44E-04	2.58E-04	1.46E-04	2.93E-04	3.12E-04	1.59E-04
3.00	2.07E-04	2.19E-04	1.37E-04	2.28E-04	2.45E-04	1.21E-04	2.74E-04	2.99E-04	1.25E-04
4.00	1.91E-04	2.04E-04	1.22E-04	2.09E-04	2.30E-04	1.01E-04	2.52E-04	2.81E-04	9.98E-05
5.00	1.74E-04	1.89E-04	1.11E-04	1.90E-04	2.12E-04	8.73E-05	2.28E-04	2.60E-04	8.11E-05
6.00	1.59E-04	1.74E-04	1.03E-04	1.71E-04	1.95E-04	7.72E-05	2.05E-04	2.40E-04	6.77E-05
7.00	1.44E-04	1.59E-04	9.78E-05	1.54E-04	1.79E-04	7.01E-05	1.84E-04	2.20E-04	5.82E-05
8.00	1.31E-04	1.46E-04	9.38E-05	1.39E-04	1.63E-04	6.51E-05	1.64E-04	2.01E-04	5.16E-05
9.00	1.19E-04	1.33E-04	9.10E-05	1.25E-04	1.49E-04	6.16E-05	1.47E-04	1.83E-04	4.69E-05
10.00	1.09E-04	1.21E-04	8.89E-05	1.12E-04	1.36E-04	5.91E-05	1.31E-04	1.66E-04	4.37E-05
11.00	9.95E-05	1.11E-04	8.74E-05	1.01E-04	1.24E-04	5.73E-05	1.17E-04	1.52E-04	4.15E-05
12.00	9.13E-05	1.01E-04	8.63E-05	9.15E-05	1.13E-04	5.61E-05	1.05E-04	1.38E-04	3.99E-05
13.00	8.40E-05	9.25E-05	8.54E-05	8.28E-05	1.03E-04	5.52E-05	9.38E-05	1.25E-04	3.88E-05
14.00	7.75E-05	8.45E-05	8.47E-05	7.52E-05	9.35E-05	5.45E-05	8.41E-05	1.14E-04	3.80E-05
15.00	7.18E-05	7.72E-05	8.41E-05	6.85E-05	8.53E-05	5.40E-05	7.56E-05	1.04E-04	3.74E-05
16.00	6.68E-05	7.07E-05	8.36E-05	6.26E-05	7.78E-05	5.36E-05	6.82E-05	9.44E-05	3.70E-05
17.00	6.24E-05	6.47E-05	8.32E-05	5.74E-05	7.10E-05	5.32E-05	6.16E-05	8.60E-05	3.67E-05
18.00	5.85E-05	5.93E-05	8.28E-05	5.28E-05	6.48E-05	5.29E-05	5.58E-05	7.83E-05	3.64E-05
19.00	5.50E-05	5.44E-05	8.24E-05	4.88E-05	5.92E-05	5.26E-05	5.07E-05	7.13E-05	3.62E-05
20.00	5.20E-05	5.00E-05	8.21E-05	4.52E-05	5.41E-05	5.24E-05	4.62E-05	6.50E-05	3.60E-05
21.00	4.93E-05	4.59E-05	8.17E-05	4.21E-05	4.95E-05	5.22E-05	4.23E-05	5.93E-05	3.58E-05
22.00	4.69E-05	4.23E-05	8.14E-05	3.93E-05	4.53E-05	5.19E-05	3.88E-05	5.41E-05	3.56E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
23.00	4.48E-05	3.89E-05	8.11E-05	3.69E-05	4.15E-05	5.17E-05	3.57E-05	4.94E-05	3.54E-05
24.00	4.30E-05	3.59E-05	8.07E-05	3.48E-05	3.81E-05	5.15E-05	3.30E-05	4.51E-05	3.53E-05
25.00	4.13E-05	3.32E-05	8.04E-05	3.29E-05	3.50E-05	5.13E-05	3.07E-05	4.13E-05	3.51E-05
26.00	3.99E-05	3.07E-05	8.01E-05	3.12E-05	3.21E-05	5.11E-05	2.86E-05	3.78E-05	3.50E-05
27.00	3.85E-05	2.84E-05	7.98E-05	2.97E-05	2.96E-05	5.09E-05	2.67E-05	3.46E-05	3.48E-05
28.00	3.74E-05	2.64E-05	7.94E-05	2.84E-05	2.72E-05	5.07E-05	2.51E-05	3.17E-05	3.47E-05
29.00	3.63E-05	2.45E-05	7.91E-05	2.72E-05	2.51E-05	5.05E-05	2.36E-05	2.90E-05	3.46E-05
30.00	3.54E-05	2.28E-05	7.88E-05	2.61E-05	2.32E-05	5.02E-05	2.24E-05	2.67E-05	3.44E-05
31.00	3.46E-05	2.13E-05	7.85E-05	2.52E-05	2.14E-05	5.00E-05	2.12E-05	2.45E-05	3.43E-05
32.00	3.38E-05	1.99E-05	7.82E-05	2.44E-05	1.98E-05	4.98E-05	2.02E-05	2.25E-05	3.41E-05
33.00	3.32E-05	1.86E-05	7.79E-05	2.37E-05	1.84E-05	4.96E-05	1.93E-05	2.07E-05	3.40E-05
34.00	3.25E-05	1.74E-05	7.76E-05	2.30E-05	1.71E-05	4.94E-05	1.85E-05	1.91E-05	3.38E-05
35.00	3.20E-05	1.64E-05	7.73E-05	2.24E-05	1.59E-05	4.92E-05	1.78E-05	1.76E-05	3.37E-05
36.00	3.15E-05	1.54E-05	7.70E-05	2.19E-05	1.48E-05	4.90E-05	1.72E-05	1.63E-05	3.36E-05

APPENDIX J

EFFECTIVE DOSE RATE 10 CM FOR 15YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.76E-04	1.76E-04	1.76E-04	2.01E-04	2.01E-04	2.01E-04	2.32E-04	2.32E-04	2.32E-04
0.25	1.81E-04	1.79E-04	1.95E-04	2.05E-04	2.04E-04	2.15E-04	2.38E-04	2.38E-04	2.33E-04
0.50	1.82E-04	1.80E-04	2.02E-04	2.06E-04	2.05E-04	2.19E-04	2.39E-04	2.40E-04	2.32E-04
1.00	1.82E-04	1.79E-04	2.09E-04	2.06E-04	2.04E-04	2.23E-04	2.39E-04	2.40E-04	2.28E-04
2.00	1.77E-04	1.72E-04	2.14E-04	1.99E-04	1.96E-04	2.24E-04	2.30E-04	2.32E-04	2.17E-04
3.00	1.69E-04	1.62E-04	2.14E-04	1.89E-04	1.84E-04	2.21E-04	2.17E-04	2.19E-04	2.07E-04
4.00	1.60E-04	1.51E-04	2.13E-04	1.78E-04	1.72E-04	2.18E-04	2.02E-04	2.04E-04	1.98E-04
5.00	1.51E-04	1.40E-04	2.11E-04	1.67E-04	1.59E-04	2.14E-04	1.88E-04	1.88E-04	1.91E-04
6.00	1.43E-04	1.29E-04	2.09E-04	1.57E-04	1.47E-04	2.12E-04	1.74E-04	1.73E-04	1.86E-04
7.00	1.35E-04	1.19E-04	2.07E-04	1.48E-04	1.35E-04	2.09E-04	1.61E-04	1.59E-04	1.82E-04
8.00	1.28E-04	1.10E-04	2.05E-04	1.39E-04	1.24E-04	2.07E-04	1.50E-04	1.46E-04	1.79E-04
9.00	1.21E-04	1.01E-04	2.04E-04	1.31E-04	1.14E-04	2.05E-04	1.39E-04	1.34E-04	1.76E-04
10.00	1.15E-04	9.29E-05	2.03E-04	1.24E-04	1.05E-04	2.04E-04	1.30E-04	1.23E-04	1.74E-04
11.00	1.10E-04	8.57E-05	2.02E-04	1.18E-04	9.66E-05	2.03E-04	1.22E-04	1.13E-04	1.73E-04
12.00	1.05E-04	7.91E-05	2.01E-04	1.12E-04	8.90E-05	2.01E-04	1.15E-04	1.03E-04	1.72E-04
13.00	1.01E-04	7.31E-05	2.00E-04	1.07E-04	8.21E-05	2.00E-04	1.08E-04	9.50E-05	1.71E-04
14.00	9.76E-05	6.76E-05	1.99E-04	1.03E-04	7.58E-05	1.99E-04	1.02E-04	8.73E-05	1.70E-04
15.00	9.44E-05	6.26E-05	1.98E-04	9.92E-05	7.01E-05	1.99E-04	9.74E-05	8.04E-05	1.69E-04
16.00	9.15E-05	5.81E-05	1.97E-04	9.58E-05	6.49E-05	1.98E-04	9.29E-05	7.40E-05	1.68E-04
17.00	8.89E-05	5.40E-05	1.96E-04	9.27E-05	6.02E-05	1.97E-04	8.89E-05	6.83E-05	1.67E-04
18.00	8.66E-05	5.03E-05	1.95E-04	9.00E-05	5.59E-05	1.96E-04	8.54E-05	6.31E-05	1.67E-04
19.00	8.45E-05	4.70E-05	1.94E-04	8.76E-05	5.21E-05	1.95E-04	8.23E-05	5.84E-05	1.66E-04
20.00	8.27E-05	4.39E-05	1.94E-04	8.54E-05	4.85E-05	1.94E-04	7.95E-05	5.41E-05	1.65E-04
21.00	8.10E-05	4.11E-05	1.93E-04	8.34E-05	4.53E-05	1.94E-04	7.71E-05	5.02E-05	1.65E-04
22.00	7.95E-05	3.86E-05	1.92E-04	8.17E-05	4.24E-05	1.93E-04	7.49E-05	4.67E-05	1.64E-04
23.00	7.82E-05	3.63E-05	1.91E-04	8.01E-05	3.98E-05	1.92E-04	7.29E-05	4.35E-05	1.63E-04
24.00	7.70E-05	3.42E-05	1.91E-04	7.87E-05	3.74E-05	1.91E-04	7.11E-05	4.05E-05	1.63E-04
25.00	7.59E-05	3.23E-05	1.90E-04	7.74E-05	3.52E-05	1.90E-04	6.96E-05	3.79E-05	1.62E-04
26.00	7.48E-05	3.06E-05	1.89E-04	7.63E-05	3.32E-05	1.90E-04	6.82E-05	3.55E-05	1.61E-04
27.00	7.39E-05	2.90E-05	1.88E-04	7.52E-05	3.14E-05	1.89E-04	6.69E-05	3.33E-05	1.61E-04
28.00	7.31E-05	2.75E-05	1.87E-04	7.43E-05	2.97E-05	1.88E-04	6.57E-05	3.13E-05	1.60E-04
29.00	7.23E-05	2.62E-05	1.87E-04	7.34E-05	2.82E-05	1.87E-04	6.47E-05	2.95E-05	1.59E-04
30.00	7.16E-05	2.50E-05	1.86E-04	7.26E-05	2.69E-05	1.87E-04	6.37E-05	2.78E-05	1.59E-04

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	7.09E-05	2.39E-05	1.85E-04	7.18E-05	2.56E-05	1.86E-04	6.29E-05	2.63E-05	1.58E-04
32.00	7.03E-05	2.29E-05	1.84E-04	7.11E-05	2.45E-05	1.85E-04	6.21E-05	2.50E-05	1.57E-04
33.00	6.97E-05	2.20E-05	1.84E-04	7.05E-05	2.34E-05	1.84E-04	6.14E-05	2.37E-05	1.57E-04
34.00	6.92E-05	2.12E-05	1.83E-04	6.99E-05	2.25E-05	1.84E-04	6.07E-05	2.26E-05	1.56E-04
35.00	6.87E-05	2.04E-05	1.82E-04	6.93E-05	2.16E-05	1.83E-04	6.01E-05	2.15E-05	1.55E-04
36.00	6.82E-05	1.97E-05	1.82E-04	6.88E-05	2.08E-05	1.82E-04	5.95E-05	2.06E-05	1.55E-04

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	2.40E-04	2.40E-04	2.40E-04	2.47E-04	2.47E-04	2.47E-04	2.94E-04	2.94E-04	2.94E-04
0.25	2.47E-04	2.49E-04	2.25E-04	2.56E-04	2.59E-04	2.22E-04	3.11E-04	3.16E-04	2.61E-04
0.50	2.49E-04	2.52E-04	2.18E-04	2.59E-04	2.64E-04	2.11E-04	3.19E-04	3.26E-04	2.46E-04
1.00	2.48E-04	2.53E-04	2.05E-04	2.60E-04	2.68E-04	1.93E-04	3.23E-04	3.35E-04	2.20E-04
2.00	2.38E-04	2.46E-04	1.82E-04	2.50E-04	2.62E-04	1.61E-04	3.14E-04	3.34E-04	1.76E-04
3.00	2.23E-04	2.33E-04	1.64E-04	2.33E-04	2.49E-04	1.37E-04	2.94E-04	3.19E-04	1.41E-04
4.00	2.06E-04	2.17E-04	1.49E-04	2.14E-04	2.33E-04	1.19E-04	2.70E-04	2.99E-04	1.14E-04
5.00	1.89E-04	2.00E-04	1.39E-04	1.95E-04	2.15E-04	1.05E-04	2.45E-04	2.77E-04	9.50E-05
6.00	1.72E-04	1.84E-04	1.31E-04	1.77E-04	1.98E-04	9.57E-05	2.20E-04	2.55E-04	8.12E-05
7.00	1.58E-04	1.69E-04	1.26E-04	1.60E-04	1.81E-04	8.89E-05	1.98E-04	2.34E-04	7.14E-05
8.00	1.44E-04	1.55E-04	1.22E-04	1.44E-04	1.66E-04	8.41E-05	1.77E-04	2.13E-04	6.45E-05
9.00	1.32E-04	1.41E-04	1.19E-04	1.31E-04	1.51E-04	8.07E-05	1.58E-04	1.95E-04	5.97E-05
10.00	1.21E-04	1.29E-04	1.17E-04	1.18E-04	1.38E-04	7.83E-05	1.42E-04	1.77E-04	5.64E-05
11.00	1.11E-04	1.18E-04	1.15E-04	1.07E-04	1.26E-04	7.65E-05	1.27E-04	1.61E-04	5.41E-05
12.00	1.03E-04	1.08E-04	1.14E-04	9.77E-05	1.15E-04	7.53E-05	1.14E-04	1.47E-04	5.24E-05
13.00	9.54E-05	9.88E-05	1.13E-04	8.91E-05	1.05E-04	7.43E-05	1.03E-04	1.34E-04	5.13E-05
14.00	8.88E-05	9.04E-05	1.12E-04	8.16E-05	9.54E-05	7.36E-05	9.24E-05	1.22E-04	5.04E-05
15.00	8.29E-05	8.28E-05	1.12E-04	7.49E-05	8.71E-05	7.30E-05	8.34E-05	1.11E-04	4.98E-05
16.00	7.77E-05	7.59E-05	1.11E-04	6.90E-05	7.95E-05	7.25E-05	7.55E-05	1.01E-04	4.93E-05
17.00	7.32E-05	6.96E-05	1.10E-04	6.39E-05	7.27E-05	7.21E-05	6.86E-05	9.19E-05	4.89E-05
18.00	6.91E-05	6.39E-05	1.10E-04	5.93E-05	6.65E-05	7.17E-05	6.25E-05	8.37E-05	4.86E-05
19.00	6.56E-05	5.88E-05	1.09E-04	5.53E-05	6.08E-05	7.14E-05	5.71E-05	7.64E-05	4.83E-05
20.00	6.24E-05	5.41E-05	1.09E-04	5.18E-05	5.57E-05	7.10E-05	5.24E-05	6.97E-05	4.80E-05
21.00	5.96E-05	4.98E-05	1.09E-04	4.86E-05	5.11E-05	7.07E-05	4.82E-05	6.36E-05	4.78E-05
22.00	5.71E-05	4.60E-05	1.08E-04	4.59E-05	4.69E-05	7.04E-05	4.45E-05	5.81E-05	4.76E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
23.00	5.49E-05	4.25E-05	1.08E-04	4.34E-05	4.30E-05	7.01E-05	4.13E-05	5.31E-05	4.74E-05
24.00	5.30E-05	3.93E-05	1.07E-04	4.13E-05	3.96E-05	6.98E-05	3.84E-05	4.86E-05	4.72E-05
25.00	5.12E-05	3.64E-05	1.07E-04	3.94E-05	3.64E-05	6.95E-05	3.59E-05	4.44E-05	4.70E-05
26.00	4.97E-05	3.38E-05	1.06E-04	3.77E-05	3.36E-05	6.92E-05	3.37E-05	4.07E-05	4.68E-05
27.00	4.83E-05	3.14E-05	1.06E-04	3.62E-05	3.10E-05	6.90E-05	3.17E-05	3.73E-05	4.66E-05
28.00	4.71E-05	2.93E-05	1.05E-04	3.48E-05	2.86E-05	6.87E-05	3.00E-05	3.43E-05	4.64E-05
29.00	4.60E-05	2.73E-05	1.05E-04	3.36E-05	2.65E-05	6.84E-05	2.84E-05	3.15E-05	4.62E-05
30.00	4.50E-05	2.55E-05	1.05E-04	3.26E-05	2.45E-05	6.81E-05	2.71E-05	2.89E-05	4.60E-05
31.00	4.41E-05	2.39E-05	1.04E-04	3.16E-05	2.28E-05	6.78E-05	2.59E-05	2.66E-05	4.58E-05
32.00	4.33E-05	2.24E-05	1.04E-04	3.08E-05	2.12E-05	6.76E-05	2.48E-05	2.45E-05	4.56E-05
33.00	4.25E-05	2.10E-05	1.03E-04	3.00E-05	1.97E-05	6.73E-05	2.38E-05	2.26E-05	4.54E-05
34.00	4.19E-05	1.98E-05	1.03E-04	2.93E-05	1.84E-05	6.70E-05	2.30E-05	2.09E-05	4.52E-05
35.00	4.13E-05	1.87E-05	1.02E-04	2.87E-05	1.72E-05	6.67E-05	2.22E-05	1.93E-05	4.50E-05
36.00	4.07E-05	1.77E-05	1.02E-04	2.82E-05	1.60E-05	6.65E-05	2.15E-05	1.79E-05	4.48E-05

