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EFFECT ON INTELLIGENCE TEST SCORE OF PRENATAL EXPOSURE TO IONIZING RADIATION IN HIROSHIMA AND NAGASAKI: A COMPARISON OF THE T65DR AND DS86 DOSIMETRY SYSTEMS

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SUMMARY

Analyses of intelligence test scores (Koga) at 10-11 years of age of individuals exposed prenatally to the atomic bombing of Hiroshima and Nagasaki using estimates of the uterine absorbed dose based on the recently introduced system of dosimetry, the Dosimetry System 1986 (DS86), reveal the following: 1) there is no evidence of a radiation-related effect on intelligence among those individuals exposed within 0-7 weeks after fertilization or in the 26th or subsequent weeks; 2) for individuals exposed at 8-15 weeks after fertilization, and to a lesser extent those exposed at 16-25 weeks, the mean tests scores but not the variances are significantly heterogeneous among exposure categories; 3) the cumulative distribution of test scores suggests a progressive shift downwards in individual scores with increasing exposure; and 4) within the group most sensitive to the occurrence of clinically recognizable severe mental retardation, individuals exposed 8 through 15 weeks after fertilization, the regression of intelligence score on estimated DS86 uterine absorbed dose is more linear than with T65DR fetal dose, the diminution in intelligence score under the linear model is 21-29 points at 1 Gy. The effect is somewhat greater when the controls receiving less than 0.01 Gy are excluded, 24-33 points at 1 Gy.

要 約

広島・長崎原爆胎内被爆者の10～11歳時における知能検査値(古賀式)を最近採用した線量推定方式，すなわち，1986年線量推定方式(DS86)に基づいた子宮吸収線量推定値を用いて解析した．結果は次のとおりである．1) 受胎後8週齢未満又は26週齢以上の胎内被爆者には知能に及ぼす放射線影響の証拠は認められなかった．2) 受胎後8～15週齢の胎内被爆者では被曝線量区分間に知能検査値の分散値の異質性は認められなかったが，平均値に有意な異質性を認めた．しかし，受胎後16～25週齢の胎内被爆者にはそれほど有意な異質性はなかった．3) 知能検査値の累積分布は，被曝線量の増加と共に知能検査値が累進的に下降することを示唆する．また，4) 臨床的に認められる重度精神遅滞の最も感受性の高い群，すなわち，受胎後8～15週齢の胎内被爆者では，DS86子宮吸収推定線量に基づく知能検査値の回帰解析は，T65DR胎児吸収推定線量による回帰傾向と比べてより線形的であり，線形モデルでの知能検査値の下降推定値は1 Gyで21～29点である．線量0.01 Gy以下の対照者を除外するとその影響は1 Gyで24～33点と幾分大きくなる．

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These findings are discussed in the light of the earlier analysis of the frequency of occurrence of mental retardation among the prenatally exposed survivors of the A-bombing of Hiroshima and Nagasaki. It is suggested that both are the consequences of the same underlying biological process or processes.

これらの所見を広島・長崎の原爆胎内被爆者の精神遅滞頻度に関する過去の解析結果と比べて考察した．両所見は同一の基本的な生物学的過程又は幾つかの過程の結果であることを示唆する．

INTRODUCTION

A voluminous literature testifies to severely deleterious, largely histogenetic effects on the embryonic and fetal brain of exposure to ionizing radiation[1]; much of the human evidence stems from studies of the prenatally exposed survivors of the A-bombing of Hiroshima and Nagasaki.[2-5] It is also clear that radiotherapy for brain tumors or acute leukemia in childhood can produce measurable changes in mental functioning.[6-9] "Significant reductions were found in overall IQ score for the majority of [treated] children, younger patients being most affected."[7] In the survivors of the A-bombings, the highest brain doses were an order of magnitude smaller than the tens of grays used in radiation therapy, but prolonged hospitalization of young children has effects on socialization and intellectual development that could be added to or confounded with the effects of radiation. However, studies of children with brain doses commensurate with those received by some of the prenatally exposed survivors in Hiroshima and Nagasaki (as in therapy for tinea capitis), also suggest an effect on mental function.[10-14]

緒　言

電離放射線被曝が主として胎芽及び胎児の脳の組織形成上極めて有害な影響を及ぼすことは多数の文献によって実証されている．[1] ヒトに関する所見の多くは，広島・長崎の原爆胎内被爆者に関する研究報告[2-5]によるものである．また，幼児期の脳腫瘍や急性白血病の治療に用いる放射線療法は，明らかに精神機能にかなりの変化をもたらす．[6-9]「多くの（治療を受けた）児童の知能指数全般に有意な低下が認められ，年少の患者ほど強い影響を受ける．」[7] 原爆被爆者の脳線量の最高値は放射線療法に用いた脳線量数十Gyの10分の1である．しかし，年少児童の長期入院治療は，放射線の影響に関して加算的であったり，また交絡するような社会的活動及び知的発達への影響を及ぼす．しかし，広島・長崎の胎内被爆者が受けた線量と同程度（頭部白癬の放射線療法の場合）の脳線量を受けた児童の研究によっても，精神機能に及ぼす影響が示唆されている．[10-14]

In 1986, Schull and Otake[15] analyzed intelligence test scores at 10-11 years of age of individuals exposed prenatally to the A-bombing of Hiroshima and Nagasaki using the fetal absorbed dose estimates of Kerr based on the revised T65 dosimetry.[16,17] The results revealed the following: 1) no evidence of a radiation-related effect on intelligence among those individuals exposed within 0-7 weeks after fertilization or after the 25th week; 2) the group most sensitive to the occurrence of clinically recognizable severe mental retardation, individuals exposed 8 through 15 weeks after fertilization, had mean tests scores but not variances significantly heterogeneous among exposure categories and a diminution in intelligence score under the linear-quadratic model of 21-27 points at 1 Gy. To a lesser extent those exposed at 16-25 weeks showed similar changes; 3) the regression of intelligence score on estimated fetal absorbed dose was linear or

1986年，Schull 及び大竹[15]は，広島・長崎の原爆胎内被爆者10～11歳時における知能検査値について，改定T65線量推定方式に基づくKerrの胎児吸収線量推定値を用いて解析した．[16,17] 結果は次のとおりである．1）受胎後8週齢未満又は26週齢以上の胎内被爆者には知能に及ぼす放射線影響の証拠は認められなかった．2）臨床的に認められた重度精神遅滞に対して最も感受性の高い受胎後8～15週齢の胎内被爆者では，被曝線量群間に分散の異質性は認められなかったが，平均知能検査値に有意な異質性を認めた．線形-2次関数モデルによる知能検査値の減少は1 Gy当たり21～27点であった．16～25週齢の胎内被爆者ではそれほど有意な異質性は認められなかった．3）知能検査値の推定胎児吸収線量への

linear-quadratic for the group exposed 8-15 weeks after fertilization and possibly linear for the 16-25 week group; and 4) the cumulative distribution of test scores suggested a progressive shift downwards in individual scores with increasing exposure.

These findings were necessarily tentative, for a comprehensive reevaluation of the exposure of the survivors of the A-bombing of Hiroshima and Nagasaki had begun in 1981. A new method for the estimation of individual doses, termed the Dosimetry System 1986 (DS86),[18] became available late in 1987 and is used in the present report to evaluate the quantitative effect on the developing fetal and embryonic human brain of exposure to ionizing radiation, as measured with intelligence test scores, and for comparison with the findings using the earlier dosimetry.

MATERIALS AND METHODS

Over the years, ABCC-RERF studies of the effects of ionizing radiation on prenatal development have been based on several overlapping samples of individuals exposed in utero to the A-bombing of Hiroshima and Nagasaki,[19] differing according to the purpose for which they were chosen. The results to be presented here are based on two samples, namely, one known as the original PE86, on which the greatest amount of data on intelligence testing is available, and the other, the clinical sample used in the analysis of mental retardation. The former sample includes virtually all prenatally exposed individuals who received tissue-absorbed doses of 0.50 Gy or more, and many more individuals in the dose range 0-0.49 Gy than in the clinical sample. The overlapping relationship between these two samples and a third, the in utero mortality cohort, has been described in detail in RERF TR 7-86.[15] Table 1 gives the composition of the original PE86 sample (IQ) and the clinical sample (mental retardation).

The Clinical Sample and Severe Mental Retardation. Of the 1,613 nonexposed and exposed individuals in the prenatally exposed sample in Hiroshima and Nagasaki reported by Wood et al,[3] 10 cases with unknown dose and 5 cases outside the date of birth restriction were excluded; thus the sample we use is based on 1,598 individuals.[20] This sample was defined in 1959, and differs from the original PE86 in two respects.[19] It does not include children prenatally exposed at distances between 2,000-2,999 m in Hiroshima (2,000-2,499 m in

回帰は，受胎後８～15週齢の胎内被爆群では線形あるいは線形-２次関数関係を示し，16～25週齢の胎内被爆群では線形関係を示した．4) 知能検査値の累積分布は，被曝線量の増加に伴い知能検査値が累進的に下降することを示唆した．

広島・長崎の原爆被爆者の被曝線量の再評価は既に1981年に開始されていたため，これらの所見は必然的に暫定的なものであった．1986年線量推定方式（DS86）[18]と呼ばれる個人線量を推定する新方式が1987年の終盤に利用され始めた．知能検査値を測定して胎児及び胎芽の脳の発達に及ぼす電離放射線被曝の定量的影響を評価し，また従来の線量推定方式を用いた所見と比較するために，その新方式が本報で利用される．

材料及び方法

電離放射線の胎内発育に及ぼす影響に関するABCC-放影研の調査研究は，永年にわたり，広島・長崎の原爆胎内被爆者の抽出目的の異なる種々の重複集団を基盤としてきた．[19] 本報で紹介する結果は二つの集団，すなわち知能検査に関する最大のデータ量を有する最初のPE86として知られている胎内被爆集団と，精神遅滞解析に用いた臨床検査胎内被爆集団に基づくものである．PE86集団は，0.50 Gy以上の組織吸収線量を有する者全員，及び臨床検査集団よりも多くの０～0.49 Gy線量域胎内被爆者を含んでいる．これら二つの胎内被爆集団ともう一つの集団，すなわち胎内被爆者死亡調査集団との重複関係は，放影研TR7-86に詳述されている．[15] 表１は，最初のPE86集団（IQ）と臨床検査集団（精神遅滞）の標本構成を示している．

臨床検査集団と重度精神遅滞． Woodら[3]が報告した広島・長崎の胎内被爆者集団の非被爆者及び被爆者1,613人のうち，線量不明の10例と生年月日の設定範囲外である５例を除外したので，利用集団は1,598人である．[20] この集団は1959年に定義され，二つの点で最初のPE86集団と異なる．[19] この集団は，広島の爆心地から2,000～2,999m（長崎で2,000～

TABLE 1 SAMPLE COMPOSITION OF THE TWO MAIN SOURCES OF INFORMATION ON INTELLIGENCE TESTING IN THE IN UTERO EXPOSED SAMPLE

表1 胎内被爆者集団の知能検査に関する二つの主要情報源の集団構成

Sources of data	Both cities	Hiroshima	Nagasaki
1. Original PE86 sample	1759	1012	747
(Unknown dose)	9	9	0
2. Clinical sample	1598	1250[a]	348
(Unknown dose)	10	10	0

[a] Denotes that 5 cases in Hiroshima were excluded in 1957 from the clinical sample of 1,265 children because they were found not to have been born between 6 August 1945 and 31 May 1946. One child (MF[redacted], exposed at 15 gestational weeks after fertilization, was assigned to the unknown dose group because two different, widely discrepant shielding interviews could not be recorrected. The children with unknown dose in Hiroshima thus increase from 8 or 9 in RERF TR 7-86 to 9 or 10.

