集団線量の数量を導入してきた（ICRP,1977,1991b）。これらの量は、１つの線源から放射線に被ばくした人の集団と特定の被ばく期間を考慮する。数量は、組織や臓器T、および集団実効線量Sに関連する集団等価線量S_Tとして定義されている（ICRP,1991b）。これら集団線量の単位の特別な名称は、manシーベルト（man Sv）である。

（B 234）集団実効線量は、集団が受けた実効線量の積分として*Publication 60*（ICRP,1991b）に定義される（パラグラフA34）。委員会は、集団実効線量と集団等価線量の両方を導入した。集団数量の目的は、特に職業被ばくに対し放射線防護の最適化における道具として提供することであり、集団等価線量が特別な環境においてのみ用いられるので、集団実効線量のみ現在の勧告では議論される。

（B 235）職業被ばくにおいて、集団実効線量は、作業者集団の計画被ばく状況の最適化に対し使用される。集団実効線量および個人の線量分布は、作業計画を開始する前に、異なる作業シナリオに対し先験的に評価される。その後、集団実効線量は作業シナリオの選択に対する決定過程において相対的なパラメータとして使用される。先験的に評価された集団実効線量および作業完了後のモニタリングデータから得られた全ての個人実効線量の合計との比較は、更なる最適化手順や放射線防護手段に対する適切な情報を提供するであろう。集団線量は医療手順における放射線技術を比較すること、および異なる場所（例えば、異なる病院、異なる国）で、同じ放射線技術を比較することに対する道具として使用することができる。

（B 236）上述したように集団数量の定義は、広範囲の線量、かなり長期間および地理的に広範囲にわたる放射線被ばくを合計することで、人々に何例かで、不正確に集団実効線量を使用させ、これを基に放射線関連の損害を計算するよう導いている。しかし、そのような集団実効線量の使用は、集団線量に寄与する全ての線量範囲における損害の放射線影響に対するリスク係数の十分な知識があるならば意義深いであろう（Kaulra,1987）。大きな不確実性により、そのようなリスク係数の知識は極く低い線量域においては通用しない。

（B 237）この内容において、例えば、低線量における発癌に対するようなリスク要因が、中程度または高放射線量の線量範囲において観察された疫学的データの外挿から得られることは認識されている。B.2項に詳述されるように、外挿は、閾値なし直線線量影響関係の仮定に基づいている（LNTモデル）。委員会は、低線量域において、リスク因子が高い不確実性を持つと考えている。これは個人線量が極めて少ない場合、そのうち自然放射線から受ける部分は極く僅かである例である。詳細なリスク予測に対し、このような状況下での集団実効線量の使用は有効な手順ではない。

（B 238）長期間および広範囲な地理的区域にわたる低い個人線量の集積を避けるため、実効線量の範囲および期間は制限され、特定されるべきである。期間$\triangle T$に対するE_1とE_2間の集団実効線量の値は、以下のように定義される：

$$S(E_1, E_2, \Delta T) = \int_{E_1}^{E_2} E\left[\frac{dN}{dE}\right]_{\Delta T} dE \qquad \text{(B.5.10)}$$

E_1からE_2の範囲において、実効線量を受ける個人の数N（E_1,E_2, △T）は、以下である：

$$N(E_1, E_2, \Delta T) = \int_{E_1}^{E_2} E\left[\frac{dN}{dE}\right]_{\Delta T} dE \qquad \text{(B.5.11)}$$

そして、期間△Tに対するE_1とE_2間の個人線量の間隔において、実効線量$\bar{E}$（E_1,E_2, △T）の平均値は以下である：

$$\overline{E}(E_1, E_2, \Delta T) = \frac{1}{N(E_1, E_2, \Delta T)} \int_{E_1}^{E_2} \left[\frac{dN}{dE}\right]_{\Delta T} dE \qquad \text{(B.5.12)}$$