APPENDIX K

EFFECTIVE DOSE RATE 10 CM FOR 10YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.85E-04	1.85E-04	1.85E-04	2.24E-04	2.24E-04	2.24E-04	2.68E-04	2.68E-04	2.68E-04
0.25	1.85E-04	1.85E-04	1.85E-04	2.28E-04	2.26E-04	2.49E-04	2.73E-04	2.72E-04	2.82E-04
0.50	1.85E-04	1.85E-04	1.84E-04	2.30E-04	2.27E-04	2.58E-04	2.75E-04	2.74E-04	2.87E-04
1.00	1.82E-04	1.82E-04	1.81E-04	2.29E-04	2.25E-04	2.68E-04	2.74E-04	2.72E-04	2.90E-04
2.00	1.73E-04	1.73E-04	1.74E-04	2.22E-04	2.15E-04	2.76E-04	2.65E-04	2.61E-04	2.88E-04
3.00	1.62E-04	1.61E-04	1.68E-04	2.12E-04	2.02E-04	2.77E-04	2.51E-04	2.46E-04	2.83E-04
4.00	1.51E-04	1.50E-04	1.63E-04	2.01E-04	1.88E-04	2.76E-04	2.36E-04	2.29E-04	2.77E-04
5.00	1.40E-04	1.38E-04	1.59E-04	1.91E-04	1.74E-04	2.74E-04	2.21E-04	2.12E-04	2.72E-04
6.00	1.31E-04	1.27E-04	1.56E-04	1.80E-04	1.61E-04	2.72E-04	2.07E-04	1.95E-04	2.68E-04
7.00	1.22E-04	1.16E-04	1.53E-04	1.70E-04	1.48E-04	2.70E-04	1.94E-04	1.80E-04	2.64E-04
8.00	1.14E-04	1.07E-04	1.51E-04	1.62E-04	1.37E-04	2.68E-04	1.82E-04	1.65E-04	2.61E-04
9.00	1.06E-04	9.81E-05	1.50E-04	1.54E-04	1.26E-04	2.66E-04	1.71E-04	1.52E-04	2.59E-04
10.00	1.00E-04	9.00E-05	1.49E-04	1.47E-04	1.16E-04	2.65E-04	1.62E-04	1.40E-04	2.57E-04
11.00	9.44E-05	8.27E-05	1.47E-04	1.40E-04	1.07E-04	2.63E-04	1.53E-04	1.28E-04	2.55E-04
12.00	8.93E-05	7.60E-05	1.47E-04	1.35E-04	9.90E-05	2.62E-04	1.46E-04	1.18E-04	2.54E-04
13.00	8.48E-05	7.00E-05	1.46E-04	1.30E-04	9.16E-05	2.61E-04	1.39E-04	1.09E-04	2.52E-04
14.00	8.08E-05	6.45E-05	1.45E-04	1.25E-04	8.48E-05	2.59E-04	1.33E-04	1.01E-04	2.51E-04
15.00	7.73E-05	5.95E-05	1.44E-04	1.21E-04	7.86E-05	2.58E-04	1.28E-04	9.29E-05	2.50E-04
16.00	7.42E-05	5.49E-05	1.44E-04	1.18E-04	7.30E-05	2.57E-04	1.23E-04	8.60E-05	2.49E-04
17.00	7.14E-05	5.08E-05	1.43E-04	1.14E-04	6.80E-05	2.56E-04	1.19E-04	7.97E-05	2.48E-04
18.00	6.90E-05	4.71E-05	1.42E-04	1.12E-04	6.34E-05	2.55E-04	1.15E-04	7.39E-05	2.47E-04
19.00	6.68E-05	4.37E-05	1.42E-04	1.09E-04	5.92E-05	2.54E-04	1.12E-04	6.87E-05	2.46E-04
20.00	6.48E-05	4.06E-05	1.41E-04	1.07E-04	5.54E-05	2.53E-04	1.09E-04	6.40E-05	2.45E-04
21.00	6.31E-05	3.78E-05	1.41E-04	1.05E-04	5.19E-05	2.52E-04	1.06E-04	5.97E-05	2.44E-04
22.00	6.15E-05	3.52E-05	1.40E-04	1.03E-04	4.88E-05	2.51E-04	1.04E-04	5.58E-05	2.43E-04
23.00	6.01E-05	3.29E-05	1.39E-04	1.01E-04	4.59E-05	2.50E-04	1.02E-04	5.23E-05	2.42E-04
24.00	5.89E-05	3.08E-05	1.39E-04	9.97E-05	4.33E-05	2.49E-04	9.99E-05	4.90E-05	2.41E-04
25.00	5.78E-05	2.89E-05	1.38E-04	9.84E-05	4.10E-05	2.48E-04	9.82E-05	4.61E-05	2.40E-04
26.00	5.67E-05	2.72E-05	1.38E-04	9.71E-05	3.88E-05	2.47E-04	9.66E-05	4.34E-05	2.39E-04
27.00	5.58E-05	2.56E-05	1.37E-04	9.59E-05	3.68E-05	2.46E-04	9.52E-05	4.10E-05	2.38E-04
28.00	5.50E-05	2.41E-05	1.37E-04	9.49E-05	3.51E-05	2.45E-04	9.39E-05	3.88E-05	2.37E-04
29.00	5.42E-05	2.28E-05	1.36E-04	9.39E-05	3.34E-05	2.43E-04	9.27E-05	3.68E-05	2.36E-04
30.00	5.35E-05	2.16E-05	1.35E-04	9.30E-05	3.19E-05	2.42E-04	9.17E-05	3.50E-05	2.35E-04

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	5.29E-05	2.05E-05	1.35E-04	9.22E-05	3.06E-05	2.41E-04	9.07E-05	3.33E-05	2.34E-04
32.00	5.23E-05	1.96E-05	1.34E-04	9.14E-05	2.93E-05	2.40E-04	8.97E-05	3.18E-05	2.33E-04
33.00	5.17E-05	1.86E-05	1.34E-04	9.06E-05	2.82E-05	2.39E-04	8.89E-05	3.04E-05	2.32E-04
34.00	5.12E-05	1.78E-05	1.33E-04	8.99E-05	2.72E-05	2.38E-04	8.81E-05	2.91E-05	2.31E-04
35.00	5.08E-05	1.71E-05	1.33E-04	8.93E-05	2.62E-05	2.38E-04	8.73E-05	2.79E-05	2.30E-04
36.00	5.03E-05	1.64E-05	1.32E-04	8.86E-05	2.53E-05	2.37E-04	8.66E-05	2.69E-05	2.29E-04

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	3.36E-05	3.36E-05	3.36E-05	3.49E-05	3.49E-05	3.49E-05	3.72E-05	3.72E-05	3.72E-05
0.25	3.41E-05	3.39E-05	3.54E-05	3.53E-05	3.53E-05	3.61E-05	3.77E-05	3.77E-05	3.79E-05
0.50	3.41E-05	3.40E-05	3.59E-05	3.54E-05	3.53E-05	3.64E-05	3.78E-05	3.78E-05	3.81E-05
1.00	3.39E-05	3.36E-05	3.64E-05	3.51E-05	3.49E-05	3.65E-05	3.75E-05	3.74E-05	3.79E-05
2.00	3.26E-05	3.21E-05	3.62E-05	3.37E-05	3.34E-05	3.59E-05	3.59E-05	3.58E-05	3.69E-05
3.00	3.09E-05	3.02E-05	3.57E-05	3.18E-05	3.14E-05	3.51E-05	3.38E-05	3.36E-05	3.57E-05
4.00	2.91E-05	2.81E-05	3.51E-05	2.98E-05	2.91E-05	3.43E-05	3.17E-05	3.12E-05	3.47E-05
5.00	2.72E-05	2.59E-05	3.45E-05	2.79E-05	2.69E-05	3.36E-05	2.95E-05	2.89E-05	3.38E-05
6.00	2.55E-05	2.39E-05	3.40E-05	2.61E-05	2.48E-05	3.30E-05	2.75E-05	2.66E-05	3.32E-05
7.00	2.40E-05	2.20E-05	3.36E-05	2.44E-05	2.28E-05	3.26E-05	2.57E-05	2.44E-05	3.26E-05
8.00	2.25E-05	2.02E-05	3.33E-05	2.29E-05	2.10E-05	3.22E-05	2.40E-05	2.24E-05	3.22E-05
9.00	2.12E-05	1.86E-05	3.30E-05	2.15E-05	1.93E-05	3.19E-05	2.25E-05	2.06E-05	3.19E-05
10.00	2.01E-05	1.71E-05	3.28E-05	2.03E-05	1.77E-05	3.17E-05	2.11E-05	1.89E-05	3.16E-05
11.00	1.91E-05	1.57E-05	3.26E-05	1.92E-05	1.63E-05	3.14E-05	1.99E-05	1.74E-05	3.14E-05
12.00	1.82E-05	1.45E-05	3.24E-05	1.82E-05	1.50E-05	3.13E-05	1.89E-05	1.60E-05	3.12E-05
13.00	1.74E-05	1.34E-05	3.22E-05	1.74E-05	1.38E-05	3.11E-05	1.79E-05	1.47E-05	3.10E-05
14.00	1.67E-05	1.23E-05	3.20E-05	1.66E-05	1.27E-05	3.09E-05	1.71E-05	1.35E-05	3.09E-05
15.00	1.60E-05	1.14E-05	3.19E-05	1.59E-05	1.17E-05	3.08E-05	1.64E-05	1.25E-05	3.07E-05
16.00	1.55E-05	1.06E-05	3.18E-05	1.53E-05	1.09E-05	3.06E-05	1.57E-05	1.15E-05	3.06E-05
17.00	1.50E-05	9.79E-06	3.16E-05	1.48E-05	1.01E-05	3.05E-05	1.51E-05	1.07E-05	3.04E-05
18.00	1.45E-05	9.10E-06	3.15E-05	1.43E-05	9.33E-06	3.04E-05	1.46E-05	9.89E-06	3.03E-05
19.00	1.41E-05	8.47E-06	3.13E-05	1.39E-05	8.67E-06	3.02E-05	1.42E-05	9.18E-06	3.02E-05
20.00	1.38E-05	7.89E-06	3.12E-05	1.35E-05	8.07E-06	3.01E-05	1.37E-05	8.53E-06	3.01E-05
21.00	1.34E-05	7.37E-06	3.11E-05	1.32E-05	7.53E-06	3.00E-05	1.34E-05	7.94E-06	2.99E-05
22.00	1.31E-05	6.89E-06	3.09E-05	1.29E-05	7.03E-06	2.99E-05	1.31E-05	7.41E-06	2.98E-05
23.00	1.29E-05	6.46E-06	3.08E-05	1.26E-05	6.58E-06	2.97E-05	1.28E-05	6.92E-06	2.97E-05
24.00	1.27E-05	6.07E-06	3.07E-05	1.24E-05	6.17E-06	2.96E-05	1.25E-05	6.48E-06	2.95E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	1.25E-05	5.71E-06	3.06E-05	1.21E-05	5.80E-06	2.95E-05	1.23E-05	6.08E-06	2.94E-05
26.00	1.23E-05	5.39E-06	3.04E-05	1.20E-05	5.46E-06	2.94E-05	1.20E-05	5.72E-06	2.93E-05
27.00	1.21E-05	5.09E-06	3.03E-05	1.18E-05	5.15E-06	2.92E-05	1.19E-05	5.39E-06	2.92E-05
28.00	1.19E-05	4.82E-06	3.02E-05	1.16E-05	4.87E-06	2.91E-05	1.17E-05	5.08E-06	2.91E-05
29.00	1.18E-05	4.58E-06	3.01E-05	1.15E-05	4.62E-06	2.90E-05	1.15E-05	4.81E-06	2.89E-05
30.00	1.17E-05	4.36E-06	2.99E-05	1.13E-05	4.38E-06	2.89E-05	1.14E-05	4.56E-06	2.88E-05
31.00	1.15E-05	4.15E-06	2.98E-05	1.12E-05	4.17E-06	2.88E-05	1.12E-05	4.33E-06	2.87E-05
32.00	1.14E-05	3.97E-06	2.97E-05	1.11E-05	3.98E-06	2.86E-05	1.11E-05	4.12E-06	2.86E-05
33.00	1.13E-05	3.80E-06	2.96E-05	1.10E-05	3.80E-06	2.85E-05	1.10E-05	3.93E-06	2.85E-05
34.00	1.12E-05	3.64E-06	2.94E-05	1.09E-05	3.64E-06	2.84E-05	1.09E-05	3.76E-06	2.83E-05
35.00	1.11E-05	3.50E-06	2.93E-05	1.08E-05	3.49E-06	2.83E-05	1.08E-05	3.60E-06	2.82E-05
36.00	1.10E-05	3.37E-06	2.92E-05	1.07E-05	3.35E-06	2.82E-05	1.07E-05	3.45E-06	2.81E-05

APPENDIX L

EFFECTIVE DOSE RATE 30 CM FOR ADULT PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.02E-04	1.02E-04	1.02E-04	1.03E-04	1.03E-04	1.03E-04	1.18E-04	1.18E-04	1.18E-04
0.25	1.04E-04	1.04E-04	1.12E-04	1.05E-04	1.05E-04	1.10E-04	1.21E-04	1.21E-04	1.19E-04
0.50	1.05E-04	1.04E-04	1.15E-04	1.06E-04	1.05E-04	1.12E-04	1.21E-04	1.22E-04	1.18E-04
1.00	1.05E-04	1.03E-04	1.19E-04	1.06E-04	1.05E-04	1.14E-04	1.21E-04	1.21E-04	1.16E-04
2.00	1.02E-04	9.90E-05	1.22E-04	1.02E-04	1.01E-04	1.14E-04	1.16E-04	1.17E-04	1.11E-04
3.00	9.71E-05	9.32E-05	1.21E-04	9.72E-05	9.48E-05	1.13E-04	1.10E-04	1.10E-04	1.06E-04
4.00	9.19E-05	8.68E-05	1.20E-04	9.15E-05	8.83E-05	1.11E-04	1.02E-04	1.03E-04	1.02E-04
5.00	8.66E-05	8.04E-05	1.19E-04	8.59E-05	8.17E-05	1.09E-04	9.50E-05	9.50E-05	9.85E-05
6.00	8.17E-05	7.42E-05	1.18E-04	8.06E-05	7.54E-05	1.07E-04	8.81E-05	8.74E-05	9.58E-05
7.00	7.71E-05	6.84E-05	1.17E-04	7.56E-05	6.94E-05	1.06E-04	8.17E-05	8.03E-05	9.38E-05
8.00	7.29E-05	6.30E-05	1.16E-04	7.12E-05	6.38E-05	1.05E-04	7.60E-05	7.37E-05	9.23E-05
9.00	6.91E-05	5.80E-05	1.15E-04	6.71E-05	5.87E-05	1.04E-04	7.08E-05	6.76E-05	9.11E-05
10.00	6.58E-05	5.34E-05	1.15E-04	6.35E-05	5.39E-05	1.03E-04	6.62E-05	6.20E-05	9.02E-05
11.00	6.28E-05	4.92E-05	1.14E-04	6.03E-05	4.96E-05	1.03E-04	6.21E-05	5.69E-05	8.95E-05
12.00	6.01E-05	4.54E-05	1.13E-04	5.74E-05	4.57E-05	1.02E-04	5.84E-05	5.22E-05	8.88E-05
13.00	5.77E-05	4.20E-05	1.13E-04	5.49E-05	4.22E-05	1.02E-04	5.52E-05	4.80E-05	8.83E-05
14.00	5.56E-05	3.88E-05	1.12E-04	5.27E-05	3.89E-05	1.01E-04	5.23E-05	4.41E-05	8.79E-05
15.00	5.37E-05	3.60E-05	1.12E-04	5.07E-05	3.60E-05	1.01E-04	4.98E-05	4.06E-05	8.74E-05
16.00	5.20E-05	3.34E-05	1.11E-04	4.89E-05	3.33E-05	1.00E-04	4.76E-05	3.74E-05	8.70E-05
17.00	5.06E-05	3.10E-05	1.11E-04	4.73E-05	3.09E-05	9.99E-05	4.56E-05	3.45E-05	8.66E-05
18.00	4.92E-05	2.89E-05	1.10E-04	4.59E-05	2.87E-05	9.95E-05	4.38E-05	3.19E-05	8.63E-05
19.00	4.80E-05	2.69E-05	1.10E-04	4.46E-05	2.67E-05	9.91E-05	4.23E-05	2.96E-05	8.59E-05
20.00	4.70E-05	2.52E-05	1.10E-04	4.35E-05	2.49E-05	9.87E-05	4.09E-05	2.74E-05	8.56E-05
21.00	4.60E-05	2.36E-05	1.09E-04	4.25E-05	2.33E-05	9.83E-05	3.96E-05	2.54E-05	8.52E-05
22.00	4.52E-05	2.21E-05	1.09E-04	4.16E-05	2.18E-05	9.80E-05	3.85E-05	2.37E-05	8.49E-05
23.00	4.44E-05	2.08E-05	1.08E-04	4.08E-05	2.04E-05	9.76E-05	3.76E-05	2.21E-05	8.46E-05
24.00	4.37E-05	1.96E-05	1.08E-04	4.01E-05	1.92E-05	9.72E-05	3.67E-05	2.06E-05	8.42E-05
25.00	4.31E-05	1.85E-05	1.07E-04	3.95E-05	1.80E-05	9.68E-05	3.59E-05	1.93E-05	8.39E-05
26.00	4.25E-05	1.75E-05	1.07E-04	3.89E-05	1.70E-05	9.64E-05	3.52E-05	1.80E-05	8.36E-05
27.00	4.20E-05	1.66E-05	1.07E-04	3.83E-05	1.61E-05	9.60E-05	3.45E-05	1.69E-05	8.32E-05
28.00	4.15E-05	1.58E-05	1.06E-04	3.78E-05	1.52E-05	9.57E-05	3.40E-05	1.59E-05	8.29E-05
29.00	4.10E-05	1.50E-05	1.06E-04	3.74E-05	1.45E-05	9.53E-05	3.34E-05	1.50E-05	8.26E-05
30.00	4.06E-05	1.43E-05	1.05E-04	3.70E-05	1.38E-05	9.49E-05	3.30E-05	1.42E-05	8.22E-05