1945年8月6日から1946年5月31日の間に出生していなかったことが判明した広島の5人は1957年に臨床検査集団1,265人から除外したことを示す．受胎後15週齢で被爆した1人の児童(MF[redacted])は，遮蔽に関して食い違いの大きい二つの異なる面接を再補正することができなかったので，線量不明群に割り当てた．したがって，広島の線量不明児童は，放影研TR 7-86の8～9人から9～10人に増えた．

Nagasaki), and those children exposed at greater distances or not present in the city were selected to match in sex and age (trimester) the group exposed within 2,000 m. However, many of these unexposed children were not enrolled in the study group until after the cessation of intelligence testing, and therefore test scores do not exist upon them.

All of the 30 cases of severe mental retardation in this sample were diagnosed before the age of 17, based upon clinical impressions and not on an IQ score, if such existed, and are unchanged here. A child was judged to be severely mentally retarded if he or she was "unable to perform simple calculations, to make simple conversation, to care for himself or herself, or if he or she was completely unmanageable or had been institutionalized."[3]

The Original PE86 Sample and Intelligence Test Scores. Of the 1,759 exposed and nonexposed individuals in the original PE86 sample, excluding 9 cases with unknown dose under the T65 system of dosimetry, intelligence test results are not available on 86 individuals either because of refusal to

2,499m）の胎内被爆児を含まず，その距離以遠の胎内被爆児，又は市内不在の胎内児を2,000m未満の被爆群と性及び年齢（3ケ月齢）とを一致させて抽出した．しかし，これら多数の非被爆児が調査群に加えられたのは知能検査を中止した後だったので，その知能検査値は存在しない．

この集団の重度精神遅滞者30人全員は，17歳以前に，IQ値が判明している場合でもIQ値でなく，臨床的所感に基づいて診断されたが，本報でもそのまま用いている．すなわち，「簡単な計算や会話ができない，身の回りのことが自分でできない，又は全く扱い難い者あるいは施設に収容されていた者」を重度精神遅滞者と判断した．[3]

最初のPE86集団と知能検査値． T65線量推定方式に基づく線量が不明である9例を除く最初のPE86集団の被爆者及び非被爆者1,759人のうち，86人については受診拒否，病気，転出などのため知能検査

undergo the test, illness, migration or the like. Thus, the prenatally exposed population considered here involves 1,673 children. The routine intelligence testing was conducted in 1955-56 in the clinical facilities at ABCC in Hiroshima and Nagasaki. Although two intelligence tests, the Tanaka-B and the Koga, were in vogue when these children were tested, both IQ tests were routinely used only in Nagasaki, and not in Hiroshima where the Koga test alone was employed. Accordingly, our analysis focuses on the Koga test, used on 1,673 survivors[15]; however, the Tanaka-B test results available on 739 subjects in Nagasaki will be examined to determine whether the findings depend upon the specific test of intelligence that is used, and where differences arise, attempt to reconcile them.

The eight mentally retarded individuals on whom IQ scores exist had IQs that varied between 56 and 64. The results to be presented will routinely include and exclude these individuals.

Dosimetry. For comparative purposes, the results of two analyses are presented, one based on the estimates of fetal absorbed dose using the T65D dosimetry after relocation of the hypocenter in Nagasaki (commonly referred to as the T65DR),[21] and the other, the DS86 organ dose.[18] The T65DR fetal absorbed doses are merely the estimates of maternal shielded kerma (T65DR) multiplied by transmission factors averaged over all stages of fetal development and without regard to maternal orientation or posture at the time of exposure.[17] Differences between transmission factors for estimating fetal and intrauterine doses were trivial.[17] Phantom studies[17] have shown that the correspondence between the dose in the uterus and in fetal tissues is high in the second half of pregnancy, and that uterus dose may overestimate the energy absorbed by the developing tissues in the first half when more fluid surrounds the embryo or fetus.

For survivors within 1,600 m in Hiroshima (2,000 m in Nagasaki) where the requisite shielding information exists, the DS86 estimates are computed individually without the use of average transmission factors taking into account orientation and posture, where known; thus in principle they allow better for the circumstances of exposure and the scattering of radiant energy that occurs within tissues.[18] At greater distances, where the individual doses are much smaller and detailed shielding information does not generally exist, doses are estimated by re-

結果が得られていない．したがって，本報で対象となる胎内被爆者は1,673人である．1955～56年に広島・長崎ABCCの臨床施設で通常の知能検査を実施した．児童の検診時には田中B式及び古賀式の二つの知能検査がよく用いられていたが，通常両IQテストを実施したのは長崎だけで，広島では古賀式検査のみを用いた．したがって，1,673人を研究対象として古賀式検査に限定して解析した.[15] しかし，長崎の739人の利用可能な対象者については田中B式検査の結果を検討して，所見が用いた特定の知能検査に左右されるかどうかを調べ，相違がある場合，一致させる努力をした．

IQ値の存在する8人の精神遅滞者のIQ値は56～64であった．ここに述べる結果については常に精神遅滞者を含める場合と除外する場合とがある．

線量推定方式． 二つの解析結果を比較のために示す．一つは，長崎の爆心地[21]の移動後のT65D線量推定方式（通常T65DRと称す）を用いた胎児吸収線量推定値に基づく解析結果と，他の一つはDS86臓器線量[18]に基づく解析結果である．T65DR胎児吸収線量は単に母親の遮蔽カーマ（T65DR）を胎児発育の全段階の平均透過係数で乗じた推定値にすぎず，被爆時の母親の身体方向又は姿勢は考慮に入れていない.[17] 胎児線量と子宮内線量を推定する透過係数間の差異はわずかであった.[17] ファントム調査[17]から，子宮内線量と胎児組織線量との一致は妊娠後期に高く，胎芽又は胎児がより多量の羊水に囲まれている妊娠前期には発達中の組織が吸収するエネルギーよりも子宮内線量を過大に推定する可能性があることが判明している．

必要な遮蔽情報が存在する広島の爆心地から1,600m（長崎で2,000m）以内の被爆者については，判明している場合には身体方向と姿勢を考慮に入れ，平均透過係数を使用しないで個別にDS86推定値を算出する．したがって，原則では被曝情況と組織内に生ずる放射エネルギーの散乱をより正確に考慮に入れる.[18] それ以遠の個々の線量は極めて小さく，詳細な遮蔽情報は一般に存在しないので，平均透過係数を用いる

gression methods that employ average transmission factors. However fetal absorbed doses under the new dosimetry are not yet available, and may not be for some time. Therefore, the mother's computed uterus dose has been used, ignoring the relative biological effectiveness (RBE) of neutrons.

The correspondence in estimated doses in the two systems is illustrated in Table 2 and Figure 1. The lowest dose group, the control or comparison group, consists of survivors receiving doses of less than 0.01 Gy plus individuals not-in-city (NIC) at the time of the bombing (ATB). The principal difference between the T65DR and DS86 samples is 1) the shift of 39 (24.4%) of the 160 prenatally exposed survivors in the 0.01-0.09 Gy T65DR-absorbed dose group to the 0.10-0.49 Gy DS86 group, and 2) an increase in the 1.00+ Gy group from 9 in the T65DR to 16 in the DS86 (Table 2). These changes reflect the higher transmission of gamma rays through tissue with the DS86 dosimetry. Neutrons have presumably not been a significant contributor to most fetal exposures either under the T65DR or DS86 system of dosimetry and thus RBE has been ignored.

回帰法で線量を推定する．しかし，新線量推定方式に基づく胎児吸収線量は現在まだ算出されておらず，ここ当分判明しないかもしれない．したがって，中性子の生物学的効果比（RBE）を考慮しない母親の子宮推定線量を用いてきた．

T65DR 及び DS86 両線量推定方式における推定線量の関連を表2と図1に例示している．最小線量群である対照群又は比較群は，0.01 Gy 未満の線量を受けた被爆者と原爆時（ATB）市内不在者（NIC）から構成されている．T65DR 集団と DS86 集団の主な相違点は，1) 0.01～0.09 Gy T65DR 吸収線量群の胎内被爆者160人のうち39人（24.4%）が0.10～0.49 Gy DS86 吸収線量群に移動し，2) 1.00＋Gy 群が T65DR では9人から DS86 では16人に増加したことである（表2）．これらの変更は，DS86 線量推定方式の方がガンマ線の組織透過係数が高いことを示している．中性子線は T65DR でも DS86 線量推定方式でも，ほとんどの胎児線量にとって有意な数値を占めないので，RBE は考慮しなかった．

TABLE 2 RELATIONSHIP OF FETAL ABSORBED DOSES AND UTERINE ABSORBED DOSES UNDER THE T65DR AND DS86 DOSIMETRIES FOR THE SAMPLES ON WHICH INTELLIGENCE TEST SCORES ARE AVAILABLE