（B 239）個人の集団では、集団実効線量Sも、以下により計算されるであろう：

$$S = \sum_i E_i N_i \qquad \text{(B.5.13)}$$

ここで、E_iは、サブグループiにおける平均実効線量で、N_iは、このサブグループにおける個人の数である（ICRP,1991b）。

（B 240）集団実効線量の計算と解釈において、以下の側面が考慮され、集団実効線量の間違った使用を避けるため十分に再検討されるべきである：

- 被ばくした個人の数；
- 被ばくした人の年齢と性別；
- 個人線量の範囲；
- 期間内の線量分布；および
- 被ばくした個人の地理的な分布。

B.5.10. B.5項の参考文献

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B.6.　放射線防護における不確実性と判定

（B 241）*Publication 60*（ICRP,1991b）で、委員会は、この文章において過去にも行なってきたように、臓器または組織における実効線量や等価線量のどちらも直接測定できないが、放射線量評価は放射線防護の基本であることを強調した。これらの線量評価において、モデルは、外部被ばくのジオメトリ、人体における摂取と放射性核種の保持の生体動態、および人体解剖をシミュレートするために必要である。方法論や実際の使用に関連して放射線測定の考慮は非常に重要である。

（B 242）これらのモデルとそれらのパラメータ値は、モデルパラメータ値の「最適評価」を導出するため実験的研究および人での研究から多くの事例において作成されている。パラメータの幾つかの値において、あるいはモデル自体の形式や構造において大きな不確実性があるかもしれないことは認識される。これらの不確実性の幾つかは、種々の刊行物（Leggettら,1998、ICRP,2002、Harrisonら,2001、Likhtarevら,2003）において取り上げられ、物理学的および解剖学的特性のような証明されている（ICRP,2002）に対して、明確にされた様々なパラメータ値の予測が実施されてきた。パラメータ値のそのような変動は、内部被ばくからの線量評価では必要なモデルに関し特に重要である。広範囲の値を有する状況から、線量評価のため荷重係数あるいは他のパラメータを評価するために判断により必要なパラメータが選択される。

（B 243）不確実性と値の変動の区別は重要である。不確実性は、一定のパラメータ値または集団線量の中央値のモデルあるいは評価の予測において設定されうる信頼値について言及する。判断されたパラメータ値の低線量域における測定には不確実性が含まれる。それは、全ての外挿手順あるいは特に放射線量や低線量域におけるそれらの影響評価において、重要な因子である。

（B 244）変動（厳密には生物学的変動）は、それらの生理学的および代謝パラメータに関し、問題になっている異なる集団間の数量的な差異を示す。例えば、同じ年齢や性別、同じ食事を取っている2人の健常者は、大腸を通る物質の通過速度が大幅に異なるかもしれない。同様に、集団の一人一人は初期摂取が同じであっても、甲状腺による放射性ヨウ素の取り込みにおいて相当な変動があるかもしれない。評価対象が僅かで、極めて変化しやすい観察に基づく場合、変動は中央値不確実性の重要な源であろう。

（B 245）w_Rとw_Tの値が導出される確率的影響に対するリスク因子は、中程度および高線量域において疫学的および実験的放射線生物学データから得られてきた。実効線量の概念と同様に放射線防護に対し重要である低線量域のリスク因子は、閾値なし直線モデル（LNTモデル）を用いて、より高線量域において測定されたデータからの外挿に基づいている。

（B 246）このモデルは、科学的に検証されてこなかったという仮定による。それは最近の実験および疫学的データを適切に解釈したものと考慮され、確率的影響の最近の理解と一致する。しかし、その使用も特に低線量および低線量率での被ばく関連において、高い不確実性をもたらす（UNSCEAR,2000）。線量-反応の仮定される直線性、および線量付加は前の項目で