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	4.03E-05	1.37E-05	1.05E-04	3.66E-05	1.31E-05	9.45E-05	3.25E-05	1.34E-05	8.19E-05
32.00	3.99E-05	1.31E-05	1.05E-04	3.62E-05	1.25E-05	9.42E-05	3.21E-05	1.28E-05	8.16E-05
33.00	3.96E-05	1.26E-05	1.04E-04	3.59E-05	1.20E-05	9.38E-05	3.18E-05	1.21E-05	8.13E-05
34.00	3.93E-05	1.21E-05	1.04E-04	3.56E-05	1.15E-05	9.34E-05	3.14E-05	1.15E-05	8.10E-05
35.00	3.90E-05	1.17E-05	1.03E-04	3.53E-05	1.11E-05	9.31E-05	3.11E-05	1.10E-05	8.06E-05
36.00	3.87E-05	1.13E-05	1.03E-04	3.51E-05	1.07E-05	9.27E-05	3.09E-05	1.05E-05	8.03E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.21E-04	1.21E-04	1.21E-04	1.27E-04	1.27E-04	1.27E-04	1.41E-04	1.41E-04	1.41E-04
0.25	1.24E-04	1.24E-04	1.16E-04	1.30E-04	1.31E-04	1.18E-04	1.45E-04	1.47E-04	1.27E-04
0.50	1.24E-04	1.26E-04	1.14E-04	1.31E-04	1.33E-04	1.13E-04	1.47E-04	1.49E-04	1.21E-04
1.00	1.24E-04	1.26E-04	1.09E-04	1.31E-04	1.34E-04	1.06E-04	1.47E-04	1.51E-04	1.11E-04
2.00	1.19E-04	1.21E-04	9.94E-05	1.25E-04	1.30E-04	9.29E-05	1.40E-04	1.47E-04	9.38E-05
3.00	1.11E-04	1.15E-04	9.17E-05	1.17E-04	1.23E-04	8.27E-05	1.31E-04	1.39E-04	8.05E-05
4.00	1.03E-04	1.07E-04	8.57E-05	1.08E-04	1.14E-04	7.49E-05	1.20E-04	1.30E-04	7.05E-05
5.00	9.49E-05	9.86E-05	8.12E-05	9.87E-05	1.06E-04	6.92E-05	1.10E-04	1.20E-04	6.33E-05
6.00	8.73E-05	9.07E-05	7.78E-05	9.01E-05	9.72E-05	6.51E-05	9.94E-05	1.10E-04	5.81E-05
7.00	8.02E-05	8.32E-05	7.54E-05	8.22E-05	8.91E-05	6.21E-05	9.01E-05	1.01E-04	5.44E-05
8.00	7.38E-05	7.62E-05	7.36E-05	7.50E-05	8.15E-05	6.00E-05	8.16E-05	9.24E-05	5.18E-05
9.00	6.81E-05	6.97E-05	7.22E-05	6.85E-05	7.45E-05	5.84E-05	7.40E-05	8.44E-05	4.99E-05
10.00	6.30E-05	6.38E-05	7.12E-05	6.27E-05	6.80E-05	5.73E-05	6.72E-05	7.70E-05	4.86E-05
11.00	5.84E-05	5.84E-05	7.05E-05	5.76E-05	6.22E-05	5.65E-05	6.11E-05	7.02E-05	4.76E-05
12.00	5.44E-05	5.35E-05	6.98E-05	5.31E-05	5.68E-05	5.58E-05	5.58E-05	6.41E-05	4.69E-05
13.00	5.08E-05	4.90E-05	6.93E-05	4.91E-05	5.19E-05	5.53E-05	5.11E-05	5.85E-05	4.64E-05
14.00	4.77E-05	4.49E-05	6.89E-05	4.55E-05	4.75E-05	5.49E-05	4.69E-05	5.34E-05	4.60E-05
15.00	4.49E-05	4.12E-05	6.85E-05	4.24E-05	4.35E-05	5.46E-05	4.33E-05	4.88E-05	4.57E-05
16.00	4.25E-05	3.79E-05	6.82E-05	3.97E-05	3.98E-05	5.43E-05	4.00E-05	4.46E-05	4.54E-05
17.00	4.03E-05	3.48E-05	6.79E-05	3.72E-05	3.65E-05	5.40E-05	3.72E-05	4.08E-05	4.51E-05
18.00	3.84E-05	3.21E-05	6.76E-05	3.51E-05	3.35E-05	5.38E-05	3.47E-05	3.73E-05	4.49E-05
19.00	3.67E-05	2.96E-05	6.73E-05	3.32E-05	3.08E-05	5.35E-05	3.24E-05	3.42E-05	4.47E-05
20.00	3.52E-05	2.73E-05	6.70E-05	3.15E-05	2.83E-05	5.33E-05	3.05E-05	3.13E-05	4.45E-05
21.00	3.38E-05	2.52E-05	6.68E-05	3.01E-05	2.61E-05	5.31E-05	2.88E-05	2.88E-05	4.43E-05
22.00	3.26E-05	2.34E-05	6.65E-05	2.87E-05	2.40E-05	5.29E-05	2.72E-05	2.64E-05	4.41E-05
23.00	3.16E-05	2.17E-05	6.62E-05	2.76E-05	2.22E-05	5.27E-05	2.59E-05	2.43E-05	4.39E-05
24.00	3.07E-05	2.01E-05	6.60E-05	2.66E-05	2.05E-05	5.24E-05	2.47E-05	2.24E-05	4.38E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	2.98E-05	1.87E-05	6.57E-05	2.56E-05	1.90E-05	5.22E-05	2.36E-05	2.06E-05	4.36E-05
26.00	2.91E-05	1.74E-05	6.54E-05	2.48E-05	1.76E-05	5.20E-05	2.27E-05	1.90E-05	4.34E-05
27.00	2.84E-05	1.63E-05	6.52E-05	2.41E-05	1.63E-05	5.18E-05	2.19E-05	1.76E-05	4.32E-05
28.00	2.78E-05	1.52E-05	6.49E-05	2.34E-05	1.52E-05	5.16E-05	2.11E-05	1.63E-05	4.31E-05
29.00	2.73E-05	1.43E-05	6.47E-05	2.29E-05	1.42E-05	5.14E-05	2.05E-05	1.51E-05	4.29E-05
30.00	2.68E-05	1.34E-05	6.44E-05	2.23E-05	1.32E-05	5.12E-05	1.99E-05	1.40E-05	4.27E-05
31.00	2.63E-05	1.26E-05	6.42E-05	2.19E-05	1.24E-05	5.10E-05	1.94E-05	1.30E-05	4.25E-05
32.00	2.59E-05	1.19E-05	6.39E-05	2.15E-05	1.16E-05	5.08E-05	1.89E-05	1.22E-05	4.24E-05
33.00	2.56E-05	1.12E-05	6.36E-05	2.11E-05	1.09E-05	5.06E-05	1.85E-05	1.13E-05	4.22E-05
34.00	2.52E-05	1.06E-05	6.34E-05	2.07E-05	1.02E-05	5.04E-05	1.81E-05	1.06E-05	4.20E-05
35.00	2.49E-05	1.01E-05	6.31E-05	2.04E-05	9.63E-06	5.02E-05	1.77E-05	9.93E-06	4.19E-05
36.00	2.46E-05	9.57E-06	6.29E-05	2.01E-05	9.09E-06	5.00E-05	1.74E-05	9.31E-06	4.17E-05

APPENDIX M

EFFECTIVE DOSE RATE 30 CM FOR 15YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	9.96E-05	9.96E-05	9.96E-05	1.09E-04	1.09E-04	1.09E-04	1.23E-04	1.23E-04	1.23E-04
0.25	1.02E-04	1.01E-04	1.10E-04	1.11E-04	1.11E-04	1.17E-04	1.26E-04	1.26E-04	1.25E-04
0.50	1.03E-04	1.02E-04	1.14E-04	1.12E-04	1.11E-04	1.20E-04	1.26E-04	1.26E-04	1.26E-04
1.00	1.03E-04	1.01E-04	1.18E-04	1.12E-04	1.10E-04	1.22E-04	1.26E-04	1.26E-04	1.25E-04
2.00	9.97E-05	9.68E-05	1.21E-04	1.08E-04	1.06E-04	1.23E-04	1.21E-04	1.21E-04	1.21E-04
3.00	9.52E-05	9.11E-05	1.21E-04	1.03E-04	9.99E-05	1.22E-04	1.14E-04	1.14E-04	1.17E-04
4.00	9.02E-05	8.49E-05	1.20E-04	9.70E-05	9.30E-05	1.20E-04	1.07E-04	1.06E-04	1.13E-04
5.00	8.51E-05	7.87E-05	1.19E-04	9.12E-05	8.61E-05	1.19E-04	9.95E-05	9.82E-05	1.09E-04
6.00	8.04E-05	7.26E-05	1.18E-04	8.56E-05	7.94E-05	1.17E-04	9.26E-05	9.05E-05	1.07E-04
7.00	7.59E-05	6.69E-05	1.17E-04	8.05E-05	7.31E-05	1.16E-04	8.62E-05	8.32E-05	1.05E-04
8.00	7.19E-05	6.16E-05	1.16E-04	7.59E-05	6.73E-05	1.15E-04	8.04E-05	7.63E-05	1.04E-04
9.00	6.82E-05	5.68E-05	1.15E-04	7.17E-05	6.19E-05	1.14E-04	7.51E-05	7.00E-05	1.02E-04
10.00	6.49E-05	5.23E-05	1.15E-04	6.79E-05	5.69E-05	1.13E-04	7.05E-05	6.43E-05	1.01E-04
11.00	6.20E-05	4.82E-05	1.14E-04	6.46E-05	5.24E-05	1.12E-04	6.63E-05	5.90E-05	1.01E-04
12.00	5.94E-05	4.45E-05	1.13E-04	6.16E-05	4.83E-05	1.12E-04	6.26E-05	5.42E-05	1.00E-04
13.00	5.71E-05	4.11E-05	1.13E-04	5.90E-05	4.46E-05	1.11E-04	5.94E-05	4.99E-05	9.94E-05
14.00	5.51E-05	3.81E-05	1.12E-04	5.67E-05	4.12E-05	1.11E-04	5.65E-05	4.59E-05	9.89E-05
15.00	5.32E-05	3.53E-05	1.12E-04	5.46E-05	3.81E-05	1.10E-04	5.39E-05	4.23E-05	9.84E-05
16.00	5.16E-05	3.27E-05	1.11E-04	5.27E-05	3.53E-05	1.10E-04	5.16E-05	3.91E-05	9.80E-05
17.00	5.02E-05	3.04E-05	1.11E-04	5.11E-05	3.27E-05	1.09E-04	4.96E-05	3.61E-05	9.76E-05
18.00	4.89E-05	2.83E-05	1.10E-04	4.96E-05	3.04E-05	1.09E-04	4.78E-05	3.34E-05	9.71E-05
19.00	4.77E-05	2.65E-05	1.10E-04	4.83E-05	2.83E-05	1.08E-04	4.63E-05	3.10E-05	9.67E-05
20.00	4.67E-05	2.47E-05	1.09E-04	4.71E-05	2.64E-05	1.08E-04	4.48E-05	2.87E-05	9.63E-05
21.00	4.57E-05	2.32E-05	1.09E-04	4.61E-05	2.47E-05	1.07E-04	4.36E-05	2.67E-05	9.59E-05
22.00	4.49E-05	2.17E-05	1.09E-04	4.51E-05	2.31E-05	1.07E-04	4.25E-05	2.49E-05	9.55E-05
23.00	4.42E-05	2.04E-05	1.08E-04	4.43E-05	2.17E-05	1.07E-04	4.15E-05	2.32E-05	9.51E-05
24.00	4.35E-05	1.93E-05	1.08E-04	4.35E-05	2.04E-05	1.06E-04	4.05E-05	2.17E-05	9.48E-05
25.00	4.28E-05	1.82E-05	1.07E-04	4.28E-05	1.92E-05	1.06E-04	3.97E-05	2.04E-05	9.44E-05
26.00	4.23E-05	1.72E-05	1.07E-04	4.22E-05	1.81E-05	1.05E-04	3.90E-05	1.91E-05	9.40E-05
27.00	4.18E-05	1.63E-05	1.06E-04	4.16E-05	1.72E-05	1.05E-04	3.83E-05	1.80E-05	9.36E-05
28.00	4.13E-05	1.55E-05	1.06E-04	4.11E-05	1.63E-05	1.04E-04	3.77E-05	1.69E-05	9.32E-05
29.00	4.08E-05	1.48E-05	1.06E-04	4.06E-05	1.55E-05	1.04E-04	3.72E-05	1.60E-05	9.29E-05
30.00	4.04E-05	1.41E-05	1.05E-04	4.02E-05	1.47E-05	1.04E-04	3.67E-05	1.51E-05	9.25E-05

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	4.01E-05	1.35E-05	1.05E-04	3.98E-05	1.40E-05	1.03E-04	3.63E-05	1.44E-05	9.21E-05
32.00	3.97E-05	1.29E-05	1.04E-04	3.94E-05	1.34E-05	1.03E-04	3.58E-05	1.36E-05	9.17E-05
33.00	3.94E-05	1.24E-05	1.04E-04	3.91E-05	1.29E-05	1.02E-04	3.55E-05	1.30E-05	9.14E-05
34.00	3.91E-05	1.20E-05	1.03E-04	3.87E-05	1.23E-05	1.02E-04	3.51E-05	1.24E-05	9.10E-05
35.00	3.88E-05	1.15E-05	1.03E-04	3.84E-05	1.19E-05	1.02E-04	3.48E-05	1.19E-05	9.06E-05
36.00	3.85E-05	1.11E-05	1.03E-04	3.81E-05	1.14E-05	1.01E-04	3.45E-05	1.14E-05	9.03E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.26E-04	1.26E-04	1.26E-04	1.29E-04	1.29E-04	1.29E-04	1.48E-04	1.48E-04	1.48E-04
0.25	1.29E-04	1.29E-04	1.22E-04	1.32E-04	1.33E-04	1.21E-04	1.52E-04	1.54E-04	1.35E-04
0.50	1.29E-04	1.30E-04	1.20E-04	1.33E-04	1.34E-04	1.17E-04	1.53E-04	1.56E-04	1.29E-04
1.00	1.29E-04	1.30E-04	1.16E-04	1.32E-04	1.35E-04	1.11E-04	1.53E-04	1.57E-04	1.18E-04
2.00	1.23E-04	1.26E-04	1.08E-04	1.27E-04	1.31E-04	9.86E-05	1.46E-04	1.53E-04	1.01E-04
3.00	1.16E-04	1.18E-04	1.01E-04	1.18E-04	1.23E-04	8.91E-05	1.37E-04	1.45E-04	8.79E-05
4.00	1.07E-04	1.10E-04	9.51E-05	1.09E-04	1.15E-04	8.19E-05	1.26E-04	1.35E-04	7.80E-05
5.00	9.92E-05	1.02E-04	9.07E-05	1.00E-04	1.06E-04	7.65E-05	1.15E-04	1.25E-04	7.08E-05
6.00	9.15E-05	9.37E-05	8.75E-05	9.18E-05	9.75E-05	7.26E-05	1.04E-04	1.14E-04	6.56E-05
7.00	8.43E-05	8.59E-05	8.51E-05	8.40E-05	8.94E-05	6.97E-05	9.45E-05	1.05E-04	6.19E-05
8.00	7.79E-05	7.88E-05	8.33E-05	7.69E-05	8.18E-05	6.77E-05	8.58E-05	9.59E-05	5.93E-05
9.00	7.21E-05	7.21E-05	8.19E-05	7.05E-05	7.48E-05	6.62E-05	7.80E-05	8.76E-05	5.74E-05
10.00	6.69E-05	6.61E-05	8.09E-05	6.48E-05	6.84E-05	6.51E-05	7.10E-05	7.99E-05	5.61E-05
11.00	6.23E-05	6.05E-05	8.01E-05	5.98E-05	6.25E-05	6.43E-05	6.49E-05	7.29E-05	5.51E-05
12.00	5.82E-05	5.54E-05	7.95E-05	5.53E-05	5.72E-05	6.36E-05	5.94E-05	6.66E-05	5.44E-05
13.00	5.46E-05	5.08E-05	7.90E-05	5.14E-05	5.23E-05	6.31E-05	5.46E-05	6.08E-05	5.38E-05
14.00	5.14E-05	4.67E-05	7.85E-05	4.79E-05	4.79E-05	6.27E-05	5.03E-05	5.55E-05	5.34E-05
15.00	4.86E-05	4.29E-05	7.81E-05	4.48E-05	4.39E-05	6.23E-05	4.65E-05	5.08E-05	5.30E-05
16.00	4.61E-05	3.94E-05	7.77E-05	4.21E-05	4.03E-05	6.20E-05	4.32E-05	4.64E-05	5.27E-05
17.00	4.39E-05	3.63E-05	7.73E-05	3.97E-05	3.70E-05	6.17E-05	4.03E-05	4.25E-05	5.24E-05
18.00	4.19E-05	3.35E-05	7.70E-05	3.76E-05	3.40E-05	6.14E-05	3.77E-05	3.89E-05	5.21E-05
19.00	4.02E-05	3.09E-05	7.67E-05	3.57E-05	3.12E-05	6.11E-05	3.54E-05	3.57E-05	5.19E-05
20.00	3.87E-05	2.85E-05	7.63E-05	3.41E-05	2.88E-05	6.08E-05	3.34E-05	3.28E-05	5.17E-05
21.00	3.73E-05	2.64E-05	7.60E-05	3.26E-05	2.65E-05	6.06E-05	3.17E-05	3.01E-05	5.14E-05
22.00	3.61E-05	2.45E-05	7.57E-05	3.13E-05	2.45E-05	6.03E-05	3.01E-05	2.77E-05	5.12E-05
23.00	3.50E-05	2.28E-05	7.54E-05	3.01E-05	2.27E-05	6.01E-05	2.87E-05	2.55E-05	5.10E-05
24.00	3.40E-05	2.12E-05	7.51E-05	2.91E-05	2.10E-05	5.98E-05	2.75E-05	2.35E-05	5.08E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	3.32E-05	1.97E-05	7.48E-05	2.82E-05	1.95E-05	5.96E-05	2.64E-05	2.17E-05	5.06E-05
26.00	3.24E-05	1.84E-05	7.45E-05	2.74E-05	1.81E-05	5.93E-05	2.54E-05	2.01E-05	5.04E-05
27.00	3.17E-05	1.72E-05	7.42E-05	2.66E-05	1.68E-05	5.91E-05	2.45E-05	1.86E-05	5.02E-05
28.00	3.11E-05	1.61E-05	7.39E-05	2.60E-05	1.57E-05	5.89E-05	2.38E-05	1.72E-05	4.99E-05
29.00	3.05E-05	1.51E-05	7.36E-05	2.54E-05	1.46E-05	5.86E-05	2.31E-05	1.60E-05	4.97E-05
30.00	3.00E-05	1.42E-05	7.33E-05	2.49E-05	1.37E-05	5.84E-05	2.25E-05	1.49E-05	4.95E-05
31.00	2.96E-05	1.34E-05	7.30E-05	2.44E-05	1.28E-05	5.81E-05	2.19E-05	1.38E-05	4.93E-05
32.00	2.91E-05	1.27E-05	7.27E-05	2.40E-05	1.20E-05	5.79E-05	2.14E-05	1.29E-05	4.91E-05
33.00	2.87E-05	1.20E-05	7.24E-05	2.36E-05	1.13E-05	5.77E-05	2.10E-05	1.21E-05	4.89E-05
34.00	2.84E-05	1.14E-05	7.21E-05	2.32E-05	1.07E-05	5.74E-05	2.06E-05	1.13E-05	4.87E-05
35.00	2.81E-05	1.08E-05	7.18E-05	2.29E-05	1.01E-05	5.72E-05	2.02E-05	1.06E-05	4.85E-05
36.00	2.78E-05	1.03E-05	7.15E-05	2.26E-05	9.55E-06	5.70E-05	1.99E-05	9.96E-06	4.83E-05