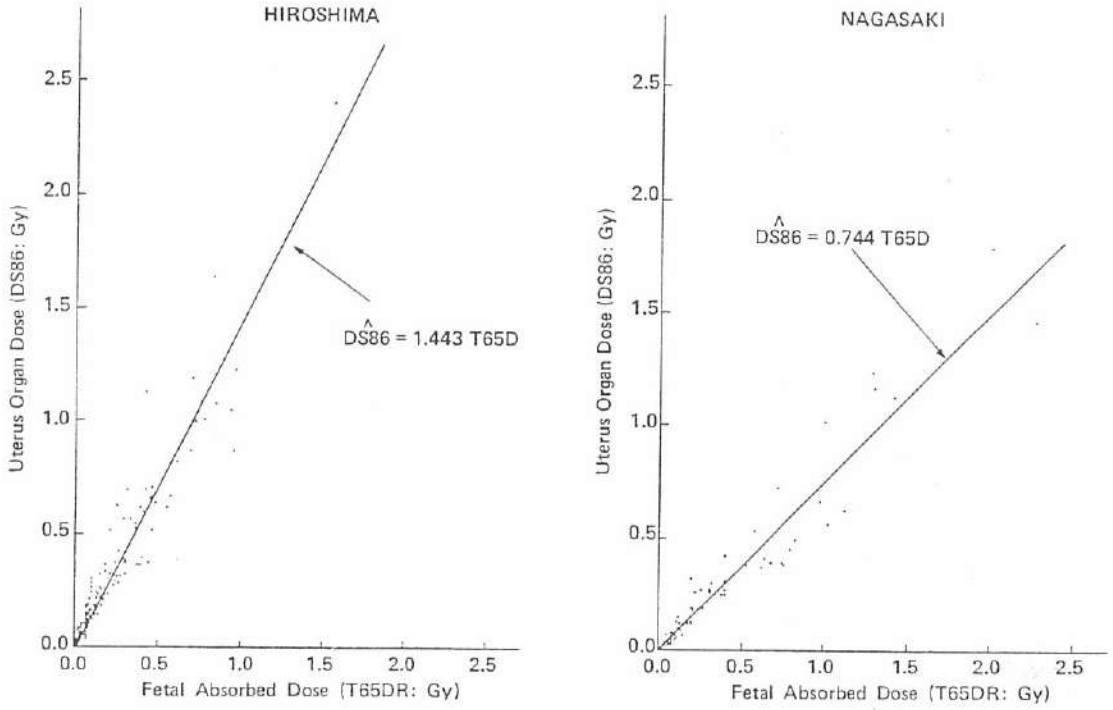
表2 知能検査値の利用可能な集団の T65DR 及び DS86 線量推定方式に基づく胎児吸収線量と子宮吸収線量との関係

Fetal absorbed dose based on T65DR(Gy)	Uterine absorbed dose based on DS86(Gy)							
	<0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+	Subsample	Unknown dose	Total
<0.01	865	47				912	291[a]	1203
0.01-0.09		121	39			160	162	322
0.10-0.49		5	74	16	1	96	15	111
0.50-0.99			9	8	8	25	1	26
1.00+				2	7	9	2	11
Total	865	173	122	26	16	1202	471	1673

[a] It should be noted that the vast majority of these cases with unknown dose stem from a change in the method of selection of the comparison group, either the not-in-city (NIC), or at distances beyond 3,000 m.
これらの線量不明者の大部分は，市内不在者（NIC）か，爆心地から3,000 m以遠の被爆者のいずれかであったが，比較群の抽出法の変更によって決まったことを注意する．

FIGURE 1 RELATIONSHIP BETWEEN T65 FETAL ABSORBED DOSE AND DS86 UTERUS ORGAN DOSE ESTIMATES FOR SUBSAMPLE OF INTELLIGENCE TEST SCORE

図1 知能検査値の部分集団のT65胎児吸収線量推定値及びDS86子宮臓器線量推定値との関係



The numbers of children with unknown DS86 doses but known T65DR doses are given in Table 2. Each of these has been tentatively assigned a uterus dose, based on the following procedure: They were aggregated into 0.10 Gy dose intervals based on their T65DR doses. This was also done for the largest Life Span Study (LSS) cohort on whom both T65DR and DS86 doses exist. The mean uterus dose within each 0.10 Gy interval was then calculated for the latter group, and this value assigned to the individuals in the same T65DR interval on whom DS86 doses are not available.

The validity of this procedure rests on a number of assumptions. Possibly the most important is the presumption that the same structural transmission factors seen among members of the LSS sample on whom DS86 doses can be computed obtain in the unknown dose group as well, and in the same

DS86 線量は不明であるが T65DR 線量は既知である児童数を表 2 に示している．以下の手順に基づいて，DS86 線量不明の個々の児童に暫定的子宮線量を付与した．T65DR 線量に基づき児童を 0.10 Gy 線量間隔に区分した．T65DR 及び DS86 線量の両方が存在する最大の寿命調査（LSS）コホートも同じ手順で区分し，後者のグループの各 0.10 Gy 区間内の平均子宮線量を求め，この平均値を DS86 線量が不明である T65DR の 0.10 Gy 区間の対象者に与えた．

この手順の有効性は幾つかの仮定の基に成立する．最も重要なものは，DS86 線量が算出できる寿命調査集団の対象者に認められる家屋透過係数と同一の係数が線量不明群にも同一頻度で得られると仮定し

relative frequencies. This cannot be true strictly, for at present, the DS86 dosimetry system has not been developed to the point where it can accommodate individuals exposed within concrete structures, air raid shelters, nonwooden factories, and the like. Individuals within such structures are not included in the 75,991 LSS sample members whose dose distribution serves as the basis for our procedure. However, the transmission factors for the structures cited above will, on average, surely be lower than those associated with wooden houses or tenements, and thus our procedure tends to err in assigning a dose which is actually higher than that probably received. Given the distances at which most of the individuals in the unknown DS86 dose group were exposed, this error should be small in absolute terms, although conceivably large relatively for these specific persons.

ている．目下のところ，DS86 線量推定方式は，コンクリート建造物，防空壕，木造以外の工場などの内部で被爆した対象者についての情報を提供するところまで開発されていないので，この仮定は厳密には正しいとは言えない．そこで，このような建造物内にいた対象者は，線量分布がここでの手順の根拠となっている寿命調査集団の75,991人の中には含まれていない．しかし，上述の建造物の透過係数は平均すると，木造家屋又は長屋の透過係数よりも低いことは確実である．したがって，この手順は，多分受けた線量よりも実際高い線量を誤って付与する傾向がある．DS86 線量不明群の大部分の対象者が被爆した距離を考えれば，この誤差は，これらの特定対象者に関しては比較的に大きいと考えられているが，絶対的には小さいものであろう．

In the analyses to follow, three different groups will be used. The first of these involves individuals on whom a DS86 dose has been either directly computed or assigned by the procedure just described; this group has been designated the "DS86: PE86 sample". The remaining two groups are termed the "T65DR: PE86 sample" and the "DS86: Clinical subsample", respectively.

後述の解析では，三つの異なる群を用いる．最初の解析では，DS86 線量が直接算出されているか又は記述した手順によって付与された対象者を含む．この群は「DS86: PE86 集団」と呼ばれている．残り二つの群は，それぞれ，「T65DR: PE86 集団」，「DS86: 臨床検査の部分集団」と呼ばれている．

Gestational Age. The date of pregnancy ATB is based upon the inferred first day of the last menstrual period, and has been calculated with the following function:

胎内週齢． 原爆時の妊娠日数は，最終月経の推定開始日に基づき，次の方式を用いて算出した．すなわち，

$$\text{Days of pregnancy ATB} = 280 - (\text{Date of birth} - 6 \text{ or } 9 \text{ August } 1945)$$

原爆時妊娠日数　　生年月日

where the mean duration of pregnancy is taken to be 280 days, and the date of birth was obtained by interview with the individual or his or her mother. To obtain the age after fertilization, 14 days have been subtracted from the "days of pregnancy ATB". Age in days was changed to age in weeks by dividing by seven and the latter quotient was presumed to be zero if it was negative.

ここで，平均妊娠期間を280日とし，生年月日は本人又は母親との面接で得られたものを用いた．受胎後の胎内日数は，「原爆時妊娠日数」から14日を引いて算出した．この胎内日数を7で割って胎内週齢を求め，後者の値が負になる場合は週齢をゼロと仮定した．

The most important single factor in determining the nature of the insult to the developing embryo or fetus resulting from ionizing radiation is its stage of development at the time of exposure. Accordingly, since different functions in the human brain are localized into different structures, and the differentiation of these takes place at different

発達中の胎芽又は胎児に与える電離放射線障害の特徴を決定する上で被爆時の発達段階は，最も重要な因子である．ヒトの脳の種々の機能は異なる組織に局在しており，また，各組織の分化は異なる発達

stages of development and over different periods of time, gestational ages have been grouped so as to reflect these phases in normal development. Four categories measured from the presumed moment of fertilization have been used: 0-7, 8-15, 16-25, and 26 or more weeks. Briefly, these correspond to the timing of the following biological events (a fuller account will be found in the report of an ICRP Task Group[22]): In the first period, the precursors of the neurons and neuroglia, the two principal types of cells that give rise to the cerebrum, have emerged and are mitotically active.[23] In the second, a rapid increase in the number of neurons occurs; they migrate to their final developmental sites and lose their capacity to divide, becoming perennial cells.[24,25] In the third, differentiation in situ accelerates, synaptogenesis that began about the eighth week increases, and the definitive cytoarchitecture of the brain unfolds. The fourth period is largely one of continued architectural and cellular differentiation and synaptogenesis.

段階及び異なる時期に起こるので，これらの正常な発達段階を反映するように胎内週齢を分類した．すなわち，推定受胎日から計算して，0～7週，8～15週，16～25週及び26週以上の四つの時期に区分した．簡単に述べると，これらの分類は次の生物学的事象の時期に対応している（詳細はICRPタスク・グループの報告書を参照するとよい[22]）．第一期では，脳を構成する主要細胞であるニューロン及びニューログリアの前駆体が発生し，両者は活発に有糸分裂する．[23] 第二期には，ニューロン数が急増し，ニューロンは最終的な発育部位へと移動し，細胞分裂の特性を失って非分裂細胞となる．[24,25] 第三期では，潜在的分化が促進され，8週目ごろに始まるシナプスの形成が増加し，脳の最終的な細胞構築が進む．第四期では，主として構築と細胞分化及びシナプス形成が継続する．

Statistical Considerations and Methods

A variety of standard regression models have been fitted to the data: a linear (L), a linear-quadratic (L-Q), a quadratic (Q), and a linear exponential (expL) dependent on the DS86 uterine absorbed doses or T65DR fetal absorbed doses. Obviously other models could have been fitted, but in the absence of an understanding of the molecular, cellular or tissue events involved in radiation-related damage to the developing brain, the ones selected are simple and provide a pragmatic basis for risk estimation. We include the linear exponential model since it is the common expression connecting cell survival to dose. In the discussion to follow, emphasis will be placed upon the linear and linear-quadratic models; however, it should be noted that neither the sensitive periods nor the significance of the dose-response relationships depends upon the specific model that is fitted. As a preliminary to the model fitting, the homogeneity of IQ means and variances among four (or five) dose categories by gestational ages after fertilization has been examined.