記述したように、特に実効線量の使用に対し、低線量域における放射線防護に使用される概念に対する必要条件である。

（B 247）放射線量や健康損害の評価に関連する不確実性は、この文章の種々の項目で議論されてきた。考慮される、より重要な因子の幾つかは以下のとおり：

- 組織内におけるエネルギー付与の不均一性は、内部被ばくと同様に低線量域の外部被ばくについて記述されてきた（B.3.2項）。
- 放射性核種の不均一分布は、アルファ粒子のような短い飛程を持つ電離粒子を考慮する場合、特に顕著である身体や、および組織において説明されてきた（B.3.2、B.3.3項）。
- 内部被ばくからの線量評価は、生体動態モデルとそれらのパラメータ値は可変であり、被ばくの特定な条件に依存する。頻繁に、動物データを用いて人に外挿しなければならない
- 人の集団は、生理学的および他のパラメータに関連する民族性の観点で、世界中で変わる（ICRP,2002）。放射生体学的モデルが、食物中の放射性核種濃度の評価に使用される場合、変動は大きくなるであろう、それゆえ、パラメータとしての習慣データからの摂取は頻繁にきわめて不確実であり、生物学的変動が大きく、測定された放射能の値は頻繁に低い。
- w_R値の選択に重要であるRBEの値は、考慮される最終目標や実験計画で変わる。頻繁に、値は動物およびインビトロデータに依存する（B.3.5項、パラグラフB73-B131）。
- 癌を誘発する標的細胞や組織内におけるそれらの位置は、不明確である。確率的影響に対する低線量域における線量反応、外挿の様式およびLNTモデルは不確実である（付録A）。
- 健康損害評価に関連するパラメータの評価では、性の平均化が実施されるので不確実性の原因となる（B.3.4項）。

（B 248）不確実性の程度は、定義された被ばく状況において種々のパラメータや異なる条件によって変わる。従って、不確実性の一般的な値を与えることはできないが、この種の考慮は行われるべきであり、特別な例に対し実施されてきた総括的な評価に含まれるべきである（例えば、CERRIE,2004、ICRP,2006c）。一般的に、放射性核種の生体動態を含む内部被ばくからの放射線量の評価における不確実性は、外部被ばくからの線量評価よりも大きい。不確実性の程度は、種々の放射性核種間で異なる。

（B 249）委員会は、これらの不確実性を承知しており、十分に評価するため、および可能な限りそれらを軽減させるために努力が行われている。しかし、規制過程において事前の線量評価で、委員会は、作業場、および環境の放射線場について定量的情報からまたは放射性核種の摂取から線量を判断することを推奨するパラメータ値と同様に線量測定モデルは、参照モデルとして扱われるべきとの姿勢を保持している。これらの値は、慣例により固定されており不確実性を条件としない。

（B 250）同様に、委員会は、線量限度や線量拘束値を推奨する目的で必要とされる線量測定モデルおよびパラメータ値が参照データとして定義され、それ故、不確実でないことを考慮する。それにもかかわらず、これらのモデルと値は定期的に再評価され、新しい科学データおよび情報が利用できるようになる場合、そのような評価を基準としてICRPにより更新されるであろう。

（B 251）委員会により推奨される線量測定モデル、換算係数、および他のパラメータは、主に第一に、通常の職業被ばく計画や評価に対し、環境放出に対する計画および線量の一般的な評価に対する計画に対し開発されてきた。それらは、線量限度の遵守を証明するのに必要とされる。これらは線量が低い場合の状況である（B.5.5項）。事故後あるいは疫学研究のような高線量では、個人および被ばく状況に関するより特定される情報が、必要とされる。そのような状況において、不確実であるあらゆる線源は、個人の解剖学的および生理学的データの多様性、放射性核種線源-用語に関する特定な情報、生体動態、および外部被ばくの例における入射放射線の方向を含み考慮されるべきである。

（B 252）結論として、参照モデルやそれらのパラメータ値は、事前の放射線防護において使用するため作成されてきた。これらのモデルとパラメータ値は、被ばくが低い場合、線量限度の遵守を実証するため使用されるが、一般的に、個人のリスク評価や疫学的調査に使用されるべきでない。これが行われた例においては、不確実性が十分に再検討されなければならない。そのような個人データが利用できないならば、参照パラメータは使用されるかもしれないが、これは明確に記述されなければならない。使用におけるこの制限は、特に実効線量に適用する。個人例の評価と判断において、臓器または組織への吸収線量は、最も適切な生体動態パラメータ、電離放射線の生物学的有効性なデータ、およびリスク係数と共に使用されるべきである。

B.6.1. B.6項の参考文献

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