APPENDIX N

EFFECTIVE DOSE RATE 30 CM FOR 10YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.13E-04	1.13E-04	1.13E-04	1.19E-04	1.19E-04	1.19E-04	1.36E-04	1.36E-04	1.36E-04
0.25	1.15E-04	1.14E-04	1.26E-04	1.21E-04	1.20E-04	1.31E-04	1.39E-04	1.38E-04	1.45E-04
0.50	1.16E-04	1.15E-04	1.31E-04	1.22E-04	1.21E-04	1.35E-04	1.39E-04	1.39E-04	1.48E-04
1.00	1.16E-04	1.13E-04	1.36E-04	1.22E-04	1.20E-04	1.39E-04	1.39E-04	1.38E-04	1.50E-04
2.00	1.12E-04	1.09E-04	1.40E-04	1.18E-04	1.14E-04	1.42E-04	1.34E-04	1.32E-04	1.51E-04
3.00	1.07E-04	1.02E-04	1.41E-04	1.12E-04	1.08E-04	1.42E-04	1.28E-04	1.24E-04	1.49E-04
4.00	1.02E-04	9.52E-05	1.40E-04	1.06E-04	1.00E-04	1.41E-04	1.20E-04	1.16E-04	1.46E-04
5.00	9.64E-05	8.82E-05	1.39E-04	1.00E-04	9.27E-05	1.40E-04	1.13E-04	1.07E-04	1.44E-04
6.00	9.12E-05	8.14E-05	1.38E-04	9.46E-05	8.56E-05	1.39E-04	1.06E-04	9.88E-05	1.42E-04
7.00	8.63E-05	7.51E-05	1.37E-04	8.94E-05	7.89E-05	1.38E-04	9.94E-05	9.09E-05	1.40E-04
8.00	8.19E-05	6.91E-05	1.36E-04	8.46E-05	7.26E-05	1.37E-04	9.35E-05	8.36E-05	1.39E-04
9.00	7.79E-05	6.37E-05	1.35E-04	8.03E-05	6.69E-05	1.36E-04	8.82E-05	7.69E-05	1.38E-04
10.00	7.43E-05	5.87E-05	1.35E-04	7.64E-05	6.16E-05	1.35E-04	8.35E-05	7.07E-05	1.37E-04
11.00	7.12E-05	5.42E-05	1.34E-04	7.30E-05	5.68E-05	1.34E-04	7.93E-05	6.51E-05	1.36E-04
12.00	6.83E-05	5.01E-05	1.33E-04	6.99E-05	5.24E-05	1.33E-04	7.55E-05	6.00E-05	1.35E-04
13.00	6.58E-05	4.63E-05	1.33E-04	6.72E-05	4.84E-05	1.33E-04	7.22E-05	5.53E-05	1.34E-04
14.00	6.35E-05	4.29E-05	1.32E-04	6.48E-05	4.48E-05	1.32E-04	6.93E-05	5.11E-05	1.34E-04
15.00	6.15E-05	3.98E-05	1.31E-04	6.26E-05	4.15E-05	1.31E-04	6.66E-05	4.72E-05	1.33E-04
16.00	5.97E-05	3.70E-05	1.31E-04	6.07E-05	3.86E-05	1.31E-04	6.43E-05	4.37E-05	1.33E-04
17.00	5.81E-05	3.44E-05	1.30E-04	5.90E-05	3.59E-05	1.30E-04	6.22E-05	4.06E-05	1.32E-04
18.00	5.67E-05	3.21E-05	1.30E-04	5.75E-05	3.34E-05	1.30E-04	6.04E-05	3.77E-05	1.31E-04
19.00	5.54E-05	3.00E-05	1.29E-04	5.61E-05	3.12E-05	1.29E-04	5.88E-05	3.51E-05	1.31E-04
20.00	5.43E-05	2.80E-05	1.29E-04	5.49E-05	2.91E-05	1.29E-04	5.73E-05	3.27E-05	1.30E-04
21.00	5.33E-05	2.63E-05	1.28E-04	5.38E-05	2.73E-05	1.28E-04	5.60E-05	3.05E-05	1.30E-04
22.00	5.23E-05	2.47E-05	1.28E-04	5.28E-05	2.56E-05	1.28E-04	5.48E-05	2.86E-05	1.29E-04
23.00	5.15E-05	2.33E-05	1.27E-04	5.19E-05	2.41E-05	1.27E-04	5.37E-05	2.68E-05	1.29E-04
24.00	5.07E-05	2.19E-05	1.27E-04	5.11E-05	2.27E-05	1.27E-04	5.28E-05	2.52E-05	1.28E-04
25.00	5.00E-05	2.08E-05	1.26E-04	5.03E-05	2.14E-05	1.26E-04	5.19E-05	2.37E-05	1.28E-04
26.00	4.94E-05	1.97E-05	1.25E-04	4.97E-05	2.03E-05	1.25E-04	5.11E-05	2.23E-05	1.27E-04
27.00	4.88E-05	1.87E-05	1.25E-04	4.91E-05	1.92E-05	1.25E-04	5.04E-05	2.11E-05	1.27E-04
28.00	4.83E-05	1.78E-05	1.24E-04	4.85E-05	1.83E-05	1.24E-04	4.97E-05	2.00E-05	1.26E-04
29.00	4.78E-05	1.69E-05	1.24E-04	4.80E-05	1.74E-05	1.24E-04	4.91E-05	1.90E-05	1.25E-04
30.00	4.73E-05	1.62E-05	1.23E-04	4.75E-05	1.66E-05	1.23E-04	4.86E-05	1.81E-05	1.25E-04

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	4.69E-05	1.55E-05	1.23E-04	4.70E-05	1.59E-05	1.23E-04	4.81E-05	1.72E-05	1.24E-04
32.00	4.65E-05	1.49E-05	1.22E-04	4.66E-05	1.52E-05	1.22E-04	4.76E-05	1.65E-05	1.24E-04
33.00	4.61E-05	1.43E-05	1.22E-04	4.62E-05	1.46E-05	1.22E-04	4.72E-05	1.58E-05	1.23E-04
34.00	4.58E-05	1.38E-05	1.21E-04	4.59E-05	1.41E-05	1.21E-04	4.68E-05	1.51E-05	1.23E-04
35.00	4.54E-05	1.33E-05	1.21E-04	4.55E-05	1.36E-05	1.21E-04	4.64E-05	1.45E-05	1.22E-04
36.00	4.51E-05	1.29E-05	1.20E-04	4.52E-05	1.31E-05	1.20E-04	4.60E-05	1.40E-05	1.22E-04

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	1.42E-04	1.42E-04	1.42E-04	1.52E-04	1.52E-04	1.52E-04	1.70E-04	1.70E-04	1.70E-04
0.25	1.45E-04	1.45E-04	1.45E-04	1.55E-04	1.56E-04	1.49E-04	1.74E-04	1.75E-04	1.60E-04
0.50	1.45E-04	1.45E-04	1.46E-04	1.56E-04	1.57E-04	1.47E-04	1.75E-04	1.77E-04	1.55E-04
1.00	1.45E-04	1.45E-04	1.45E-04	1.55E-04	1.56E-04	1.43E-04	1.74E-04	1.77E-04	1.47E-04
2.00	1.39E-04	1.39E-04	1.41E-04	1.48E-04	1.51E-04	1.33E-04	1.67E-04	1.71E-04	1.32E-04
3.00	1.31E-04	1.31E-04	1.37E-04	1.39E-04	1.42E-04	1.25E-04	1.56E-04	1.62E-04	1.20E-04
4.00	1.23E-04	1.22E-04	1.33E-04	1.30E-04	1.32E-04	1.19E-04	1.44E-04	1.51E-04	1.10E-04
5.00	1.15E-04	1.13E-04	1.29E-04	1.20E-04	1.22E-04	1.14E-04	1.32E-04	1.39E-04	1.04E-04
6.00	1.07E-04	1.04E-04	1.26E-04	1.11E-04	1.12E-04	1.10E-04	1.21E-04	1.28E-04	9.86E-05
7.00	9.95E-05	9.53E-05	1.24E-04	1.02E-04	1.03E-04	1.08E-04	1.11E-04	1.17E-04	9.49E-05
8.00	9.29E-05	8.75E-05	1.23E-04	9.46E-05	9.44E-05	1.06E-04	1.02E-04	1.07E-04	9.22E-05
9.00	8.70E-05	8.03E-05	1.21E-04	8.77E-05	8.65E-05	1.04E-04	9.34E-05	9.83E-05	9.03E-05
10.00	8.17E-05	7.37E-05	1.20E-04	8.16E-05	7.93E-05	1.03E-04	8.60E-05	8.99E-05	8.89E-05
11.00	7.70E-05	6.77E-05	1.19E-04	7.61E-05	7.26E-05	1.02E-04	7.94E-05	8.22E-05	8.78E-05
12.00	7.28E-05	6.23E-05	1.18E-04	7.13E-05	6.66E-05	1.01E-04	7.36E-05	7.52E-05	8.69E-05
13.00	6.91E-05	5.73E-05	1.18E-04	6.70E-05	6.11E-05	1.00E-04	6.84E-05	6.88E-05	8.62E-05
14.00	6.58E-05	5.28E-05	1.17E-04	6.33E-05	5.61E-05	9.98E-05	6.39E-05	6.30E-05	8.56E-05
15.00	6.29E-05	4.86E-05	1.17E-04	5.99E-05	5.16E-05	9.93E-05	5.99E-05	5.78E-05	8.51E-05
16.00	6.03E-05	4.49E-05	1.16E-04	5.70E-05	4.75E-05	9.88E-05	5.63E-05	5.30E-05	8.47E-05
17.00	5.80E-05	4.15E-05	1.16E-04	5.43E-05	4.37E-05	9.83E-05	5.32E-05	4.87E-05	8.43E-05
18.00	5.60E-05	3.85E-05	1.15E-04	5.20E-05	4.04E-05	9.79E-05	5.04E-05	4.47E-05	8.39E-05
19.00	5.42E-05	3.57E-05	1.15E-04	5.00E-05	3.73E-05	9.74E-05	4.80E-05	4.12E-05	8.35E-05
20.00	5.26E-05	3.31E-05	1.14E-04	4.81E-05	3.45E-05	9.70E-05	4.58E-05	3.79E-05	8.31E-05
21.00	5.11E-05	3.08E-05	1.14E-04	4.65E-05	3.20E-05	9.66E-05	4.39E-05	3.50E-05	8.28E-05
22.00	4.99E-05	2.87E-05	1.13E-04	4.51E-05	2.97E-05	9.62E-05	4.22E-05	3.23E-05	8.24E-05
23.00	4.87E-05	2.68E-05	1.13E-04	4.38E-05	2.76E-05	9.58E-05	4.06E-05	2.99E-05	8.21E-05
24.00	4.77E-05	2.51E-05	1.12E-04	4.26E-05	2.57E-05	9.54E-05	3.93E-05	2.77E-05	8.17E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	4.67E-05	2.35E-05	1.12E-04	4.16E-05	2.40E-05	9.50E-05	3.81E-05	2.57E-05	8.14E-05
26.00	4.59E-05	2.21E-05	1.11E-04	4.07E-05	2.24E-05	9.46E-05	3.70E-05	2.39E-05	8.10E-05
27.00	4.51E-05	2.08E-05	1.11E-04	3.99E-05	2.10E-05	9.42E-05	3.61E-05	2.23E-05	8.07E-05
28.00	4.45E-05	1.96E-05	1.10E-04	3.91E-05	1.97E-05	9.38E-05	3.52E-05	2.08E-05	8.03E-05
29.00	4.38E-05	1.86E-05	1.10E-04	3.84E-05	1.85E-05	9.34E-05	3.44E-05	1.94E-05	8.00E-05
30.00	4.33E-05	1.76E-05	1.09E-04	3.78E-05	1.74E-05	9.30E-05	3.37E-05	1.82E-05	7.97E-05
31.00	4.27E-05	1.67E-05	1.09E-04	3.73E-05	1.64E-05	9.26E-05	3.31E-05	1.70E-05	7.93E-05
32.00	4.22E-05	1.59E-05	1.08E-04	3.67E-05	1.55E-05	9.22E-05	3.25E-05	1.60E-05	7.90E-05
33.00	4.18E-05	1.51E-05	1.08E-04	3.63E-05	1.47E-05	9.19E-05	3.20E-05	1.51E-05	7.87E-05
34.00	4.14E-05	1.44E-05	1.08E-04	3.58E-05	1.40E-05	9.15E-05	3.16E-05	1.42E-05	7.84E-05
35.00	4.10E-05	1.38E-05	1.07E-04	3.55E-05	1.33E-05	9.11E-05	3.11E-05	1.35E-05	7.80E-05
36.00	4.06E-05	1.33E-05	1.07E-04	3.51E-05	1.27E-05	9.07E-05	3.07E-05	1.27E-05	7.77E-05

APPENDIX O

EFFECTIVE DOSE RATE 100 CM FOR ADULT PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	2.85E-05	2.85E-05	2.85E-05	2.85E-05	2.85E-05	2.85E-05	3.09E-05	3.09E-05	3.09E-05
0.25	2.91E-05	2.89E-05	3.08E-05	2.91E-05	2.89E-05	3.07E-05	3.14E-05	3.13E-05	3.26E-05
0.50	2.92E-05	2.89E-05	3.15E-05	2.92E-05	2.90E-05	3.15E-05	3.16E-05	3.14E-05	3.31E-05
1.00	2.90E-05	2.87E-05	3.23E-05	2.91E-05	2.87E-05	3.22E-05	3.14E-05	3.12E-05	3.35E-05
2.00	2.81E-05	2.74E-05	3.26E-05	2.81E-05	2.75E-05	3.25E-05	3.03E-05	2.98E-05	3.33E-05
3.00	2.67E-05	2.58E-05	3.24E-05	2.67E-05	2.58E-05	3.23E-05	2.87E-05	2.81E-05	3.28E-05
4.00	2.52E-05	2.40E-05	3.21E-05	2.52E-05	2.41E-05	3.19E-05	2.70E-05	2.61E-05	3.21E-05
5.00	2.37E-05	2.22E-05	3.17E-05	2.37E-05	2.23E-05	3.15E-05	2.53E-05	2.41E-05	3.16E-05
6.00	2.23E-05	2.05E-05	3.13E-05	2.23E-05	2.05E-05	3.11E-05	2.37E-05	2.23E-05	3.11E-05
7.00	2.10E-05	1.89E-05	3.10E-05	2.10E-05	1.89E-05	3.08E-05	2.22E-05	2.05E-05	3.07E-05
8.00	1.98E-05	1.74E-05	3.07E-05	1.98E-05	1.74E-05	3.05E-05	2.09E-05	1.88E-05	3.04E-05
9.00	1.88E-05	1.60E-05	3.05E-05	1.87E-05	1.60E-05	3.03E-05	1.97E-05	1.73E-05	3.02E-05
10.00	1.78E-05	1.47E-05	3.03E-05	1.78E-05	1.47E-05	3.01E-05	1.86E-05	1.59E-05	2.99E-05
11.00	1.70E-05	1.35E-05	3.01E-05	1.69E-05	1.36E-05	2.99E-05	1.76E-05	1.46E-05	2.97E-05
12.00	1.62E-05	1.25E-05	3.00E-05	1.62E-05	1.25E-05	2.98E-05	1.68E-05	1.35E-05	2.96E-05
13.00	1.55E-05	1.15E-05	2.98E-05	1.55E-05	1.15E-05	2.96E-05	1.60E-05	1.24E-05	2.94E-05
14.00	1.50E-05	1.07E-05	2.97E-05	1.49E-05	1.07E-05	2.95E-05	1.54E-05	1.15E-05	2.93E-05
15.00	1.44E-05	9.87E-06	2.96E-05	1.44E-05	9.88E-06	2.94E-05	1.48E-05	1.06E-05	2.92E-05
16.00	1.40E-05	9.15E-06	2.95E-05	1.39E-05	9.16E-06	2.93E-05	1.42E-05	9.81E-06	2.90E-05
17.00	1.35E-05	8.50E-06	2.93E-05	1.35E-05	8.50E-06	2.91E-05	1.38E-05	9.10E-06	2.89E-05
18.00	1.32E-05	7.91E-06	2.92E-05	1.31E-05	7.91E-06	2.90E-05	1.34E-05	8.45E-06	2.88E-05
19.00	1.28E-05	7.37E-06	2.91E-05	1.28E-05	7.37E-06	2.89E-05	1.30E-05	7.86E-06	2.87E-05
20.00	1.25E-05	6.88E-06	2.90E-05	1.25E-05	6.88E-06	2.88E-05	1.27E-05	7.32E-06	2.86E-05
21.00	1.23E-05	6.43E-06	2.89E-05	1.22E-05	6.44E-06	2.87E-05	1.24E-05	6.83E-06	2.85E-05
22.00	1.20E-05	6.03E-06	2.88E-05	1.20E-05	6.03E-06	2.86E-05	1.21E-05	6.39E-06	2.83E-05
23.00	1.18E-05	5.66E-06	2.86E-05	1.18E-05	5.66E-06	2.85E-05	1.19E-05	5.99E-06	2.82E-05
24.00	1.16E-05	5.33E-06	2.85E-05	1.16E-05	5.33E-06	2.83E-05	1.16E-05	5.63E-06	2.81E-05
25.00	1.15E-05	5.03E-06	2.84E-05	1.14E-05	5.02E-06	2.82E-05	1.14E-05	5.29E-06	2.80E-05
26.00	1.13E-05	4.75E-06	2.83E-05	1.12E-05	4.75E-06	2.81E-05	1.13E-05	4.99E-06	2.79E-05
27.00	1.11E-05	4.50E-06	2.82E-05	1.11E-05	4.50E-06	2.80E-05	1.11E-05	4.72E-06	2.78E-05
28.00	1.10E-05	4.27E-06	2.81E-05	1.10E-05	4.27E-06	2.79E-05	1.10E-05	4.47E-06	2.77E-05
29.00	1.09E-05	4.06E-06	2.80E-05	1.08E-05	4.06E-06	2.78E-05	1.08E-05	4.24E-06	2.76E-05
30.00	1.08E-05	3.87E-06	2.79E-05	1.07E-05	3.87E-06	2.77E-05	1.07E-05	4.03E-06	2.75E-05