Three questions have been addressed in this analysis. First, do the means (or variances) of the distribution of intelligence test scores within a gestational age-group differ significantly and systematically between exposure categories? Second, do the test scores within a gestational age-group appear to conform to a single unimodal probability

統計学的検討及び方法

種々の標準的回帰モデルをデータに適合させた．すなわち，線形モデル（L），線形-2次モデル（L-Q），2次モデル（Q）及び線形指数モデル（expL）をDS86子宮吸収線量又はT65DR胎児吸収線量に対応させる．明らかに，他のモデルを適合させることもできるが，発達中の脳に及ぼす放射線障害に関与する分子，細胞又は組織事象についてはまだわかっていないので，選ばれたモデルは単純であり，リスク推定の実際的基盤を与えている．細胞の生存と線量との関係は共通の関連式なので線形指数モデルを含める．後の「考察」の項では，線形モデル及び線形-2次モデルに重点をおく．しかし，感受性の危険期も線量反応関係の有意性も適合させる特定モデルに依存しない点に留意すべきである．モデル適合への手始めとして，受胎後胎内週例別の四つ（又は五つ）の線量群間でIQの平均及び分散の等質性を調べた．

本解析では，三つの問題について検討した．第一に，特定の胎内週齢群内における知能検査値の平均（又は分散）は，被曝線量群間で有意にかつ系統的に異なるのかどうか．第二に，特定の胎内週齢群内における知能検査値は簡単な単峰形確立分布を示すかどうか，

distribution, or is there any evidence that the small group of survivors with clinically recognized severe mental retardation form a category sui generis? Finally, do test scores within an age-group vary with the level of an individual's radiation exposure, and if so, what is the form of the dose-response relationship?

RESULTS

Means and Variances. Tables 3a and b present estimates of mean test scores (and standard deviations) for the four previously identified categories of embryonic or fetal age (0-7, 8-15, 16-25, and 26 weeks or more), and five categories of absorbed dose (less than 0.01, 0.01-0.09, 0.10-0.49, 0.50-0.99, and 1 Gy or more) in the PE86 sample based on the T65DR doses, the clinical subsample based on the DS86 doses and the PE86 sample based on the DS86 doses.

Table 3a includes data on those eight mentally retarded children (5 in Hiroshima; 3 in Nagasaki) who were given intelligence tests; Table 3b does not. These eight children, whose diagnosis of mental retardation was made clinically without reference to the intelligence tests, had scores that ranged from 56 to 64; of the eight, six (3 in the 8-15 week group, and 3 in the 16-25 week one) had estimated T65DR exposures of 0.5 Gy or more. Furthermore all three in the 16-25 week group in the clinical sample and the PE86 sample had exposures of 1 Gy or more based on the DS86 system. Clearly, their presence has an important effect on the mean score among the 45 individuals of all gestational ages with DS86 exposures of 0.5 Gy or more, and they have been excluded from some of the analyses in an effort to ascertain whether an effect on intelligence also exists among the children not clinically recognized as retarded.

As is apparent from Table 3a, the mean IQ scores decrease significantly and systematically with uterine or fetal tissue dose within the age-groups 8-15 and 16-25 weeks. If these differences are pursued further at the sex and city levels (data not shown), the means for males (cities combined) are found to vary significantly with dose only in the age-group 8-15 weeks; the means for females are significantly different among dose categories in the age-groups 8-15 and 16-25 weeks for the PE86 sample based on the T65DR doses. A similarly highly significant decreasing trend, however, was observed for males

又は，臨床的に認められた重度精神遅滞を有する胎内被爆者の部分集団は特殊なカテゴリーを形成するのかどうか．最後に，特定の週齢群内における知能検査値は個人線量に対して直接変動するのか，また，もしそうであれば，どのような線量反応関係の形状を示すのかという点である．

結　果

平均及び分散． 表3a及びbは，T65DR線量に基づくPE86集団，DS86線量に基づく臨床検査の部分集団及びDS86線量に基づくPE86集団において前に確認した四つの胎内週齢群(0～7週，8～15週，16～25週及び26週以上)並びに五つの胎児吸収線量群(0.01 Gy未満，0.01～0.09 Gy，0.10～0.49 Gy，0.50～0.99 Gy及び1 Gy以上)のそれぞれの平均知能検査値(及び標準偏差)の推定値を示している．

表3aは，知能検査を受けた精神遅滞児8人(広島5人，長崎3人)に関するデータを含んでいるが，表3bは含んでいない．これら8人の精神遅滞児は臨床的に認められたものであり，知能検査の結果によるものではない．8人の検査値の範囲は56～64点である．このうち6人(8～15週齢群3人，16～25週齢群3人)の推定T65DR線量は0.5 Gy以上であった．更に，臨床検査集団及びPE86集団における16～25週齢群の3人全員とも，DS86線量推定方式に基づく被曝線量は1 Gy以上であった．これら8人の存在は明らかに，DS86被曝線量が0.5 Gy以上である全胎内週齢の45人の対象者の平均知能検査値に重要な影響を及ぼす．臨床的に遅滞と認められなかった児童の間で知能に対する影響が存在するかどうかを確認するために幾つかの解析についてはこの8人を除外した．

表3aから明らかなように，8～15週齢群及び16～25週齢群における平均IQ値は，子宮又は胎児組織線量と共に有意にかつ系統的に低下する．更に，これらの差異を性及び都市別に検討すると(データは示していない)，男性の平均(両市合計)は，8～15週齢群においてのみ線量と共に有意に変動し，女性の平均では，T65DR線量に基づくPE86集団の8～15週齢群及び16～25週齢群で被曝線量群間に有意な差異が

and females in the 8-15 week group and also for males and females in the clinical subsample based on the DS86 doses, and for males and females in both the 8-15 and 16-25 weeks in the PE86 sample, again, based on the DS86 doses.

Within cities (sexes pooled), all IQ means except for the 0-7 week group are significantly heterogeneous among dose categories in Hiroshima and Nagasaki, as judged by the PE86 sample and the T65DR dosimetry. However, significant heterogeneity among dose categories is restricted to the two sensitive gestational age categories in Hiroshima [8-15 (significant at the 1% level) and 16-25 (1%)] for the clinical subsample based on the DS86 system, and also in both cities [8-15 (1%) and 16-25 (1%)] for the PE86 sample based on the same dosimetric system. These further subdivisions make the individual sample sizes smaller, and the possible distorting effect of the inclusion of the clinically mentally retarded greater.

認められる．しかし，８～15週齢群の男女，DS86線量に基づく臨床検査集団の男女，及びDS86線量に基づくPE86集団の８～15週齢群及び16～25週齢群の男女については，やはり同じように有意性の高い低下傾向が観察された．

都市別（男女合計）では，PE86集団及びT65DR線量推定方式から判断されるように，広島・長崎の線量群間で，０～７週齢群を除く平均IQ値すべてに有意な異質性を認めた．しかし，線量群間に有意な異質性が認められるものは，DS86線量推定方式に基づく臨床検査の部分集団では広島における感受性の高い二つの胎内週齢群，すなわち，〔８～15週齢群（１％レベルで有意）及び16～25週齢群（１％で有意）〕，また同一線量方式に基づくPE86集団の場合では両市においても同じ週齢群〔８～15週齢群（１％）及び16～25週齢群（１％）〕に限定される．したがって，このような細区分により，各群内集団の規模は小さくなり，臨床的に確認された精神遅滞者を含めることから起こる歪みの影響は大きくなる．

TABLE 3a MEAN INTELLIGENCE SCORE (KOGA) BY GESTATIONAL AGE AT EXPOSURE AND FETAL OR UTERINE ABSORBED DOSE BASED ON THE T65DR AND DS86 DOSIMETRIES. ALL INDIVIDUALS ON WHOM INTELLIGENCE TEST DATA ARE AVAILABLE ARE TABULATED, INCLUDING THOSE DIAGNOSED CLINICALLY AS MENTALLY RETARDED

表3a 平均知能検査値（古賀式），原爆時胎内週齢別，並びにT65DR及びDS86線量推定方式に基づく胎児又は子宮吸収線量別．臨床的に診断された精神遅滞者を含む知能検査データの利用可能な全対象者

Gestational ages (Weeks)	Dose Categories (Gy)						F^+ (df_1, df_2)	P
	<0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+	All		
A. PE86 sample based on T65DR								
0-7 Weeks								
N	200	49	16	2	2	269	1.58	
Mean	107.0	102.1	108.9	98.5	95.0	106.1	(4, 264)	0.18
SD	14.54	15.41	15.24	19.09	42.43	15.03		
8-15 Weeks								
N	229	78	32	7	4	350	9.88	
Mean	108.4	111.8	102.0	83.1	76.3	107.7	(4, 345)	<0.01
SD	15.76	17.35	16.88	25.53	9.74	17.22		
16-25 Weeks								
N	341	96	28	13	2	480	6.29	
Mean	110.7	106.5	107.6	97.0	71.5	109.2	(4, 475)	<0.01
SD	15.54	16.57	10.66	25.78	16.26	16.21		
26+ Weeks								
N	433	99	35	4	3	574	2.09	
Mean	108.2	103.7	104.9	114.5	108.0	107.3	(4, 569)	0.08
SD	15.46	16.40	15.98	10.50	8.89	15.67		
All gestational ages								
N	1203	322	111	26	11	1673	10.54	
Mean	108.8	106.3	105.3	96.1	87.5	107.7	(4, 1668)	<0.01
SD	15.43	16.82	15.01	24.60	22.13	16.08		

(Continue 続く)

TABLE 3a Continued 続き

Gestational ages (Weeks)	Dose Categories (Gy)						F^+ (df_1, df_2)	P
	<0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+	All		
B. Clinical subsample based on DS86								
0-7 Weeks								
N	142	21	13	1	2	179	1.61	
Mean	106.2	109.1	97.9	115.0	95.0	105.9	(3,175)	0.19
SD	14.76	16.62	12.68	-	42.43	15.25		
8-15 Weeks								
N	171	39	34	7	5	256	10.92	
Mean	107.3	110.5	102.4	90.6	69.2	105.9	(4, 251)	<0.01
SD	14.57	17.01	14.27	22.58	9.86	16.24		
16-25 Weeks								
N	253	48	34	13	4	352	6.40	<0.01
Mean	111.0	108.3	107.9	104.1	73.3	109.7	(4, 347)	
SD	15.21	18.49	15.02	15.83	24.60	16.28		
26+ Weeks								
N	299	65	41	5	5	415	1.70	
Mean	108.2	103.2	106.0	101.0	105.2	107.1	(4, 410)	0.15
SD	15.24	16.52	14.10	12.10	21.31	15.43		
All gestational ages								
N	865	173	122	26	16	1202	11.96	
Mean	108.5	107.0	104.7	100.3	84.7	107.4	(4, 1197)	<0.01
SD	15.10	17.33	14.44	17.57	25.64	15.89		
C. PE86 sample based on DS86								
0-7 Weeks								
N	196	52	18	1	2	269	0.39	
Mean	106.6	105.1	103.7	115.0	95.0	106.1	(3, 265)	0.76
SD	14.33	16.53	15.79	-	42.43	15.03		
8-15 Weeks								
N	218	79	40	7	6	350	10.89	
Mean	108.4	111.6	104.7	90.6	71.5	107.7	(4, 345)	<0.01
SD	15.81	17.82	15.39	22.58	10.46	17.22		
16-25 Weeks								
N	327	99	35	15	4	480	7.42	
Mean	110.7	107.4	107.4	100.7	73.3	109.2	(4, 475)	<0.01
SD	15.42	16.67	15.11	17.17	24.60	17.11		
26+ Weeks								
N	415	105	44	5	5	574	1.52	
Mean	108.2	104.4	106.5	101.0	105.2	107.3	(4, 569)	0.19
SD	15.47	16.85	13.92	12.10	21.31	15.67		
All gestational ages								
N	1156	335	137	28	17	1673	12.95	
Mean	108.7	107.1	105.8	98.8	84.6	107.7	(4, 1668)	<0.01
SD	15.38	17.14	14.81	17.84	24.83	16.08		

\+ Indicates the significance of the difference among dose means within an age-group.
同一週齢群内の線量群の平均検査値間の差の有意性を示す.

The two high dose categories were combined when the cases were few in number.
症例数が少ない場合には二つの高線量群を合計した.

The average fetal absorbed doses, corresponding to each dose category, are 0, 0.04, 0.24, 0.72, 1.51 for the original PE86 based on T65DR (A); 0, 0.04, 0.23, 0.64, 1.29 for the clinical subsample based on DS86(B), and 0, 0.04, 0.23, 0.65, 1.33 for the original PE86 based on DS86(C).
胎児吸収線量の平均は，各線量群に対応し，T65DRに基づく最初のPE86集団(A)では，0，0.04，0.24，0.72，1.51；DS86に基づく臨床検査の部分集団(B)では0，0.04，0.23，0.64，1.29，及びDS86に基づく最初のPE86集団(C)では0，0.04，0.23，0.65，1.33である.

TABLE 3b MEAN INTELLIGENCE SCORE (KOGA) BY GESTATIONAL AGE AT EXPOSURE AND FETAL OR UTERINE ABSORBED DOSE BASED ON THE T65DR AND DS86 DOSIMETRIES. ALL INDIVIDUALS ON WHOM IQ DATA ARE AVAILABLE ARE INCLUDED EXCEPT THOSE DIAGNOSED CLINICALLY AS MENTALLY RETARDED

表3b 平均知能検査値（古賀式），原爆時胎内週齢別，並びにT65DR及びDS86線量推定方式に基づく胎児又は子宮吸収線量別．臨床的に診断された精神遅滞者を除いたIQデータの利用可能な全対象者

Gestational ages (Weeks)	Dose Categories (Gy)						$F^{\dagger}$ (df_1, df_2)	P
	<0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+	All		
A. PE86 sample based on T65DR								
0-7 Weeks								
N	200	49	16	2	2	269	1.58 (4, 264)	0.18
Mean	107.0	102.1	108.9	98.5	95.0	106.1		
SD	14.54	15.41	15.24	19.09	42.43	15.03		
8-15 Weeks								
N	228	78	32	5	3	346	5.54 (4, 341)	<0.01
Mean	108.6	111.8	102.0	92.4	81.0	108.3		
SD	15.40	17.35	16.88	24.39	2.65	16.51		
16-25 Weeks								
N	341	96	28	11	1	477	2.93 (3, 473)	0.03
Mean	110.7	106.5	107.6	103.5	83.0	109.5		
SD	15.54	16.57	10.66	22.32	-	15.80		
26+ Weeks								
N	432	99	35	4	3	573	2.22 (4, 568)	0.07
Mean	108.3	103.7	104.9	114.5	108.0	107.4		
SD	15.30	16.40	15.98	10.50	8.89	15.56		
All gestational ages								
N	1201	322	111	22	9	1665	5.30 (4, 1660)	<0.01
Mean	108.8	106.3	105.3	102.5	93.3	107.9		
SD	15.30	16.82	15.01	20.91	19.96	15.78		
B. Clinical subsample based on DS86								
0-7 Weeks								
N	142	21	13	1	2	179	1.61 (3, 175)	0.19
Mean	106.2	109.1	97.9	115.0	95.0	105.9		
SD	14.76	16.62	12.68	-	42.43	15.25		
8-15 Weeks								
N	170	39	34	6	3	252	5.76 (4, 247)	<0.01
Mean	107.6	110.5	102.4	95.0	76.0	106.7		
SD	14.07	17.01	14.27	21.15	3.46	15.26		
16-25 Weeks								
N	253	48	34	13	1	349	1.35 (3,345)	0.26
Mean	111.0	108.3	107.9	104.1	110.0	110.1		
SD	15.21	18.49	15.02	15.87	-	15.71		
26+ Weeks								
N	298	65	41	5	5	414	1.86 (4, 409)	0.12
Mean	108.4	103.2	106.0	101.0	105.2	107.2		
SD	15.00	16.52	14.10	12.10	21.31	15.28		
All gestational ages								
N	863	173	122	25	11	1194	4.71 (4, 1189)	<0.01
Mean	108.7	107.0	104.7	101.7	95.8	107.7		
SD	14.92	17.33	14.44	16.27	23.37	15.46		
C. PE86 sample based on DS86								
0-7 Weeks								
N	196	52	18	1	2	269	0.39 (3, 265)	0.76
Mean	106.6	105.1	103.7	115.0	95.0	106.1		
SD	14.33	16.53	15.79	-	42.43	15.03		
8-15 Weeks								
N	217	79	40	6	4	346	6.04 (4, 341)	< 0.01
Mean	108.6	111.6	104.7	95.0	77.8	108.3		
SD	15.44	17.82	15.39	21.15	4.50	16.51		
16-25 Weeks								
N	327	99	35	15	1	477	2.87 (3, 473)	0.04
Mean	110.7	107.4	107.4	100.7	110.0	109.5		
SD	15.42	16.67	15.11	17.17	-	15.80		
26+ Weeks								
N	414	105	44	5	5	573	1.64 (4, 568)	0.16
Mean	108.3	104.4	106.5	101.0	105.2	107.4		
SD	15.30	16.85	13.92	12.10	21.31	15.56		
All gestational ages								
N	1154	335	137	27	12	1665	5.49 (4, 1 660)	<0.01
Mean	108.8	107.1	105.8	100.0	94.8	107.9		
SD	15.24	17.14	14.81	16.80	22.59	15.78		

See footnote in Table 3a. 表3aの脚注参照.

Table 3b exhibits the IQ means when the mentally retarded are excluded; again, they vary significantly with dose for the age-groups 8-15 and 16-25 weeks for the PE86 sample based on the T65DR doses. Significant heterogeneity is also noted in the 8-15 week interval in both the DS86 clinical subsample and the DS86 PE86 sample, but not for the 16-25 week group in the DS86 clinical subsample. Three of the four children who were exposed to 1 Gy or more 16-25 weeks after fertilization were severely mentally retarded.

Rigorous interpretation of these results hinges on an examination of the issue of inhomogeneities in the data for three reasons. First, if there is a mixture of individuals within the different embryonic and fetal age-groups, some of whom were affected and some not, the results to be described have applicability only to the former. Second, the validity of the statistical procedures used rests upon certain assumptions about the nature of the underlying distribution of the variables under scrutiny. These include normality and equality of variances. If a commingling of populations has occurred, neither of these assumptions is fulfilled and the tests are at best approximations, and may be actively misleading. Third, if one is to conclude that the effects are due to exposure to ionizing radiation, it must be shown that the dose groupings are not related to other factors affecting intelligence.

When examined by Bartlett's test (Figure 2), there is no compelling evidence that the variances are different either among dose groups for fixed gestational ages, or among gestational ages for fixed dose groups.

The Distributions of Intelligence Test Scores. Most of the tests of significance we have or will use have been derived under the assumption that the variable of interest is normally distributed. Although generally robust against modest departures from normality, they presuppose a symmetric, bell-shaped curve. To determine whether this is or is not so in the present instance, the skewness of the distributions of intelligence test scores within age- and age-exposure-groups was examined using Fisher's estimate[26] and the cumulative distributions were plotted to search for inflections that might suggest asymmetry. In the DS86 clinical subsample, of the 20 measures of skewness in the age-exposure cells in Table 3a, 9 are positive, 9 are negative,

精神遅滞者を除外した場合の平均IQ値を表3bに示したが，この平均値は，T65DR線量に基づくPE86集団の8～15週齢群及び16～25週齢群において線量と共に有意に変化する．DS86臨床検査の部分集団及びDS86 PE86集団における8～15週齢群でも有意な異質性が認められたが，DS86臨床検査の部分集団の16～25週齢群では認められなかった．受胎後16～25週齢群で1 Gy以上の被曝児4人のうち3人は重度精神遅滞児であった．