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	1.07E-05	3.70E-06	2.77E-05	1.06E-05	3.69E-06	2.76E-05	1.06E-05	3.84E-06	2.74E-05
32.00	1.06E-05	3.54E-06	2.76E-05	1.05E-05	3.53E-06	2.75E-05	1.05E-05	3.67E-06	2.72E-05
33.00	1.05E-05	3.40E-06	2.75E-05	1.04E-05	3.39E-06	2.74E-05	1.04E-05	3.51E-06	2.71E-05
34.00	1.04E-05	3.27E-06	2.74E-05	1.03E-05	3.26E-06	2.72E-05	1.03E-05	3.37E-06	2.70E-05
35.00	1.03E-05	3.14E-06	2.73E-05	1.03E-05	3.13E-06	2.71E-05	1.02E-05	3.23E-06	2.69E-05
36.00	1.03E-05	3.03E-06	2.72E-05	1.02E-05	3.02E-06	2.70E-05	1.02E-05	3.11E-06	2.68E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	3.11E-05	3.11E-05	3.11E-05	3.19E-05	3.19E-05	3.19E-05	3.35E-05	3.35E-05	3.35E-05
0.25	3.16E-05	3.15E-05	3.20E-05	3.24E-05	3.24E-05	3.24E-05	3.40E-05	3.41E-05	3.35E-05
0.50	3.17E-05	3.16E-05	3.23E-05	3.25E-05	3.25E-05	3.25E-05	3.41E-05	3.42E-05	3.33E-05
1.00	3.14E-05	3.13E-05	3.23E-05	3.22E-05	3.22E-05	3.22E-05	3.39E-05	3.40E-05	3.27E-05
2.00	3.02E-05	3.00E-05	3.17E-05	3.09E-05	3.09E-05	3.12E-05	3.25E-05	3.26E-05	3.12E-05
3.00	2.86E-05	2.82E-05	3.09E-05	2.92E-05	2.91E-05	3.01E-05	3.05E-05	3.07E-05	2.98E-05
4.00	2.68E-05	2.62E-05	3.01E-05	2.73E-05	2.70E-05	2.92E-05	2.85E-05	2.86E-05	2.87E-05
5.00	2.50E-05	2.43E-05	2.94E-05	2.54E-05	2.50E-05	2.84E-05	2.64E-05	2.64E-05	2.77E-05
6.00	2.33E-05	2.23E-05	2.89E-05	2.36E-05	2.30E-05	2.78E-05	2.45E-05	2.43E-05	2.70E-05
7.00	2.18E-05	2.05E-05	2.85E-05	2.20E-05	2.11E-05	2.73E-05	2.28E-05	2.23E-05	2.65E-05
8.00	2.04E-05	1.89E-05	2.81E-05	2.06E-05	1.94E-05	2.70E-05	2.12E-05	2.05E-05	2.61E-05
9.00	1.92E-05	1.73E-05	2.79E-05	1.92E-05	1.78E-05	2.67E-05	1.97E-05	1.88E-05	2.58E-05
10.00	1.81E-05	1.59E-05	2.76E-05	1.81E-05	1.63E-05	2.65E-05	1.85E-05	1.72E-05	2.55E-05
11.00	1.71E-05	1.46E-05	2.74E-05	1.70E-05	1.50E-05	2.63E-05	1.73E-05	1.58E-05	2.53E-05
12.00	1.62E-05	1.35E-05	2.73E-05	1.61E-05	1.38E-05	2.61E-05	1.63E-05	1.45E-05	2.51E-05
13.00	1.54E-05	1.24E-05	2.71E-05	1.53E-05	1.27E-05	2.60E-05	1.54E-05	1.33E-05	2.50E-05
14.00	1.47E-05	1.14E-05	2.70E-05	1.46E-05	1.17E-05	2.58E-05	1.47E-05	1.23E-05	2.49E-05
15.00	1.41E-05	1.06E-05	2.69E-05	1.39E-05	1.08E-05	2.57E-05	1.40E-05	1.13E-05	2.47E-05
16.00	1.36E-05	9.75E-06	2.68E-05	1.33E-05	9.95E-06	2.56E-05	1.33E-05	1.04E-05	2.46E-05
17.00	1.31E-05	9.03E-06	2.67E-05	1.28E-05	9.20E-06	2.55E-05	1.28E-05	9.61E-06	2.45E-05
18.00	1.26E-05	8.37E-06	2.65E-05	1.24E-05	8.52E-06	2.54E-05	1.23E-05	8.88E-06	2.44E-05
19.00	1.23E-05	7.77E-06	2.64E-05	1.20E-05	7.90E-06	2.53E-05	1.19E-05	8.23E-06	2.43E-05
20.00	1.19E-05	7.23E-06	2.63E-05	1.16E-05	7.34E-06	2.52E-05	1.15E-05	7.63E-06	2.42E-05
21.00	1.16E-05	6.74E-06	2.62E-05	1.13E-05	6.83E-06	2.51E-05	1.12E-05	7.09E-06	2.41E-05
22.00	1.14E-05	6.29E-06	2.61E-05	1.10E-05	6.37E-06	2.50E-05	1.09E-05	6.60E-06	2.40E-05
23.00	1.11E-05	5.88E-06	2.60E-05	1.08E-05	5.95E-06	2.49E-05	1.06E-05	6.15E-06	2.39E-05
24.00	1.09E-05	5.52E-06	2.59E-05	1.06E-05	5.57E-06	2.48E-05	1.03E-05	5.74E-06	2.38E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	1.07E-05	5.18E-06	2.58E-05	1.03E-05	5.22E-06	2.47E-05	1.01E-05	5.37E-06	2.37E-05
26.00	1.05E-05	4.87E-06	2.57E-05	1.02E-05	4.90E-06	2.46E-05	9.93E-06	5.04E-06	2.36E-05
27.00	1.04E-05	4.60E-06	2.56E-05	1.00E-05	4.62E-06	2.45E-05	9.75E-06	4.73E-06	2.36E-05
28.00	1.02E-05	4.34E-06	2.55E-05	9.85E-06	4.35E-06	2.44E-05	9.59E-06	4.46E-06	2.35E-05
29.00	1.01E-05	4.11E-06	2.54E-05	9.71E-06	4.12E-06	2.43E-05	9.45E-06	4.20E-06	2.34E-05
30.00	9.96E-06	3.90E-06	2.53E-05	9.58E-06	3.90E-06	2.42E-05	9.31E-06	3.97E-06	2.33E-05
31.00	9.84E-06	3.71E-06	2.52E-05	9.47E-06	3.70E-06	2.41E-05	9.19E-06	3.76E-06	2.32E-05
32.00	9.74E-06	3.54E-06	2.51E-05	9.36E-06	3.52E-06	2.40E-05	9.08E-06	3.57E-06	2.31E-05
33.00	9.65E-06	3.38E-06	2.50E-05	9.27E-06	3.36E-06	2.39E-05	8.98E-06	3.40E-06	2.30E-05
34.00	9.56E-06	3.23E-06	2.49E-05	9.18E-06	3.21E-06	2.38E-05	8.89E-06	3.24E-06	2.29E-05
35.00	9.48E-06	3.10E-06	2.48E-05	9.10E-06	3.07E-06	2.37E-05	8.80E-06	3.09E-06	2.28E-05
36.00	9.40E-06	2.98E-06	2.47E-05	9.02E-06	2.94E-06	2.36E-05	8.72E-06	2.96E-06	2.27E-05

APPENDIX P

EFFECTIVE DOSE RATE 100 CM FOR 15YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	2.80E-05	2.80E-05	2.80E-05	2.91E-05	2.91E-05	2.91E-05	3.13E-05	3.13E-05	3.13E-05
0.25	2.85E-05	2.83E-05	3.05E-05	2.97E-05	2.95E-05	3.14E-05	3.19E-05	3.17E-05	3.30E-05
0.50	2.87E-05	2.84E-05	3.14E-05	2.98E-05	2.96E-05	3.22E-05	3.20E-05	3.18E-05	3.36E-05
1.00	2.86E-05	2.81E-05	3.24E-05	2.97E-05	2.93E-05	3.29E-05	3.18E-05	3.15E-05	3.40E-05
2.00	2.77E-05	2.70E-05	3.30E-05	2.87E-05	2.80E-05	3.33E-05	3.06E-05	3.02E-05	3.39E-05
3.00	2.64E-05	2.53E-05	3.29E-05	2.73E-05	2.64E-05	3.31E-05	2.90E-05	2.84E-05	3.33E-05
4.00	2.49E-05	2.36E-05	3.26E-05	2.57E-05	2.45E-05	3.27E-05	2.73E-05	2.64E-05	3.27E-05
5.00	2.35E-05	2.18E-05	3.23E-05	2.42E-05	2.27E-05	3.23E-05	2.56E-05	2.44E-05	3.22E-05
6.00	2.22E-05	2.02E-05	3.20E-05	2.28E-05	2.09E-05	3.19E-05	2.40E-05	2.25E-05	3.17E-05
7.00	2.09E-05	1.86E-05	3.17E-05	2.14E-05	1.93E-05	3.16E-05	2.25E-05	2.07E-05	3.13E-05
8.00	1.98E-05	1.71E-05	3.15E-05	2.02E-05	1.77E-05	3.13E-05	2.11E-05	1.90E-05	3.10E-05
9.00	1.87E-05	1.57E-05	3.12E-05	1.91E-05	1.63E-05	3.11E-05	1.99E-05	1.75E-05	3.07E-05
10.00	1.78E-05	1.45E-05	3.10E-05	1.82E-05	1.50E-05	3.09E-05	1.89E-05	1.61E-05	3.05E-05
11.00	1.70E-05	1.34E-05	3.09E-05	1.73E-05	1.38E-05	3.07E-05	1.79E-05	1.48E-05	3.03E-05
12.00	1.63E-05	1.23E-05	3.07E-05	1.65E-05	1.28E-05	3.05E-05	1.70E-05	1.36E-05	3.02E-05
13.00	1.56E-05	1.14E-05	3.06E-05	1.59E-05	1.18E-05	3.04E-05	1.63E-05	1.26E-05	3.00E-05
14.00	1.51E-05	1.05E-05	3.04E-05	1.52E-05	1.09E-05	3.03E-05	1.56E-05	1.16E-05	2.99E-05
15.00	1.45E-05	9.76E-06	3.03E-05	1.47E-05	1.01E-05	3.01E-05	1.50E-05	1.07E-05	2.97E-05
16.00	1.41E-05	9.05E-06	3.02E-05	1.42E-05	9.35E-06	3.00E-05	1.45E-05	9.93E-06	2.96E-05
17.00	1.37E-05	8.41E-06	3.00E-05	1.38E-05	8.68E-06	2.99E-05	1.40E-05	9.21E-06	2.95E-05
18.00	1.33E-05	7.83E-06	2.99E-05	1.34E-05	8.07E-06	2.97E-05	1.36E-05	8.55E-06	2.93E-05
19.00	1.30E-05	7.30E-06	2.98E-05	1.31E-05	7.52E-06	2.96E-05	1.32E-05	7.95E-06	2.92E-05
20.00	1.27E-05	6.83E-06	2.97E-05	1.28E-05	7.02E-06	2.95E-05	1.29E-05	7.41E-06	2.91E-05
21.00	1.25E-05	6.39E-06	2.95E-05	1.25E-05	6.57E-06	2.94E-05	1.26E-05	6.92E-06	2.90E-05
22.00	1.22E-05	5.99E-06	2.94E-05	1.23E-05	6.16E-06	2.93E-05	1.23E-05	6.47E-06	2.89E-05
23.00	1.20E-05	5.63E-06	2.93E-05	1.20E-05	5.78E-06	2.91E-05	1.20E-05	6.07E-06	2.87E-05
24.00	1.18E-05	5.31E-06	2.92E-05	1.18E-05	5.44E-06	2.90E-05	1.18E-05	5.70E-06	2.86E-05
25.00	1.16E-05	5.01E-06	2.91E-05	1.16E-05	5.13E-06	2.89E-05	1.16E-05	5.36E-06	2.85E-05
26.00	1.15E-05	4.74E-06	2.89E-05	1.15E-05	4.85E-06	2.88E-05	1.15E-05	5.05E-06	2.84E-05
27.00	1.13E-05	4.49E-06	2.88E-05	1.13E-05	4.59E-06	2.87E-05	1.13E-05	4.78E-06	2.83E-05
28.00	1.12E-05	4.27E-06	2.87E-05	1.12E-05	4.35E-06	2.85E-05	1.11E-05	4.52E-06	2.82E-05
29.00	1.11E-05	4.06E-06	2.86E-05	1.11E-05	4.14E-06	2.84E-05	1.10E-05	4.29E-06	2.81E-05
30.00	1.10E-05	3.87E-06	2.85E-05	1.10E-05	3.94E-06	2.83E-05	1.09E-05	4.08E-06	2.79E-05

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	1.09E-05	3.70E-06	2.84E-05	1.08E-05	3.77E-06	2.82E-05	1.08E-05	3.89E-06	2.78E-05
32.00	1.08E-05	3.55E-06	2.82E-05	1.07E-05	3.60E-06	2.81E-05	1.07E-05	3.71E-06	2.77E-05
33.00	1.07E-05	3.41E-06	2.81E-05	1.07E-05	3.46E-06	2.80E-05	1.06E-05	3.55E-06	2.76E-05
34.00	1.06E-05	3.28E-06	2.80E-05	1.06E-05	3.32E-06	2.79E-05	1.05E-05	3.41E-06	2.75E-05
35.00	1.05E-05	3.16E-06	2.79E-05	1.05E-05	3.20E-06	2.78E-05	1.04E-05	3.27E-06	2.74E-05
36.00	1.04E-05	3.05E-06	2.78E-05	1.04E-05	3.08E-06	2.76E-05	1.03E-05	3.15E-06	2.73E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	3.16E-05	3.16E-05	3.16E-05	3.18E-05	3.18E-05	3.18E-05	3.41E-05	3.41E-05	3.41E-05
0.25	3.20E-05	3.20E-05	3.25E-05	3.22E-05	3.22E-05	3.22E-05	3.46E-05	3.47E-05	3.40E-05
0.50	3.21E-05	3.20E-05	3.28E-05	3.23E-05	3.23E-05	3.22E-05	3.47E-05	3.48E-05	3.38E-05
1.00	3.19E-05	3.18E-05	3.28E-05	3.21E-05	3.21E-05	3.19E-05	3.44E-05	3.45E-05	3.32E-05
2.00	3.06E-05	3.04E-05	3.22E-05	3.07E-05	3.07E-05	3.09E-05	3.29E-05	3.31E-05	3.17E-05
3.00	2.89E-05	2.86E-05	3.13E-05	2.90E-05	2.89E-05	2.98E-05	3.10E-05	3.11E-05	3.02E-05
4.00	2.71E-05	2.66E-05	3.05E-05	2.71E-05	2.68E-05	2.89E-05	2.89E-05	2.90E-05	2.91E-05
5.00	2.53E-05	2.46E-05	2.99E-05	2.52E-05	2.48E-05	2.81E-05	2.68E-05	2.67E-05	2.81E-05
6.00	2.36E-05	2.26E-05	2.93E-05	2.35E-05	2.28E-05	2.75E-05	2.49E-05	2.46E-05	2.74E-05
7.00	2.21E-05	2.08E-05	2.89E-05	2.18E-05	2.10E-05	2.70E-05	2.31E-05	2.26E-05	2.69E-05
8.00	2.07E-05	1.91E-05	2.85E-05	2.04E-05	1.93E-05	2.67E-05	2.15E-05	2.07E-05	2.64E-05
9.00	1.94E-05	1.75E-05	2.83E-05	1.91E-05	1.77E-05	2.64E-05	2.00E-05	1.90E-05	2.61E-05
10.00	1.83E-05	1.61E-05	2.80E-05	1.79E-05	1.62E-05	2.61E-05	1.87E-05	1.74E-05	2.59E-05
11.00	1.73E-05	1.48E-05	2.79E-05	1.69E-05	1.49E-05	2.60E-05	1.76E-05	1.60E-05	2.57E-05
12.00	1.64E-05	1.36E-05	2.77E-05	1.60E-05	1.37E-05	2.58E-05	1.66E-05	1.47E-05	2.55E-05
13.00	1.56E-05	1.25E-05	2.75E-05	1.51E-05	1.26E-05	2.56E-05	1.56E-05	1.35E-05	2.53E-05
14.00	1.49E-05	1.16E-05	2.74E-05	1.44E-05	1.16E-05	2.55E-05	1.48E-05	1.24E-05	2.52E-05
15.00	1.43E-05	1.07E-05	2.73E-05	1.38E-05	1.07E-05	2.54E-05	1.41E-05	1.14E-05	2.51E-05
16.00	1.37E-05	9.87E-06	2.72E-05	1.32E-05	9.88E-06	2.53E-05	1.35E-05	1.05E-05	2.50E-05
17.00	1.32E-05	9.14E-06	2.70E-05	1.27E-05	9.13E-06	2.52E-05	1.30E-05	9.74E-06	2.48E-05
18.00	1.28E-05	8.47E-06	2.69E-05	1.22E-05	8.45E-06	2.51E-05	1.25E-05	9.00E-06	2.47E-05
19.00	1.24E-05	7.87E-06	2.68E-05	1.18E-05	7.84E-06	2.50E-05	1.20E-05	8.34E-06	2.46E-05
20.00	1.21E-05	7.32E-06	2.67E-05	1.15E-05	7.28E-06	2.49E-05	1.16E-05	7.73E-06	2.45E-05
21.00	1.18E-05	6.82E-06	2.66E-05	1.12E-05	6.77E-06	2.47E-05	1.13E-05	7.18E-06	2.44E-05
22.00	1.15E-05	6.37E-06	2.65E-05	1.09E-05	6.31E-06	2.46E-05	1.10E-05	6.68E-06	2.43E-05
23.00	1.12E-05	5.95E-06	2.64E-05	1.06E-05	5.90E-06	2.45E-05	1.07E-05	6.23E-06	2.42E-05
24.00	1.10E-05	5.58E-06	2.63E-05	1.04E-05	5.52E-06	2.44E-05	1.05E-05	5.82E-06	2.41E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	1.08E-05	5.24E-06	2.62E-05	1.02E-05	5.17E-06	2.43E-05	1.02E-05	5.44E-06	2.40E-05
26.00	1.06E-05	4.93E-06	2.61E-05	1.00E-05	4.86E-06	2.42E-05	1.00E-05	5.10E-06	2.39E-05
27.00	1.05E-05	4.65E-06	2.60E-05	9.86E-06	4.57E-06	2.42E-05	9.86E-06	4.79E-06	2.38E-05
28.00	1.03E-05	4.39E-06	2.58E-05	9.71E-06	4.31E-06	2.41E-05	9.70E-06	4.51E-06	2.37E-05
29.00	1.02E-05	4.16E-06	2.57E-05	9.58E-06	4.07E-06	2.40E-05	9.55E-06	4.25E-06	2.36E-05
30.00	1.01E-05	3.95E-06	2.56E-05	9.45E-06	3.86E-06	2.39E-05	9.42E-06	4.02E-06	2.35E-05
31.00	9.96E-06	3.75E-06	2.55E-05	9.34E-06	3.66E-06	2.38E-05	9.29E-06	3.81E-06	2.35E-05
32.00	9.85E-06	3.58E-06	2.54E-05	9.23E-06	3.48E-06	2.37E-05	9.18E-06	3.61E-06	2.34E-05
33.00	9.76E-06	3.41E-06	2.53E-05	9.13E-06	3.32E-06	2.36E-05	9.08E-06	3.43E-06	2.33E-05
34.00	9.67E-06	3.27E-06	2.52E-05	9.04E-06	3.17E-06	2.35E-05	8.98E-06	3.27E-06	2.32E-05
35.00	9.58E-06	3.13E-06	2.51E-05	8.96E-06	3.03E-06	2.34E-05	8.89E-06	3.12E-06	2.31E-05
36.00	9.50E-06	3.01E-06	2.50E-05	8.88E-06	2.91E-06	2.33E-05	8.81E-06	2.99E-06	2.30E-05