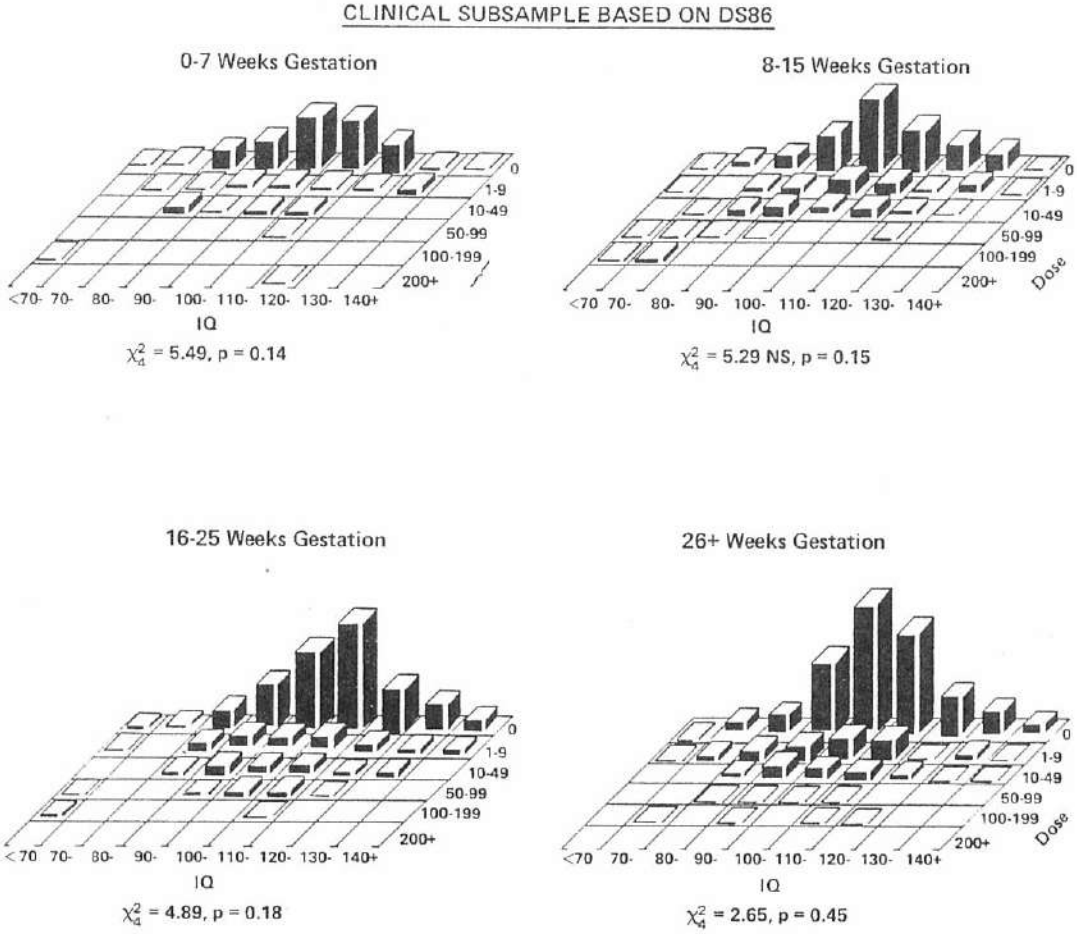
これらの結果を正確に解釈するためには，三つの理由からデータに内在する異質性の問題を検討しなければならない．すなわち，第一に，異なる胎内週齢群に属する子供が混在し，ある者は知能に影響を受け，ある者はそうでないとすれば，本報で述べる結果は前者にしか適用できない．第二に，適用した統計的方法の妥当性は，検討下にある変数の基礎分布の性質についてのある仮定に基づいている．これらは変数の正規性及び分散の等質性などを含む．異質な対象集団の混在がある場合は，いずれの仮定も成立せず，また，テストは最も良い状態でも近似にすぎず，実際には誤解を導きやすい．第三に，観察された影響が電離放射線被曝によるものであると結論付ける場合に，線量区分は知能に影響を及ぼす他の因子に関連していないことを示さねばならない．

Bartlett検定で調べると（図2），固定した胎内週齢群に対する線量群間，あるいは固定した線量群に対する胎内週齢群間のいずれにも分散の差異が認められることを強く示唆する証拠はない．

知能検査値の分布． 現在利用し，又は利用する大抵の有意性検定は，興味ある変数が正規分布するという仮定に基づいている．有意性検定は正規性からの小さな逸脱に対しては強く一般的にロバストであるが，対称，鐘形曲線を前提としている．今回，この仮定が正しいかどうかを決定するために，週齢群及び週齢-被曝線量群内の知能検査値分布の歪度をFisherの推定値[26]を用いて調べ，更に，非正規性を示唆する歪みの探知については累積分布をプロットした．DS86臨床検査の部分集団において，表3aの年齢-被曝線量区分での歪度の20推定値のうち，9が正，9が負，2が不確定である（標本規模は2以下

FIGURE 2 DISTRIBUTION OF INTELLIGENCE TEST SCORES BY GESTATIONAL AGE ATB AND ESTIMATED UTERINE ABSORBED DOSE

図 2 知能検査値の分布，原爆時胎内週齢別及び子宮吸収推定線量別



Chi-square value denotes a test of homogeneity of variances.
See Table 3a for number of individuals in each dose category.

and 2 are indeterminate (the sample sizes are two or less). They range from −0.96 to 0.34 and no one deviates significantly from zero. These findings are consistent with a single unimodal probability distribution; alternatively, there is no evidence of a commingling of two or more distributions which could be interpreted as supporting the notion of groups of individuals with differing sensitivities to ionizing radiation.

である）．その範囲は−0.96から0.34であり，ゼロから有意に離れているものはない．これらの所見は，簡単な単峰形確率分布をもつものと一致する．換言すると，二つ以上の分布が混在していて，それが電離放射線に対して異なる感受性をもつ対象者のグループがあるという考え方を支持していると解釈できる証拠はなかった．

Figure 2 presents graphically the age-by-dose group-specific frequency distributions of the intelligence test scores for the DS86 clinical sample. The cumulative probability distributions associated with the test scores, with and without inclusion of the clinically diagnosed cases of mental retardation, differ little, if at all, from that expected of a homogeneous sample from a normal distribution (data not shown). This suggests that the difference in means (but not variances) previously described results from a shift in the distribution of scores downwards as exposure increases, and is not attributable solely to the inclusion of a qualitatively different group of individuals who respond more extremely to exposure to ionizing radiation.

Regression Analyses. A better analytic approach than analysis of variance, one that does not depend upon grouping of data and provides explicit estimates of risk, is to fit a regression of intelligence test scores on the individual estimates of exposure within an age-group. This has been done both with and without the inclusion of the mentally retarded (see Figure 3 for the mean scores and their 95% confidence intervals).

Table 4a presents the regression coefficients obtained when a linear dose-response model is fitted to all of the data available for the three samples and for the two systems of dosimetry. Significant linear coefficients occur for the 8-15, and 16-25 week age-groups in all three samples. Significant heterogeneity exists among the four age-group-specific regression coefficients. When the eight clinically diagnosed cases of mental retardation are removed, the regression coefficients associated with the 8-15 and the 16-25 week age-groups are again significant but less strikingly so. Those associated with the 8-15 week age-group change little, but those for the 16-25 weeks become a little smaller (about half to two-thirds of their former values). The coefficients for the four age-groups are not significantly heterogeneous for the PE86 sample based on the T65DR doses, but are for the clinical subsample and PE86 sample based on DS86. The loss in IQ appears substantial (21 to 29 points per gray of absorbed energy, based on DS86, for the 8-15 week group and 10 to 21 for the 16-25).

To examine the internal consistency of the data further, the control cases, those individuals who received less than 0.01 Gy or were not in Hiroshima or Nagasaki ATB, have been excluded and the

図2は，DS86臨床検査集団の知能検査値の週齢別及び線量群別度数分布を図示したものである．臨床的に診断された精神遅滞例を含めても含めなくても，知能検査値の累積確率分布は，正規分布からの等質標本（データは示していない）とは異質であるとしても，ほんのわずかな差異を示すにすぎない．このデータが示唆するところによれば，先述の（分散ではなく）平均値に差があるのは被曝線量の増加と共に知能検査値の分布が下降するためであり，電離放射線に過度に反応する質的に異なる集団が含まれているためではないと考えられる．

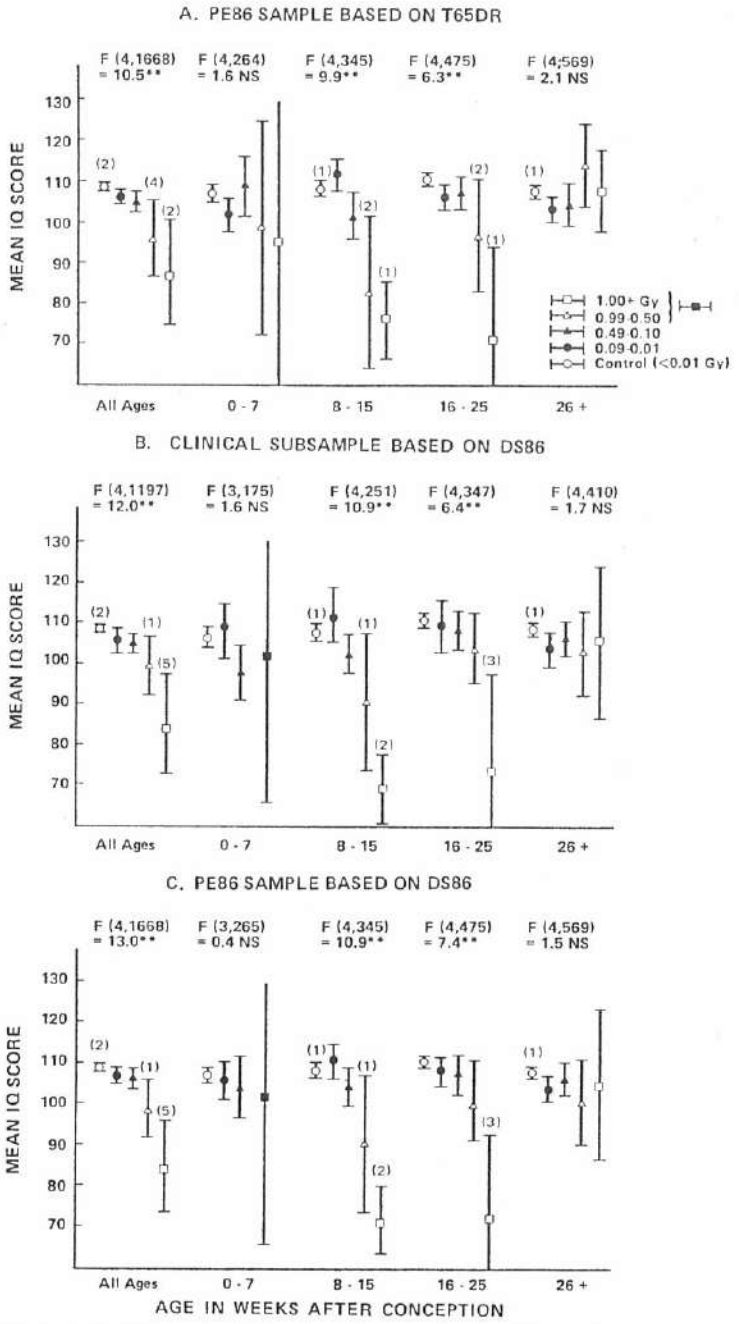
回帰解析． 分散解析より優れた解析法，すなわち，データ区分の仕方に依存しないで，明確なリスク推定値を求める方法は，ある週齢群内の個人推定線量に対する知能検査値への回帰を当てはめる方法である．精神遅滞者を含めた場合と除外した場合のいずれにも，この方法を適用した（平均知能検査値とその95%信頼区間については図3を参照）．