APPENDIX Q

EFFECTIVE DOSE RATE 100 CM FOR 10YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	3.03E-05	3.03E-05	3.03E-05	3.09E-05	3.09E-05	3.09E-05	3.31E-05	3.31E-05	3.31E-05
0.25	3.08E-05	3.06E-05	3.30E-05	3.14E-05	3.12E-05	3.34E-05	3.37E-05	3.35E-05	3.55E-05
0.50	3.10E-05	3.07E-05	3.39E-05	3.15E-05	3.12E-05	3.43E-05	3.38E-05	3.35E-05	3.63E-05
1.00	3.08E-05	3.03E-05	3.48E-05	3.13E-05	3.09E-05	3.51E-05	3.36E-05	3.32E-05	3.70E-05
2.00	2.98E-05	2.90E-05	3.54E-05	3.02E-05	2.95E-05	3.56E-05	3.24E-05	3.17E-05	3.73E-05
3.00	2.83E-05	2.72E-05	3.53E-05	2.87E-05	2.77E-05	3.55E-05	3.07E-05	2.98E-05	3.70E-05
4.00	2.68E-05	2.53E-05	3.50E-05	2.71E-05	2.58E-05	3.51E-05	2.90E-05	2.77E-05	3.65E-05
5.00	2.52E-05	2.35E-05	3.47E-05	2.56E-05	2.38E-05	3.47E-05	2.72E-05	2.56E-05	3.60E-05
6.00	2.38E-05	2.16E-05	3.43E-05	2.41E-05	2.20E-05	3.44E-05	2.56E-05	2.36E-05	3.56E-05
7.00	2.24E-05	1.99E-05	3.40E-05	2.27E-05	2.02E-05	3.41E-05	2.41E-05	2.17E-05	3.52E-05
8.00	2.12E-05	1.83E-05	3.37E-05	2.14E-05	1.86E-05	3.38E-05	2.27E-05	2.00E-05	3.49E-05
9.00	2.01E-05	1.69E-05	3.35E-05	2.03E-05	1.71E-05	3.35E-05	2.15E-05	1.84E-05	3.46E-05
10.00	1.91E-05	1.56E-05	3.33E-05	1.93E-05	1.58E-05	3.33E-05	2.04E-05	1.69E-05	3.44E-05
11.00	1.82E-05	1.43E-05	3.31E-05	1.84E-05	1.45E-05	3.31E-05	1.94E-05	1.56E-05	3.42E-05
12.00	1.75E-05	1.32E-05	3.29E-05	1.76E-05	1.34E-05	3.30E-05	1.85E-05	1.44E-05	3.40E-05
13.00	1.68E-05	1.22E-05	3.28E-05	1.69E-05	1.24E-05	3.28E-05	1.77E-05	1.33E-05	3.38E-05
14.00	1.61E-05	1.13E-05	3.26E-05	1.63E-05	1.15E-05	3.26E-05	1.71E-05	1.23E-05	3.37E-05
15.00	1.56E-05	1.05E-05	3.25E-05	1.57E-05	1.06E-05	3.25E-05	1.64E-05	1.14E-05	3.35E-05
16.00	1.51E-05	9.72E-06	3.23E-05	1.52E-05	9.85E-06	3.24E-05	1.59E-05	1.05E-05	3.34E-05
17.00	1.47E-05	9.03E-06	3.22E-05	1.48E-05	9.15E-06	3.22E-05	1.54E-05	9.77E-06	3.32E-05
18.00	1.43E-05	8.41E-06	3.20E-05	1.44E-05	8.51E-06	3.21E-05	1.50E-05	9.08E-06	3.31E-05
19.00	1.39E-05	7.84E-06	3.19E-05	1.40E-05	7.94E-06	3.19E-05	1.46E-05	8.46E-06	3.29E-05
20.00	1.36E-05	7.33E-06	3.18E-05	1.37E-05	7.42E-06	3.18E-05	1.42E-05	7.90E-06	3.28E-05
21.00	1.33E-05	6.86E-06	3.16E-05	1.34E-05	6.94E-06	3.17E-05	1.39E-05	7.39E-06	3.27E-05
22.00	1.31E-05	6.43E-06	3.15E-05	1.31E-05	6.51E-06	3.15E-05	1.37E-05	6.92E-06	3.25E-05
23.00	1.29E-05	6.05E-06	3.14E-05	1.29E-05	6.12E-06	3.14E-05	1.34E-05	6.50E-06	3.24E-05
24.00	1.27E-05	5.70E-06	3.12E-05	1.27E-05	5.76E-06	3.13E-05	1.32E-05	6.11E-06	3.23E-05
25.00	1.25E-05	5.38E-06	3.11E-05	1.25E-05	5.43E-06	3.11E-05	1.30E-05	5.76E-06	3.21E-05
26.00	1.23E-05	5.09E-06	3.10E-05	1.23E-05	5.14E-06	3.10E-05	1.28E-05	5.44E-06	3.20E-05
27.00	1.21E-05	4.82E-06	3.09E-05	1.22E-05	4.87E-06	3.09E-05	1.26E-05	5.15E-06	3.19E-05
28.00	1.20E-05	4.58E-06	3.07E-05	1.20E-05	4.62E-06	3.08E-05	1.25E-05	4.89E-06	3.17E-05
29.00	1.19E-05	4.36E-06	3.06E-05	1.19E-05	4.40E-06	3.06E-05	1.23E-05	4.64E-06	3.16E-05
30.00	1.17E-05	4.16E-06	3.05E-05	1.18E-05	4.19E-06	3.05E-05	1.22E-05	4.42E-06	3.15E-05

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	1.16E-05	3.97E-06	3.03E-05	1.17E-05	4.01E-06	3.04E-05	1.21E-05	4.22E-06	3.13E-05
32.00	1.15E-05	3.81E-06	3.02E-05	1.16E-05	3.84E-06	3.03E-05	1.19E-05	4.04E-06	3.12E-05
33.00	1.14E-05	3.65E-06	3.01E-05	1.15E-05	3.68E-06	3.01E-05	1.18E-05	3.87E-06	3.11E-05
34.00	1.13E-05	3.51E-06	3.00E-05	1.14E-05	3.54E-06	3.00E-05	1.17E-05	3.72E-06	3.09E-05
35.00	1.13E-05	3.39E-06	2.98E-05	1.13E-05	3.41E-06	2.99E-05	1.16E-05	3.58E-06	3.08E-05
36.00	1.12E-05	3.27E-06	2.97E-05	1.12E-05	3.29E-06	2.98E-05	1.16E-05	3.45E-06	3.07E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	3.36E-05	3.36E-05	3.36E-05	3.49E-05	3.49E-05	3.49E-05	3.72E-05	3.72E-05	3.72E-05
0.25	3.41E-05	3.39E-05	3.54E-05	3.53E-05	3.53E-05	3.61E-05	3.77E-05	3.77E-05	3.79E-05
0.50	3.41E-05	3.40E-05	3.59E-05	3.54E-05	3.53E-05	3.64E-05	3.78E-05	3.78E-05	3.81E-05
1.00	3.39E-05	3.36E-05	3.64E-05	3.51E-05	3.49E-05	3.65E-05	3.75E-05	3.74E-05	3.79E-05
2.00	3.26E-05	3.21E-05	3.62E-05	3.37E-05	3.34E-05	3.59E-05	3.59E-05	3.58E-05	3.69E-05
3.00	3.09E-05	3.02E-05	3.57E-05	3.18E-05	3.14E-05	3.51E-05	3.38E-05	3.36E-05	3.57E-05
4.00	2.91E-05	2.81E-05	3.51E-05	2.98E-05	2.91E-05	3.43E-05	3.17E-05	3.12E-05	3.47E-05
5.00	2.72E-05	2.59E-05	3.45E-05	2.79E-05	2.69E-05	3.36E-05	2.95E-05	2.89E-05	3.38E-05
6.00	2.55E-05	2.39E-05	3.40E-05	2.61E-05	2.48E-05	3.30E-05	2.75E-05	2.66E-05	3.32E-05
7.00	2.40E-05	2.20E-05	3.36E-05	2.44E-05	2.28E-05	3.26E-05	2.57E-05	2.44E-05	3.26E-05
8.00	2.25E-05	2.02E-05	3.33E-05	2.29E-05	2.10E-05	3.22E-05	2.40E-05	2.24E-05	3.22E-05
9.00	2.12E-05	1.86E-05	3.30E-05	2.15E-05	1.93E-05	3.19E-05	2.25E-05	2.06E-05	3.19E-05
10.00	2.01E-05	1.71E-05	3.28E-05	2.03E-05	1.77E-05	3.17E-05	2.11E-05	1.89E-05	3.16E-05
11.00	1.91E-05	1.57E-05	3.26E-05	1.92E-05	1.63E-05	3.14E-05	1.99E-05	1.74E-05	3.14E-05
12.00	1.82E-05	1.45E-05	3.24E-05	1.82E-05	1.50E-05	3.13E-05	1.89E-05	1.60E-05	3.12E-05
13.00	1.74E-05	1.34E-05	3.22E-05	1.74E-05	1.38E-05	3.11E-05	1.79E-05	1.47E-05	3.10E-05
14.00	1.67E-05	1.23E-05	3.20E-05	1.66E-05	1.27E-05	3.09E-05	1.71E-05	1.35E-05	3.09E-05
15.00	1.60E-05	1.14E-05	3.19E-05	1.59E-05	1.17E-05	3.08E-05	1.64E-05	1.25E-05	3.07E-05
16.00	1.55E-05	1.06E-05	3.18E-05	1.53E-05	1.09E-05	3.06E-05	1.57E-05	1.15E-05	3.06E-05
17.00	1.50E-05	9.79E-06	3.16E-05	1.48E-05	1.01E-05	3.05E-05	1.51E-05	1.07E-05	3.04E-05
18.00	1.45E-05	9.10E-06	3.15E-05	1.43E-05	9.33E-06	3.04E-05	1.46E-05	9.89E-06	3.03E-05
19.00	1.41E-05	8.47E-06	3.13E-05	1.39E-05	8.67E-06	3.02E-05	1.42E-05	9.18E-06	3.02E-05
20.00	1.38E-05	7.89E-06	3.12E-05	1.35E-05	8.07E-06	3.01E-05	1.37E-05	8.53E-06	3.01E-05
21.00	1.34E-05	7.37E-06	3.11E-05	1.32E-05	7.53E-06	3.00E-05	1.34E-05	7.94E-06	2.99E-05
22.00	1.31E-05	6.89E-06	3.09E-05	1.29E-05	7.03E-06	2.99E-05	1.31E-05	7.41E-06	2.98E-05
23.00	1.29E-05	6.46E-06	3.08E-05	1.26E-05	6.58E-06	2.97E-05	1.28E-05	6.92E-06	2.97E-05
24.00	1.27E-05	6.07E-06	3.07E-05	1.24E-05	6.17E-06	2.96E-05	1.25E-05	6.48E-06	2.95E-05

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	1.25E-05	5.71E-06	3.06E-05	1.21E-05	5.80E-06	2.95E-05	1.23E-05	6.08E-06	2.94E-05
26.00	1.23E-05	5.39E-06	3.04E-05	1.20E-05	5.46E-06	2.94E-05	1.20E-05	5.72E-06	2.93E-05
27.00	1.21E-05	5.09E-06	3.03E-05	1.18E-05	5.15E-06	2.92E-05	1.19E-05	5.39E-06	2.92E-05
28.00	1.19E-05	4.82E-06	3.02E-05	1.16E-05	4.87E-06	2.91E-05	1.17E-05	5.08E-06	2.91E-05
29.00	1.18E-05	4.58E-06	3.01E-05	1.15E-05	4.62E-06	2.90E-05	1.15E-05	4.81E-06	2.89E-05
30.00	1.17E-05	4.36E-06	2.99E-05	1.13E-05	4.38E-06	2.89E-05	1.14E-05	4.56E-06	2.88E-05
31.00	1.15E-05	4.15E-06	2.98E-05	1.12E-05	4.17E-06	2.88E-05	1.12E-05	4.33E-06	2.87E-05
32.00	1.14E-05	3.97E-06	2.97E-05	1.11E-05	3.98E-06	2.86E-05	1.11E-05	4.12E-06	2.86E-05
33.00	1.13E-05	3.80E-06	2.96E-05	1.10E-05	3.80E-06	2.85E-05	1.10E-05	3.93E-06	2.85E-05
34.00	1.12E-05	3.64E-06	2.94E-05	1.09E-05	3.64E-06	2.84E-05	1.09E-05	3.76E-06	2.83E-05
35.00	1.11E-05	3.50E-06	2.93E-05	1.08E-05	3.49E-06	2.83E-05	1.08E-05	3.60E-06	2.82E-05
36.00	1.10E-05	3.37E-06	2.92E-05	1.07E-05	3.35E-06	2.82E-05	1.07E-05	3.45E-06	2.81E-05

APPENDIX R

EFFECTIVE DOSE RATE 300 CM FOR ADULT PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	4.84E-06	4.84E-06	4.84E-06	4.79E-06	4.79E-06	4.79E-06	5.05E-06	5.05E-06	5.05E-06
0.25	4.91E-06	4.88E-06	5.24E-06	4.87E-06	4.84E-06	5.19E-06	5.13E-06	5.10E-06	5.44E-06
0.50	4.93E-06	4.88E-06	5.38E-06	4.88E-06	4.84E-06	5.32E-06	5.14E-06	5.10E-06	5.57E-06
1.00	4.90E-06	4.83E-06	5.52E-06	4.86E-06	4.79E-06	5.46E-06	5.11E-06	5.04E-06	5.69E-06
2.00	4.73E-06	4.61E-06	5.61E-06	4.69E-06	4.57E-06	5.55E-06	4.93E-06	4.81E-06	5.76E-06
3.00	4.50E-06	4.33E-06	5.59E-06	4.46E-06	4.29E-06	5.53E-06	4.68E-06	4.52E-06	5.73E-06
4.00	4.25E-06	4.03E-06	5.54E-06	4.21E-06	3.99E-06	5.48E-06	4.42E-06	4.20E-06	5.67E-06
5.00	4.01E-06	3.73E-06	5.49E-06	3.97E-06	3.69E-06	5.42E-06	4.16E-06	3.88E-06	5.60E-06
6.00	3.77E-06	3.44E-06	5.43E-06	3.74E-06	3.41E-06	5.37E-06	3.91E-06	3.58E-06	5.54E-06
7.00	3.56E-06	3.16E-06	5.38E-06	3.52E-06	3.14E-06	5.32E-06	3.68E-06	3.30E-06	5.49E-06
8.00	3.36E-06	2.91E-06	5.34E-06	3.33E-06	2.89E-06	5.28E-06	3.48E-06	3.03E-06	5.45E-06
9.00	3.19E-06	2.68E-06	5.31E-06	3.16E-06	2.66E-06	5.24E-06	3.30E-06	2.79E-06	5.41E-06
10.00	3.03E-06	2.47E-06	5.27E-06	3.00E-06	2.45E-06	5.21E-06	3.13E-06	2.57E-06	5.38E-06
11.00	2.89E-06	2.28E-06	5.25E-06	2.86E-06	2.26E-06	5.18E-06	2.98E-06	2.37E-06	5.35E-06
12.00	2.77E-06	2.10E-06	5.22E-06	2.74E-06	2.08E-06	5.16E-06	2.85E-06	2.18E-06	5.32E-06
13.00	2.66E-06	1.94E-06	5.20E-06	2.63E-06	1.92E-06	5.13E-06	2.74E-06	2.02E-06	5.29E-06
14.00	2.56E-06	1.79E-06	5.17E-06	2.54E-06	1.78E-06	5.11E-06	2.64E-06	1.87E-06	5.27E-06
15.00	2.48E-06	1.66E-06	5.15E-06	2.45E-06	1.65E-06	5.09E-06	2.54E-06	1.73E-06	5.25E-06
16.00	2.40E-06	1.54E-06	5.13E-06	2.37E-06	1.53E-06	5.07E-06	2.46E-06	1.60E-06	5.23E-06
17.00	2.33E-06	1.43E-06	5.11E-06	2.30E-06	1.42E-06	5.04E-06	2.39E-06	1.49E-06	5.20E-06
18.00	2.27E-06	1.33E-06	5.09E-06	2.24E-06	1.32E-06	5.02E-06	2.33E-06	1.38E-06	5.18E-06
19.00	2.21E-06	1.24E-06	5.07E-06	2.19E-06	1.23E-06	5.00E-06	2.27E-06	1.29E-06	5.16E-06
20.00	2.17E-06	1.16E-06	5.05E-06	2.14E-06	1.15E-06	4.98E-06	2.22E-06	1.21E-06	5.14E-06
21.00	2.12E-06	1.09E-06	5.03E-06	2.10E-06	1.08E-06	4.96E-06	2.17E-06	1.13E-06	5.12E-06
22.00	2.08E-06	1.02E-06	5.01E-06	2.06E-06	1.01E-06	4.94E-06	2.13E-06	1.06E-06	5.10E-06
23.00	2.05E-06	9.60E-07	4.99E-06	2.02E-06	9.51E-07	4.93E-06	2.09E-06	9.94E-07	5.08E-06
24.00	2.01E-06	9.05E-07	4.97E-06	1.99E-06	8.96E-07	4.91E-06	2.06E-06	9.36E-07	5.06E-06
25.00	1.98E-06	8.54E-07	4.95E-06	1.96E-06	8.46E-07	4.89E-06	2.03E-06	8.83E-07	5.04E-06
26.00	1.96E-06	8.08E-07	4.93E-06	1.93E-06	8.00E-07	4.87E-06	2.00E-06	8.35E-07	5.02E-06
27.00	1.93E-06	7.66E-07	4.91E-06	1.91E-06	7.58E-07	4.85E-06	1.97E-06	7.91E-07	5.00E-06
28.00	1.91E-06	7.28E-07	4.89E-06	1.89E-06	7.20E-07	4.83E-06	1.95E-06	7.51E-07	4.98E-06
29.00	1.89E-06	6.93E-07	4.87E-06	1.87E-06	6.86E-07	4.81E-06	1.93E-06	7.15E-07	4.96E-06
30.00	1.87E-06	6.61E-07	4.85E-06	1.85E-06	6.54E-07	4.79E-06	1.91E-06	6.82E-07	4.94E-06

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	1.85E-06	6.32E-07	4.83E-06	1.83E-06	6.26E-07	4.77E-06	1.89E-06	6.52E-07	4.92E-06
32.00	1.84E-06	6.06E-07	4.81E-06	1.82E-06	5.99E-07	4.75E-06	1.88E-06	6.24E-07	4.90E-06
33.00	1.82E-06	5.81E-07	4.79E-06	1.80E-06	5.75E-07	4.74E-06	1.86E-06	5.99E-07	4.88E-06
34.00	1.81E-06	5.59E-07	4.78E-06	1.79E-06	5.53E-07	4.72E-06	1.85E-06	5.76E-07	4.87E-06
35.00	1.80E-06	5.39E-07	4.76E-06	1.77E-06	5.33E-07	4.70E-06	1.83E-06	5.55E-07	4.85E-06
36.00	1.78E-06	5.21E-07	4.74E-06	1.76E-06	5.15E-07	4.68E-06	1.82E-06	5.35E-07	4.83E-06

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	5.02E-06	5.02E-06	5.02E-06	5.17E-06	5.17E-06	5.17E-06	5.31E-06	5.31E-06	5.31E-06
0.25	5.09E-06	5.07E-06	5.37E-06	5.24E-06	5.21E-06	5.49E-06	5.38E-06	5.36E-06	5.59E-06
0.50	5.10E-06	5.06E-06	5.49E-06	5.25E-06	5.21E-06	5.60E-06	5.39E-06	5.36E-06	5.67E-06
1.00	5.07E-06	5.01E-06	5.61E-06	5.20E-06	5.15E-06	5.69E-06	5.35E-06	5.30E-06	5.74E-06
2.00	4.89E-06	4.78E-06	5.66E-06	5.01E-06	4.91E-06	5.72E-06	5.14E-06	5.06E-06	5.72E-06
3.00	4.64E-06	4.49E-06	5.61E-06	4.75E-06	4.61E-06	5.66E-06	4.87E-06	4.75E-06	5.63E-06
4.00	4.37E-06	4.17E-06	5.55E-06	4.47E-06	4.28E-06	5.58E-06	4.58E-06	4.42E-06	5.54E-06
5.00	4.11E-06	3.86E-06	5.48E-06	4.20E-06	3.96E-06	5.51E-06	4.29E-06	4.08E-06	5.45E-06
6.00	3.87E-06	3.56E-06	5.42E-06	3.95E-06	3.65E-06	5.44E-06	4.02E-06	3.76E-06	5.37E-06
7.00	3.64E-06	3.27E-06	5.37E-06	3.71E-06	3.36E-06	5.39E-06	3.77E-06	3.46E-06	5.31E-06
8.00	3.44E-06	3.01E-06	5.32E-06	3.50E-06	3.09E-06	5.34E-06	3.55E-06	3.18E-06	5.26E-06
9.00	3.25E-06	2.77E-06	5.28E-06	3.31E-06	2.84E-06	5.30E-06	3.35E-06	2.92E-06	5.22E-06
10.00	3.09E-06	2.55E-06	5.25E-06	3.14E-06	2.62E-06	5.26E-06	3.17E-06	2.69E-06	5.18E-06
11.00	2.94E-06	2.35E-06	5.22E-06	2.98E-06	2.41E-06	5.23E-06	3.01E-06	2.48E-06	5.15E-06
12.00	2.81E-06	2.17E-06	5.19E-06	2.85E-06	2.22E-06	5.21E-06	2.87E-06	2.28E-06	5.12E-06
13.00	2.69E-06	2.00E-06	5.17E-06	2.73E-06	2.05E-06	5.18E-06	2.74E-06	2.10E-06	5.10E-06
14.00	2.59E-06	1.85E-06	5.14E-06	2.62E-06	1.89E-06	5.16E-06	2.63E-06	1.94E-06	5.08E-06
15.00	2.50E-06	1.71E-06	5.12E-06	2.53E-06	1.75E-06	5.14E-06	2.53E-06	1.80E-06	5.05E-06
16.00	2.42E-06	1.59E-06	5.10E-06	2.44E-06	1.62E-06	5.11E-06	2.44E-06	1.66E-06	5.03E-06
17.00	2.35E-06	1.47E-06	5.08E-06	2.37E-06	1.51E-06	5.09E-06	2.37E-06	1.54E-06	5.01E-06
18.00	2.28E-06	1.37E-06	5.06E-06	2.30E-06	1.40E-06	5.07E-06	2.30E-06	1.43E-06	4.99E-06
19.00	2.22E-06	1.28E-06	5.04E-06	2.24E-06	1.31E-06	5.05E-06	2.23E-06	1.33E-06	4.97E-06
20.00	2.17E-06	1.19E-06	5.02E-06	2.19E-06	1.22E-06	5.03E-06	2.18E-06	1.24E-06	4.95E-06
21.00	2.13E-06	1.12E-06	5.00E-06	2.14E-06	1.14E-06	5.01E-06	2.13E-06	1.16E-06	4.93E-06
22.00	2.09E-06	1.05E-06	4.98E-06	2.10E-06	1.07E-06	4.99E-06	2.09E-06	1.09E-06	4.91E-06
23.00	2.05E-06	9.83E-07	4.96E-06	2.06E-06	1.00E-06	4.97E-06	2.05E-06	1.02E-06	4.89E-06
24.00	2.01E-06	9.25E-07	4.94E-06	2.03E-06	9.43E-07	4.95E-06	2.01E-06	9.58E-07	4.87E-06

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	1.98E-06	8.72E-07	4.92E-06	2.00E-06	8.88E-07	4.93E-06	1.98E-06	9.02E-07	4.85E-06
26.00	1.96E-06	8.24E-07	4.90E-06	1.97E-06	8.39E-07	4.91E-06	1.95E-06	8.51E-07	4.83E-06
27.00	1.93E-06	7.81E-07	4.88E-06	1.94E-06	7.94E-07	4.89E-06	1.92E-06	8.05E-07	4.82E-06
28.00	1.91E-06	7.41E-07	4.86E-06	1.92E-06	7.54E-07	4.88E-06	1.90E-06	7.62E-07	4.80E-06
29.00	1.89E-06	7.05E-07	4.84E-06	1.90E-06	7.16E-07	4.86E-06	1.87E-06	7.24E-07	4.78E-06
30.00	1.87E-06	6.72E-07	4.82E-06	1.88E-06	6.82E-07	4.84E-06	1.85E-06	6.89E-07	4.76E-06
31.00	1.85E-06	6.42E-07	4.81E-06	1.86E-06	6.52E-07	4.82E-06	1.83E-06	6.57E-07	4.74E-06
32.00	1.83E-06	6.14E-07	4.79E-06	1.84E-06	6.23E-07	4.80E-06	1.82E-06	6.28E-07	4.72E-06
33.00	1.82E-06	5.89E-07	4.77E-06	1.82E-06	5.97E-07	4.78E-06	1.80E-06	6.01E-07	4.70E-06
34.00	1.80E-06	5.66E-07	4.75E-06	1.81E-06	5.74E-07	4.76E-06	1.79E-06	5.77E-07	4.68E-06
35.00	1.79E-06	5.45E-07	4.73E-06	1.80E-06	5.52E-07	4.74E-06	1.77E-06	5.54E-07	4.67E-06
36.00	1.78E-06	5.26E-07	4.71E-06	1.78E-06	5.33E-07	4.72E-06	1.76E-06	5.34E-07	4.65E-06

APPENDIX S

EFFECTIVE DOSE RATE 300 CM FOR 15YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	4.79E-06	4.79E-06	4.79E-06	4.86E-06	4.86E-06	4.86E-06	5.07E-06	5.07E-06	5.07E-06
0.25	4.86E-06	4.83E-06	5.19E-06	4.93E-06	4.90E-06	5.25E-06	5.14E-06	5.12E-06	5.45E-06
0.50	4.88E-06	4.83E-06	5.33E-06	4.95E-06	4.90E-06	5.38E-06	5.16E-06	5.11E-06	5.58E-06
1.00	4.85E-06	4.78E-06	5.47E-06	4.92E-06	4.85E-06	5.52E-06	5.12E-06	5.05E-06	5.70E-06
2.00	4.69E-06	4.57E-06	5.56E-06	4.74E-06	4.63E-06	5.60E-06	4.94E-06	4.82E-06	5.77E-06
3.00	4.46E-06	4.29E-06	5.55E-06	4.51E-06	4.34E-06	5.57E-06	4.69E-06	4.53E-06	5.74E-06
4.00	4.21E-06	3.99E-06	5.50E-06	4.26E-06	4.04E-06	5.52E-06	4.42E-06	4.21E-06	5.67E-06
5.00	3.97E-06	3.69E-06	5.44E-06	4.01E-06	3.74E-06	5.46E-06	4.16E-06	3.89E-06	5.61E-06
6.00	3.74E-06	3.41E-06	5.39E-06	3.78E-06	3.45E-06	5.41E-06	3.92E-06	3.59E-06	5.55E-06
7.00	3.53E-06	3.14E-06	5.34E-06	3.56E-06	3.17E-06	5.36E-06	3.69E-06	3.31E-06	5.50E-06
8.00	3.33E-06	2.89E-06	5.30E-06	3.36E-06	2.92E-06	5.31E-06	3.48E-06	3.04E-06	5.45E-06
9.00	3.16E-06	2.66E-06	5.26E-06	3.19E-06	2.69E-06	5.28E-06	3.30E-06	2.80E-06	5.41E-06
10.00	3.01E-06	2.45E-06	5.23E-06	3.03E-06	2.48E-06	5.24E-06	3.13E-06	2.58E-06	5.38E-06
11.00	2.87E-06	2.26E-06	5.20E-06	2.89E-06	2.28E-06	5.21E-06	2.99E-06	2.37E-06	5.35E-06
12.00	2.75E-06	2.08E-06	5.17E-06	2.77E-06	2.10E-06	5.19E-06	2.86E-06	2.19E-06	5.32E-06
13.00	2.64E-06	1.92E-06	5.15E-06	2.65E-06	1.94E-06	5.16E-06	2.74E-06	2.02E-06	5.29E-06
14.00	2.54E-06	1.78E-06	5.12E-06	2.56E-06	1.80E-06	5.14E-06	2.64E-06	1.87E-06	5.27E-06
15.00	2.45E-06	1.65E-06	5.10E-06	2.47E-06	1.67E-06	5.12E-06	2.55E-06	1.73E-06	5.25E-06
16.00	2.38E-06	1.53E-06	5.08E-06	2.39E-06	1.54E-06	5.09E-06	2.46E-06	1.61E-06	5.22E-06
17.00	2.31E-06	1.42E-06	5.06E-06	2.32E-06	1.44E-06	5.07E-06	2.39E-06	1.49E-06	5.20E-06
18.00	2.25E-06	1.32E-06	5.04E-06	2.26E-06	1.34E-06	5.05E-06	2.33E-06	1.39E-06	5.18E-06
19.00	2.19E-06	1.23E-06	5.02E-06	2.20E-06	1.25E-06	5.03E-06	2.27E-06	1.29E-06	5.16E-06
20.00	2.14E-06	1.15E-06	5.00E-06	2.15E-06	1.16E-06	5.01E-06	2.22E-06	1.21E-06	5.14E-06
21.00	2.10E-06	1.08E-06	4.98E-06	2.11E-06	1.09E-06	4.99E-06	2.17E-06	1.13E-06	5.12E-06
22.00	2.06E-06	1.01E-06	4.96E-06	2.07E-06	1.02E-06	4.97E-06	2.13E-06	1.06E-06	5.10E-06
23.00	2.02E-06	9.51E-07	4.94E-06	2.03E-06	9.60E-07	4.95E-06	2.09E-06	9.95E-07	5.07E-06
24.00	1.99E-06	8.96E-07	4.92E-06	2.00E-06	9.04E-07	4.93E-06	2.06E-06	9.37E-07	5.05E-06
25.00	1.96E-06	8.46E-07	4.90E-06	1.97E-06	8.53E-07	4.91E-06	2.02E-06	8.84E-07	5.03E-06
26.00	1.94E-06	8.00E-07	4.88E-06	1.94E-06	8.07E-07	4.89E-06	2.00E-06	8.35E-07	5.01E-06
27.00	1.91E-06	7.58E-07	4.86E-06	1.92E-06	7.65E-07	4.87E-06	1.97E-06	7.91E-07	4.99E-06
28.00	1.89E-06	7.20E-07	4.84E-06	1.90E-06	7.26E-07	4.85E-06	1.95E-06	7.51E-07	4.97E-06
29.00	1.87E-06	6.85E-07	4.82E-06	1.88E-06	6.91E-07	4.83E-06	1.93E-06	7.15E-07	4.95E-06
30.00	1.85E-06	6.54E-07	4.80E-06	1.86E-06	6.59E-07	4.81E-06	1.91E-06	6.81E-07	4.93E-06

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	1.83E-06	6.25E-07	4.78E-06	1.84E-06	6.30E-07	4.79E-06	1.89E-06	6.51E-07	4.91E-06
32.00	1.82E-06	5.99E-07	4.76E-06	1.82E-06	6.03E-07	4.77E-06	1.87E-06	6.23E-07	4.89E-06
33.00	1.80E-06	5.75E-07	4.74E-06	1.81E-06	5.79E-07	4.75E-06	1.85E-06	5.98E-07	4.87E-06
34.00	1.79E-06	5.53E-07	4.72E-06	1.79E-06	5.57E-07	4.73E-06	1.84E-06	5.75E-07	4.85E-06
35.00	1.77E-06	5.33E-07	4.70E-06	1.78E-06	5.36E-07	4.71E-06	1.83E-06	5.53E-07	4.83E-06
36.00	1.76E-06	5.14E-07	4.68E-06	1.77E-06	5.17E-07	4.70E-06	1.81E-06	5.34E-07	4.81E-06