線形線量反応モデルを三つのすべての標本と両線量推定方式について利用可能な全データに当てはめた場合に得られる回帰係数を表4aに示した．有意な線形係数は三つのすべての集団において8～15週齢群及び16～25週齢群に認められた．四つの週齢群別回帰係数間に有意な異質性が存在する．臨床的に診断された精神遅滞者8人を除外すると，8～15週齢群と16～25週齢群の回帰係数はやはり有意ではあるが，顕著ではない．8～15週齢群の回帰係数はほとんど変化しないが，16～25週齢群の係数は若干小さくなる（除外しない値の1/2から2/3程度）．四つの週齢群の回帰係数は，T65DR線量に基づくPE86集団の場合には有意な異質性は認められないが，DS86に基づく臨床検査の部分集団並びにPE86集団の場合には有意な異質性が認められる．IQの低下は本質的であるように思われる（8～15週齢群は，DS86に基づく場合，吸収線量1 Gy当たり21～29点の低下を示し，16～25週齢群は10～21点の低下を示した）．

更にデータの内的一致性を調べるために，対照者，すなわち，被曝線量が0.01 Gy未満の者，又は原爆時に広島・長崎にいなかった者を除外して，上述の

FIGURE 3 MEAN IQ SCORE AND 95% CONFIDENCE LIMITS BY GESTATIONAL AGE IN WEEKS AND TISSUE-ABSORBED DOSE

図3 平均IQ値及び95%信頼限界，胎内週齢別及び組織吸収線量別



The numbers in parentheses are severe mentally retarded cases, where the highest IQ score among them was 64.
括弧内の数は重度精神遅滞者数．重度精神遅滞者のIQ最高値は64であった．

See Table 3b on these results of A, B, and C, respectively, when the severe mentally retarded cases were excluded.
重度精神遅滞者を除外した場合のA，B，Cそれぞれの結果については表3bを参照．

TABLE 4a THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE

表4a 個人の胎児又は子宮吸収線量に対する知能検査値への線形モデルを利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	b	S_b	
All cases included					
A. PE86 sample based on T65DR					
0-7	106.3	0.942	-0.0570	0.0613	226.0
8-15	109.0	0.920	-0.2119**	0.0394	274.4
16-25	110.2	0.752	-0.2070**	0.0424	250.7
26+	107.4	0.676	-0.0334	0.0548	245.9
All	108.4	0.402	-0.1551**	0.0234	252.1
Heterogeneity χ^2(df=3)			11.07	P=0.01	
B. Clinical subsample based on DS86					
0-7	106.0	1.170	-0.0274	0.0527	233.4
8-15	108.2	0.990	-0.2900**	0.0422	223.2
16-25	111.0	0.892	-0.2036**	0.0441	250.6
26+	107.3	0.796	-0.0420	0.0503	238.3
All	108.4	0.472	-0.1579**	0.0237	243.5
Heterogeneity χ^2(df=3)			22.30	P<0.01	
C. PE86 sample based on DS86					
0-7	106.1	0.941	-0.0170	0.0510	226.6
8-15	109.5	0.916	-0.2530**	0.0395	266.0
16-25	110.3	0.758	-0.2138**	0.0417	249.5
26+	107.5	0.682	-0.0469	0.0503	245.7
All	108.5	0.404	-0.1572**	0.0224	251.4
Heterogeneity χ^2(df=3)			20.08	P<0.01	
After exclusion of clinically diagnosed cases of retardation					
A. PE86 sample based on T65DR					
0-7	106.3	0.942	-0.0570	0.0613	226.0
8-15	109.2	0.899	-0.1675**	0.0415	260.9
16-25	110.0	0.753	-0.1333*	0.0529	246.9
26+	107.5	0.672	-0.0352	0.0544	242.4
All	108.4	0.398	-0.1113**	0.0253	246.2
Heterogeneity χ^2(df=3)			4.75	P=0.19	
B. Clinical subsample based on DS86					
0-7	106.0	1.170	-0.0274	0.0527	233.4
8-15	108.3	0.977	-0.2501**	0.0508	213.1
16-25	110.6	0.894	-0.0976Sug	0.0566	245.3
26+	107.4	0.789	-0.0444	0.0498	233.5
All	108.3	0.467	-0.1021**	0.0264	236.1
Heterogeneity χ^2(df=3)			11.82	P<0.01	
C. PE86 sample based on DS86					
0-7	106.1	0.941	-0.0170	0.0510	226.6
8-15	109.5	0.905	-0.2100**	0.0450	257.0
16-25	110.1	0.761	-0.1329**	0.0522	246.8
26+	107.6	0.678	-0.0487	0.0500	242.2
All	108.4	0.401	-0.1095**	0.0247	246.1
Heterogeneity χ^2(df=3)			9.96	P=0.02	

The coefficients are expressed as change in IQ points per 0.01 Gy of exposure.

各係数は0.01Gy当たりのIQ点の変化を示す.

** Significant at <0.01 level, * at <0.05 level, and Sug at <0.10 level.

<0.01水準で有意, * <0.05水準で有意, Sug. <0.10水準で示唆的

analysis just described repeated. The results are found in Table 4b. There is again a significant effect of exposure during the 8-15 week interval and the regression coefficients are little changed. The loss in IQ is 24-33 points per gray based on the DS86 doses. However, the results are less clear-cut with regard to the period 16-25 weeks; the regression coefficient is significant only if the mentally retarded are included. The coefficients among the four age-groups are significantly heterogeneous in all three samples irrespective of the exclusion of the mentally retarded.

解析を再度行った．その結果を表4bに示す．ここでも，8～15週齢の期間内に被爆した場合に有意な被爆の影響が認められ，回帰係数はほとんど変わらない．IQ値の低下は，DS86線量に基づいた場合1 Gy当たり24～33点である．しかし，16～25週齢群の結果はそれほど明瞭でなく，精神遅滞者を含めた場合にのみ回帰係数は有意である．四つの週齢群の回帰係数は，精神遅滞者の除外に関係なく，三つのすべての集団において有意な異質性を認める．

Table 5a gives the results of fitting a linear-quadratic model to the data with the controls included. For the age-group 8-15 weeks, the linear regression coefficients are significantly different from zero in all three samples whether the mentally retarded are or are not included, but a significant quadratic coefficient obtains only in the T65DR PE86 sample when all cases are included and it is positive, not negative. For the age-group 16-25 weeks, there is only one significant quadratic coefficient; it occurs in the clinical subsample when all cases are included. Regression coefficients associated with the linear and quadratic terms in dose are significantly different from zero for the 0-7 week group in the clinical subsample and the PE86 sample based on the DS86 doses, but they seem not to suggest a substantial decline in IQ with the dose since the coefficients of the quadratic term are not negative but positive. When tested separately, the quadratic terms in the clinical subsample are statistically heterogeneous among the four age-groups but the other quadratic terms and all linear terms are not so. After exclusion of the clinically diagnosed cases of mental retardation, no significant heterogeneity is observed among the linear or quadratic terms. The results of fitting a linear-quadratic model, when the controls are excluded, are shown in Table 5b. The results are almost the same as those with the controls included for the 8-15 and 16-25 weeks age-groups. For the 0-7 weeks, significant regression coefficients are obtained only in the clinical subsample with or without the inclusion of the mentally retarded. The linear coefficients are significantly different among the four age-specific groups in all three samples with and without inclusion of the cases of mental retardation, but the quadratic terms are heterogeneous only if the cases of mental retardation are included.

対照者を含めたデータに線形-2次モデルを当てはめた結果は表5aに示した．8～15週齢群については，精神遅滞者を含めた場合にも含めない場合にも，三つのすべての集団においてゼロから有意に異なる線形回帰係数を示したが，対照者全員を含めた場合T65DR PE86集団においてのみ有意な2次係数が得られ，その係数は正であり，負ではない．16～25週齢群については，有意な2次係数は一つ認めるだけで，対象者全員を含めた場合の臨床検査の部分集団において認められる．線量における線形回帰係数及び2次回帰係数は，DS86線量に基づいた臨床検査の部分集団及びPE86集団における0～7週齢群ではゼロから有意に異なるが，2次係数は負でなく正であるので，線量に伴いIQ値が本質的に低下することを示唆しているようには思えない．別々に検定した場合，臨床検査の部分集団の2次係数は四つの週齢群間で有意な異質性を認めたが，その他の2次係数及びすべての線形係数には有意な異質性は認められなかった．臨床的に診断された精神遅滞者を除いた場合には，線形係数にも2次係数にも有意な異質性は認められなかった．対照者を除外した場合の線形-2次モデルを当てはめた結果を表5bに示した．その結果は，8～15週齢群及び16～25週齢群では対照者を含めた場合の結果とほぼ同じであった．0～7週齢群については，精神遅滞者を含めた場合にも除外した場合にも臨床検査の部分集団に限り有意な回帰係数が認められた．精神遅滞者を含めた場合と除外した場合の三つのすべての集団の四つの週齢群に有意に異なる線形係数を認めたが，2次係数は，精神遅滞者を含めた場合にのみ異質性を認めた．

TABLE 4b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA EXCLUDING THE CONTROL CASES