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	5.02E-06	5.02E-06	5.02E-06	5.18E-06	5.18E-06	5.18E-06	5.35E-06	5.35E-06	5.35E-06
0.25	5.09E-06	5.06E-06	5.38E-06	5.24E-06	5.22E-06	5.46E-06	5.42E-06	5.39E-06	5.67E-06
0.50	5.10E-06	5.06E-06	5.50E-06	5.25E-06	5.22E-06	5.54E-06	5.42E-06	5.39E-06	5.78E-06
1.00	5.07E-06	5.00E-06	5.61E-06	5.20E-06	5.15E-06	5.61E-06	5.38E-06	5.32E-06	5.87E-06
2.00	4.89E-06	4.78E-06	5.66E-06	5.00E-06	4.91E-06	5.60E-06	5.17E-06	5.07E-06	5.89E-06
3.00	4.64E-06	4.48E-06	5.62E-06	4.73E-06	4.61E-06	5.52E-06	4.90E-06	4.76E-06	5.83E-06
4.00	4.37E-06	4.17E-06	5.55E-06	4.45E-06	4.28E-06	5.43E-06	4.61E-06	4.42E-06	5.74E-06
5.00	4.11E-06	3.86E-06	5.49E-06	4.17E-06	3.96E-06	5.35E-06	4.33E-06	4.09E-06	5.67E-06
6.00	3.87E-06	3.56E-06	5.42E-06	3.91E-06	3.64E-06	5.28E-06	4.07E-06	3.77E-06	5.60E-06
7.00	3.64E-06	3.27E-06	5.37E-06	3.67E-06	3.35E-06	5.22E-06	3.82E-06	3.47E-06	5.54E-06
8.00	3.44E-06	3.01E-06	5.32E-06	3.46E-06	3.08E-06	5.17E-06	3.60E-06	3.19E-06	5.49E-06
9.00	3.25E-06	2.77E-06	5.29E-06	3.26E-06	2.83E-06	5.13E-06	3.41E-06	2.93E-06	5.45E-06
10.00	3.09E-06	2.55E-06	5.25E-06	3.09E-06	2.61E-06	5.09E-06	3.23E-06	2.70E-06	5.41E-06
11.00	2.94E-06	2.35E-06	5.22E-06	2.93E-06	2.40E-06	5.06E-06	3.07E-06	2.48E-06	5.38E-06
12.00	2.81E-06	2.17E-06	5.19E-06	2.80E-06	2.21E-06	5.04E-06	2.93E-06	2.29E-06	5.35E-06
13.00	2.69E-06	2.00E-06	5.17E-06	2.68E-06	2.04E-06	5.01E-06	2.81E-06	2.11E-06	5.32E-06
14.00	2.59E-06	1.85E-06	5.14E-06	2.57E-06	1.88E-06	4.99E-06	2.70E-06	1.95E-06	5.30E-06
15.00	2.50E-06	1.71E-06	5.12E-06	2.47E-06	1.74E-06	4.96E-06	2.60E-06	1.81E-06	5.28E-06
16.00	2.42E-06	1.59E-06	5.10E-06	2.39E-06	1.61E-06	4.94E-06	2.51E-06	1.67E-06	5.25E-06
17.00	2.34E-06	1.47E-06	5.08E-06	2.31E-06	1.50E-06	4.92E-06	2.44E-06	1.55E-06	5.23E-06
18.00	2.28E-06	1.37E-06	5.06E-06	2.25E-06	1.39E-06	4.90E-06	2.37E-06	1.45E-06	5.21E-06
19.00	2.22E-06	1.28E-06	5.04E-06	2.19E-06	1.30E-06	4.88E-06	2.31E-06	1.35E-06	5.19E-06
20.00	2.17E-06	1.19E-06	5.02E-06	2.13E-06	1.21E-06	4.86E-06	2.25E-06	1.26E-06	5.17E-06
21.00	2.12E-06	1.12E-06	5.00E-06	2.08E-06	1.13E-06	4.84E-06	2.20E-06	1.17E-06	5.14E-06
22.00	2.08E-06	1.05E-06	4.98E-06	2.04E-06	1.06E-06	4.82E-06	2.16E-06	1.10E-06	5.12E-06
23.00	2.05E-06	9.82E-07	4.95E-06	2.00E-06	9.91E-07	4.80E-06	2.12E-06	1.03E-06	5.10E-06
24.00	2.01E-06	9.24E-07	4.93E-06	1.97E-06	9.31E-07	4.78E-06	2.08E-06	9.70E-07	5.08E-06

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	1.98E-06	8.71E-07	4.91E-06	1.93E-06	8.77E-07	4.76E-06	2.05E-06	9.15E-07	5.06E-06
26.00	1.95E-06	8.23E-07	4.89E-06	1.91E-06	8.27E-07	4.74E-06	2.02E-06	8.64E-07	5.04E-06
27.00	1.93E-06	7.80E-07	4.88E-06	1.88E-06	7.83E-07	4.72E-06	1.99E-06	8.17E-07	5.02E-06
28.00	1.90E-06	7.40E-07	4.86E-06	1.86E-06	7.42E-07	4.70E-06	1.97E-06	7.75E-07	5.00E-06
29.00	1.88E-06	7.04E-07	4.84E-06	1.83E-06	7.04E-07	4.69E-06	1.94E-06	7.37E-07	4.98E-06
30.00	1.86E-06	6.71E-07	4.82E-06	1.81E-06	6.70E-07	4.67E-06	1.92E-06	7.01E-07	4.96E-06
31.00	1.84E-06	6.40E-07	4.80E-06	1.80E-06	6.39E-07	4.65E-06	1.90E-06	6.69E-07	4.94E-06
32.00	1.83E-06	6.13E-07	4.78E-06	1.78E-06	6.11E-07	4.63E-06	1.89E-06	6.40E-07	4.92E-06
33.00	1.81E-06	5.88E-07	4.76E-06	1.76E-06	5.85E-07	4.61E-06	1.87E-06	6.13E-07	4.90E-06
34.00	1.80E-06	5.65E-07	4.74E-06	1.75E-06	5.61E-07	4.59E-06	1.85E-06	5.89E-07	4.88E-06
35.00	1.78E-06	5.44E-07	4.72E-06	1.73E-06	5.40E-07	4.57E-06	1.84E-06	5.67E-07	4.86E-06
36.00	1.77E-06	5.24E-07	4.70E-06	1.72E-06	5.20E-07	4.56E-06	1.83E-06	5.46E-07	4.84E-06

APPENDIX T

EFFECTIVE DOSE RATE 300 CM FOR 10YO PATIENT

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	5.04E-06	5.04E-06	5.04E-06	5.08E-06	5.08E-06	5.08E-06	5.28E-06	5.28E-06	5.28E-06
0.25	5.11E-06	5.08E-06	5.41E-06	5.15E-06	5.12E-06	5.45E-06	5.35E-06	5.31E-06	5.68E-06
0.50	5.11E-06	5.07E-06	5.54E-06	5.15E-06	5.11E-06	5.58E-06	5.35E-06	5.31E-06	5.82E-06
1.00	5.08E-06	5.01E-06	5.67E-06	5.11E-06	5.04E-06	5.70E-06	5.31E-06	5.24E-06	5.95E-06
2.00	4.89E-06	4.78E-06	5.73E-06	4.92E-06	4.81E-06	5.76E-06	5.12E-06	4.99E-06	6.03E-06
3.00	4.65E-06	4.48E-06	5.70E-06	4.67E-06	4.51E-06	5.73E-06	4.86E-06	4.68E-06	6.00E-06
4.00	4.38E-06	4.17E-06	5.64E-06	4.41E-06	4.19E-06	5.67E-06	4.59E-06	4.35E-06	5.95E-06
5.00	4.12E-06	3.85E-06	5.58E-06	4.15E-06	3.87E-06	5.61E-06	4.32E-06	4.03E-06	5.88E-06
6.00	3.88E-06	3.55E-06	5.52E-06	3.90E-06	3.57E-06	5.55E-06	4.07E-06	3.71E-06	5.82E-06
7.00	3.66E-06	3.27E-06	5.47E-06	3.68E-06	3.29E-06	5.50E-06	3.83E-06	3.42E-06	5.77E-06
8.00	3.45E-06	3.01E-06	5.42E-06	3.47E-06	3.03E-06	5.45E-06	3.62E-06	3.15E-06	5.72E-06
9.00	3.27E-06	2.77E-06	5.38E-06	3.29E-06	2.78E-06	5.41E-06	3.43E-06	2.90E-06	5.68E-06
10.00	3.11E-06	2.55E-06	5.35E-06	3.12E-06	2.56E-06	5.38E-06	3.26E-06	2.67E-06	5.65E-06
11.00	2.96E-06	2.35E-06	5.32E-06	2.98E-06	2.36E-06	5.35E-06	3.11E-06	2.46E-06	5.61E-06
12.00	2.83E-06	2.17E-06	5.29E-06	2.85E-06	2.18E-06	5.32E-06	2.98E-06	2.27E-06	5.58E-06
13.00	2.72E-06	2.00E-06	5.26E-06	2.73E-06	2.01E-06	5.29E-06	2.86E-06	2.09E-06	5.56E-06
14.00	2.62E-06	1.85E-06	5.24E-06	2.63E-06	1.86E-06	5.27E-06	2.75E-06	1.94E-06	5.53E-06
15.00	2.52E-06	1.71E-06	5.22E-06	2.54E-06	1.72E-06	5.24E-06	2.66E-06	1.79E-06	5.51E-06
16.00	2.44E-06	1.59E-06	5.19E-06	2.46E-06	1.60E-06	5.22E-06	2.57E-06	1.66E-06	5.48E-06
17.00	2.37E-06	1.48E-06	5.17E-06	2.38E-06	1.48E-06	5.20E-06	2.50E-06	1.55E-06	5.46E-06
18.00	2.31E-06	1.37E-06	5.15E-06	2.32E-06	1.38E-06	5.18E-06	2.43E-06	1.44E-06	5.43E-06
19.00	2.25E-06	1.28E-06	5.13E-06	2.26E-06	1.29E-06	5.15E-06	2.37E-06	1.34E-06	5.41E-06
20.00	2.20E-06	1.20E-06	5.10E-06	2.21E-06	1.20E-06	5.13E-06	2.32E-06	1.25E-06	5.39E-06
21.00	2.15E-06	1.12E-06	5.08E-06	2.16E-06	1.13E-06	5.11E-06	2.27E-06	1.17E-06	5.37E-06
22.00	2.11E-06	1.05E-06	5.06E-06	2.12E-06	1.06E-06	5.09E-06	2.22E-06	1.10E-06	5.34E-06
23.00	2.07E-06	9.87E-07	5.04E-06	2.08E-06	9.92E-07	5.07E-06	2.19E-06	1.03E-06	5.32E-06
24.00	2.04E-06	9.29E-07	5.02E-06	2.05E-06	9.34E-07	5.05E-06	2.15E-06	9.74E-07	5.30E-06
25.00	2.01E-06	8.76E-07	5.00E-06	2.02E-06	8.81E-07	5.03E-06	2.12E-06	9.19E-07	5.28E-06
26.00	1.98E-06	8.28E-07	4.98E-06	1.99E-06	8.33E-07	5.00E-06	2.09E-06	8.69E-07	5.26E-06
27.00	1.96E-06	7.85E-07	4.96E-06	1.97E-06	7.89E-07	4.98E-06	2.06E-06	8.23E-07	5.23E-06
28.00	1.93E-06	7.45E-07	4.94E-06	1.94E-06	7.49E-07	4.96E-06	2.04E-06	7.82E-07	5.21E-06
29.00	1.91E-06	7.09E-07	4.92E-06	1.92E-06	7.13E-07	4.94E-06	2.02E-06	7.44E-07	5.19E-06
30.00	1.89E-06	6.76E-07	4.90E-06	1.90E-06	6.80E-07	4.92E-06	1.99E-06	7.10E-07	5.17E-06

	Adult			15yo			10yo		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
31.00	1.87E-06	6.46E-07	4.88E-06	1.88E-06	6.49E-07	4.90E-06	1.97E-06	6.78E-07	5.15E-06
32.00	1.85E-06	6.18E-07	4.86E-06	1.86E-06	6.22E-07	4.88E-06	1.96E-06	6.50E-07	5.13E-06
33.00	1.84E-06	5.93E-07	4.84E-06	1.85E-06	5.96E-07	4.86E-06	1.94E-06	6.23E-07	5.10E-06
34.00	1.82E-06	5.70E-07	4.82E-06	1.83E-06	5.73E-07	4.84E-06	1.92E-06	5.99E-07	5.08E-06
35.00	1.81E-06	5.49E-07	4.80E-06	1.82E-06	5.52E-07	4.82E-06	1.91E-06	5.77E-07	5.06E-06
36.00	1.80E-06	5.30E-07	4.78E-06	1.81E-06	5.33E-07	4.80E-06	1.90E-06	5.57E-07	5.04E-06

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
0.00	5.22E-06	5.22E-06	5.22E-06	5.29E-06	5.29E-06	5.29E-06	5.35E-06	5.35E-06	5.35E-06
0.25	5.29E-06	5.26E-06	5.60E-06	5.36E-06	5.34E-06	5.64E-06	5.43E-06	5.41E-06	5.75E-06
0.50	5.30E-06	5.25E-06	5.72E-06	5.37E-06	5.33E-06	5.75E-06	5.45E-06	5.40E-06	5.88E-06
1.00	5.25E-06	5.19E-06	5.85E-06	5.33E-06	5.27E-06	5.86E-06	5.41E-06	5.34E-06	6.01E-06
2.00	5.06E-06	4.94E-06	5.91E-06	5.13E-06	5.02E-06	5.90E-06	5.22E-06	5.10E-06	6.07E-06
3.00	4.80E-06	4.64E-06	5.87E-06	4.86E-06	4.71E-06	5.84E-06	4.96E-06	4.79E-06	6.03E-06
4.00	4.53E-06	4.31E-06	5.81E-06	4.58E-06	4.38E-06	5.77E-06	4.67E-06	4.45E-06	5.96E-06
5.00	4.26E-06	3.98E-06	5.74E-06	4.30E-06	4.05E-06	5.69E-06	4.40E-06	4.12E-06	5.89E-06
6.00	4.01E-06	3.67E-06	5.68E-06	4.04E-06	3.73E-06	5.63E-06	4.13E-06	3.80E-06	5.82E-06
7.00	3.78E-06	3.38E-06	5.62E-06	3.81E-06	3.44E-06	5.57E-06	3.89E-06	3.50E-06	5.76E-06
8.00	3.56E-06	3.11E-06	5.58E-06	3.59E-06	3.16E-06	5.52E-06	3.67E-06	3.22E-06	5.71E-06
9.00	3.38E-06	2.86E-06	5.54E-06	3.39E-06	2.91E-06	5.48E-06	3.48E-06	2.96E-06	5.67E-06
10.00	3.21E-06	2.64E-06	5.50E-06	3.22E-06	2.68E-06	5.44E-06	3.30E-06	2.73E-06	5.63E-06
11.00	3.06E-06	2.43E-06	5.47E-06	3.06E-06	2.46E-06	5.41E-06	3.15E-06	2.51E-06	5.60E-06
12.00	2.92E-06	2.24E-06	5.44E-06	2.93E-06	2.27E-06	5.38E-06	3.01E-06	2.32E-06	5.57E-06
13.00	2.80E-06	2.07E-06	5.41E-06	2.80E-06	2.10E-06	5.35E-06	2.88E-06	2.14E-06	5.54E-06
14.00	2.70E-06	1.91E-06	5.39E-06	2.70E-06	1.94E-06	5.33E-06	2.77E-06	1.98E-06	5.52E-06
15.00	2.60E-06	1.77E-06	5.36E-06	2.60E-06	1.79E-06	5.30E-06	2.67E-06	1.83E-06	5.49E-06
16.00	2.52E-06	1.64E-06	5.34E-06	2.51E-06	1.66E-06	5.28E-06	2.59E-06	1.70E-06	5.47E-06
17.00	2.44E-06	1.53E-06	5.32E-06	2.44E-06	1.54E-06	5.26E-06	2.51E-06	1.58E-06	5.44E-06
18.00	2.38E-06	1.42E-06	5.29E-06	2.37E-06	1.44E-06	5.24E-06	2.44E-06	1.47E-06	5.42E-06
19.00	2.32E-06	1.32E-06	5.27E-06	2.31E-06	1.34E-06	5.21E-06	2.38E-06	1.37E-06	5.40E-06
20.00	2.26E-06	1.24E-06	5.25E-06	2.25E-06	1.25E-06	5.19E-06	2.32E-06	1.28E-06	5.38E-06
21.00	2.22E-06	1.16E-06	5.23E-06	2.20E-06	1.17E-06	5.17E-06	2.27E-06	1.19E-06	5.35E-06
22.00	2.17E-06	1.08E-06	5.21E-06	2.16E-06	1.09E-06	5.15E-06	2.23E-06	1.12E-06	5.33E-06
23.00	2.13E-06	1.02E-06	5.18E-06	2.12E-06	1.03E-06	5.13E-06	2.19E-06	1.05E-06	5.31E-06
24.00	2.10E-06	9.59E-07	5.16E-06	2.08E-06	9.66E-07	5.10E-06	2.15E-06	9.88E-07	5.29E-06

	05yo			01yo			Newborn		
Time (hrs)	Normal	DTC	Hyper	Normal	DTC	Hyper	Normal	DTC	Hyper
25.00	2.07E-06	9.05E-07	5.14E-06	2.05E-06	9.11E-07	5.08E-06	2.12E-06	9.32E-07	5.26E-06
26.00	2.04E-06	8.55E-07	5.12E-06	2.02E-06	8.60E-07	5.06E-06	2.09E-06	8.81E-07	5.24E-06
27.00	2.01E-06	8.10E-07	5.10E-06	2.00E-06	8.14E-07	5.04E-06	2.06E-06	8.34E-07	5.22E-06
28.00	1.99E-06	7.69E-07	5.08E-06	1.97E-06	7.73E-07	5.02E-06	2.04E-06	7.92E-07	5.20E-06
29.00	1.97E-06	7.31E-07	5.06E-06	1.95E-06	7.34E-07	5.00E-06	2.01E-06	7.53E-07	5.18E-06
30.00	1.95E-06	6.97E-07	5.04E-06	1.93E-06	7.00E-07	4.98E-06	1.99E-06	7.18E-07	5.16E-06
31.00	1.93E-06	6.66E-07	5.01E-06	1.91E-06	6.68E-07	4.96E-06	1.97E-06	6.85E-07	5.13E-06
32.00	1.91E-06	6.38E-07	4.99E-06	1.89E-06	6.39E-07	4.94E-06	1.96E-06	6.56E-07	5.11E-06
33.00	1.89E-06	6.12E-07	4.97E-06	1.87E-06	6.13E-07	4.92E-06	1.94E-06	6.29E-07	5.09E-06
34.00	1.88E-06	5.88E-07	4.95E-06	1.86E-06	5.88E-07	4.90E-06	1.92E-06	6.04E-07	5.07E-06
35.00	1.86E-06	5.66E-07	4.93E-06	1.84E-06	5.66E-07	4.88E-06	1.91E-06	5.82E-07	5.05E-06
36.00	1.85E-06	5.46E-07	4.91E-06	1.83E-06	5.46E-07	4.86E-06	1.89E-06	5.61E-07	5.03E-06