表4b 個人の胎児又は子宮吸収線量に対する知能検査値への線形モデルを対照例を除く全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	b	S_b	
All cases except the controls included					
A. PE86 sample based on T65DR					
0-7	103.6	2.207	-0.0175	0.0727	265.6
8-15	110.6	1.845	-0.2297**	0.0465	324.2
16-25	108.4	1.633	-0.1788**	0.0495	272.2
26+	104.0	1.572	0.0369	0.0631	258.5
All	107.2	0.892	-0.1370**	0.0275	287.5
Heterogeneity χ^2(df=3)			14.95	P<0.01	
B. Clinical subsample based on DS86					
0-7	105.0	3.248	-0.0172	0.0665	300.9
8-15	111.0	2.064	-0.3290**	0.0507	241.2
16-25	110.9	2.216	-0.2014**	0.0581	303.1
26+	103.8	1.781	0.0266	0.0595	245.8
All	107.7	1.114	-0.1483**	0.0296	284.0
Heterogeneity χ^2(df=3)			26.02	P<0.01	
C. PE86 sample based on DS86					
0-7	104.6	2.185	0.0017	0.0617	285.8
8-15	112.0	1.705	-0.2857**	0.0452	288.0
16-25	109.3	1.599	-0.1960**	0.0497	275.6
26+	104.7	1.511	0.0104	0.0586	257.7
All	108.0	0.860	-0.1495**	0.0265	285.2
Heterogeneity χ^2(df=3)			23.41	P<0.01	
After exclusion of clinically diagnosed cases of retardation and the controls					
A. PE86 sample based on T65DR					
0-7	103.6	2.207	-0.0175	0.0727	265.6
8-15	110.5	1.800	-0.1836**	0.0485	307.3
16-25	107.5	1.645	-0.0812	0.0618	256.5
26+	104.0	1.572	0.0369	0.0631	258.5
All	106.8	0.881	-0.0863**	0.0296	275.8
Heterogeneity χ^2(df=3)			8.73	P=0.03	
B. Clinical subsample based on DS86					
0-7	105.0	3.248	-0.0172	0.0665	300.9
8-15	110.5	2.136	-0.2891**	0.0634	243.2
16-25	108.7	2.293	0.0542	0.0762	282.7
26+	103.8	1.781	0.0266	0.0595	245.8
All	106.9	1.108	-0.0775*	0.0330	270.7
Heterogeneity χ^2(df=3)			15.08	P<0.01	
C. PE86 sample based on DS86					
0-7	104.6	2.185	0.0017	0.0617	285.8
8-15	111.6	1.718	-0.2415**	0.0522	286.0
16-25	108.1	1.636	-0.0882	0.0629	265.0
26+	104.7	1.511	0.0104	0.0586	257.7
All	107.5	0.858	-0.0926**	0.0293	276.9
Heterogeneity χ^2(df=3)			13.57	P<0.01	

See the footnote in Table 4a.

表4aの脚注参照.

TABLE 5a THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR-QUADRATIC MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE

表5a 個人の胎児又は子宮吸収線量に対する知能検査値への線形-2次モデルを利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients						Mean Squares about Regression
	a	S_a	b	S_b	c	S_c	
All cases included							
A. PE86 sample based on T65DR							
0-7	106.3	0.972	-0.1007	0.1657	0.000380	0.001339	226.8
8-15	109.6	0.950	-0.3970**	0.0926	0.001119*	0.000507	271.4
16-25	110.0	0.770	-0.1372	0.0868	-0.000611	0.000663	250.8
26+	107.6	0.694	-0.1501	0.1271	0.001328	0.001304	245.9
All	108.4	0.411	-0.1692**	0.0487	0.000110	0.000330	252.3
Heterogeneity χ^2(df=3)			5.38	P=0.15	4.70	P=0.20	
B. Clinical subsample based on DS86							
0-7	106.7	1.186	-0.3399*	0.1347	0.001641*	0.000653	226.6
8-15	108.1	1.034	-0.2584*	0.1106	-0.000285	0.000921	224.0
16-25	110.6	0.911	-0.0361	0.0928	-0.001675*	0.000818	248.3
26+	107.4	0.824	-0.1009	0.1280	0.000708	0.001415	238.8
All	108.5	0.484	-0.2069**	0.0481	0.000419	0.000358	243.4
Heterogeneity χ^2(df=3)			4.57	P=0.20	10.52	P=0.01	
C. PE86 sample based on DS86							
0-7	106.6	0.970	-0.2413Sug	0.1245	0.001208*	0.000612	224.2
8-15	109.7	0.956	-0.3355**	0.0966	0.000613	0.000655	266.1
16-25	110.0	0.774	-0.0689	0.0884	-0.001491Sug	0.000802	248.2
26+	107.6	0.707	-0.1192	0.1250	0.000883	0.001396	246.0
All	108.6	0.415	-0.2024**	0.0458	0.000369	0.000326	251.3
Heterogeneity χ^2(df=3)			4.63	P=0.20	7.53	P=0.06	
After exclusion of clinically diagnosed cases of retardation							
A. PE86 sample based on T65DR							
0-7	106.3	0.972	-0.1007	0.1657	0.000380	0.001339	226.8
8-15	109.5	0.937	-0.2866**	0.1004	0.000683	0.000524	260.4
16-25	109.9	0.774	-0.0654	0.1242	-0.000873	0.001447	247.2
26+	107.7	0.690	-0.1555	0.1262	0.001368	0.001295	242.4
All	108.4	0.407	-0.1187*	0.0502	0.000060	0.000349	246.3
Heterogeneity χ^2(df=3)			2.24	P=0.52	1.44	P=0.70	
B. Clinical subsample based on DS86							
0-7	106.7	1.186	-0.3399*	0.1347	0.001641*	0.000653	226.6
8-15	108.3	1.019	-0.2611*	0.1217	0.000117	0.001170	213.9
16-25	110.6	0.921	-0.0593	0.1560	-0.000615	0.002330	246.0
26+	107.6	0.817	-0.1083	0.1267	0.000768	0.001400	233.9
All	108.5	0.477	-0.1898**	0.0483	0.000813*	0.000375	235.4
Heterogeneity χ^2(df=3)			2.67	P=0.45	1.99	P=0.58	
C. PE86 sample based on DS86							
0-7	106.6	0.970	-0.2413Sug	0.1245	0.001208*	0.000612	224.2
8-15	109.8	0.944	-0.2930**	0.0990	0.000630	0.000669	257.1
16-25	110.0	0.788	-0.0514	0.1497	-0.001278	0.002202	247.1
26+	107.7	0.702	-0.1252	0.1241	0.000933	0.001386	242.4
All	108.6	0.411	-0.1775**	0.0462	0.000587Sug	0.000336	245.8
Heterogeneity χ^2(df=3)			2.34	P=0.51	1.39	P=0.71	

See the footnote in Table 4a.

表4aの脚注参照.

TABLE 5b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR-QUADRATIC MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA EXCLUDING THE CONTROL CASES

表5b 個人の胎児又は子宮吸収線量に対する知能検査値への線形-2次モデルを対照例を除く全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients						Mean Squares about Regression
	a	S_a	b	S_b	c	S_c	
All cases except the controls included							
A. PE86 sample based on T65DR							
0-7	103.1	2.594	0.0682	0.2185	-0.000688	0.001653	268.9
8-15	113.4	2.067	-0.5296**	0.1165	0.001670**	0.000598	306.7
16-25	107.1	1.812	-0.0342	0.1072	-0.001138	0.000750	269.7
26+	103.8	1.839	0.0649	0.1624	-0.000285	0.001524	260.3
All	107.0	1.001	-0.1175*	0.0616	-0.000136	0.000386	288.0
Heterogeneity χ^2(df=3)			14.41	P<0.01	9.35	P=0.03	
B. Clinical subsample based on DS86							
0-7	110.4	3.689	-0.4634*	0.1860	0.002112*	0.000831	260.3
8-15	111.8	2.514	-0.4073**	0.1481	0.000629	0.001116	243.2
16-25	108.1	2.520	0.0514	0.1298	-0.002171*	0.001001	291.9
26+	102.8	2.169	0.1547	0.1701	-0.001359	0.001689	246.6
All	108.3	1.276	-0.1997**	0.0650	0.000384	0.000432	284.2
Heterogeneity χ^2(df=3)			11.46	P<0.01	11.89	P<0.01	
C. PE86 sample based on DS86							
0-7	106.8	2.578	-0.2467	0.1703	0.001229	0.000787	280.1
8-15	113.9	1.966	-0.4941**	0.1192	0.001421Sug	0.000753	282.5
16-25	107.5	1.756	0.0263	0.1095	-0.002058*	0.000906	268.2
26+	104.2	1.827	0.0875	0.1645	-0.000838	0.001669	258.9
All	108.4	0.970	-0.1945**	0.0583	0.000330	0.000381	285.3
Heterogeneity χ^2(df=3)			13.26	P<0.01	10.84	P=0.01	
After exclusion of clinically diagnosed cases of retardation and the controls							
A. PE86 sample based on T65DR							
0-7	103.1	2.594	0.0682	0.2185	-0.000688	0.001653	268.9
8-15	112.6	2.092	-0.4033**	0.1292	0.001162Sug	0.000635	301.2
16-25	106.1	1.878	0.1364	0.1548	-0.002509	0.001638	253.9
26+	103.8	1.839	0.0649	0.1624	-0.000285	0.001524	260.3
All	106.5	0.987	-0.0471	0.0631	-0.000284	0.000404	276.1
Heterogeneity χ^2(df=3)			9.45	P=0.02	5.23	P=0.16	
B. Clinical subsample based on DS86							
0-7	110.4	3.689	-0.4634*	0.1860	0.002112*	0.000831	260.3
8-15	111.8	2.606	-0.4206*	0.1702	0.001216	0.001462	244.2
16-25	107.3	2.777	0.1304	0.2550	-0.002565	0.002940	283.5
26+	102.8	2.169	0.1547	0.1701	-0.001359	0.001689	246.6
All	107.8	1.250	-0.1644*	0.0649	0.000691	0.000444	269.5
Heterogeneity χ^2(df=3)			10.08	P=0.02	5.14	P=0.16	
C. PE86 sample based on DS86							
0-7	106.8	2.578	-0.2467	0.1703	0.001229	0.000787	280.1
8-15	113.4	1.986	-0.4386**	0.1249	0.001355Sug	0.000782	281.5
16-25	106.7	1.921	0.1674	0.1929	-0.003627	0.002589	263.2
26+	104.2	1.827	0.0875	0.1645	-0.000838	0.001669	258.9
All	108.0	0.961	-0.1552**	0.0587	0.000479	0.000390	276.6
Heterogeneity χ^2(df=3)			10.33	P=0.02	4.66	P=0.20	

See the footnote in Table 4a.
表4aの脚注参照.

Appendix 2a shows the results of fitting a quadratic model to the data with the controls included, and Appendix 2b the results when the controls are excluded. In Appendix 2a, significant quadratic coefficients are seen for the 8-15 and 16-25 weeks age-groups for all three samples, and the four age-

対照者を含めたデータに2次モデルを当てはめた結果を付表2aに，対照者を除外した場合の結果を付表2bに示した．付表2aでは，三つのすべての集団において8～15週齢群及び16～25週齢群に有意な2次係数が認められ，DS86線量に基づく臨床検査

group-specific regression coefficients are significantly heterogeneous in the clinical subsample and PE86 sample based on the DS86 doses. When the eight cases of mental retardation are excluded, the regression coefficients associated with the 8-15 and 16-25 week age-groups are again significant but less strikingly so; however, the actual values of the coefficients change little. In Appendix 2b, there is again a significant effect of exposure in the 8-15 week interval and the regression coefficients are little changed. However, the results are less clear-cut with regard to the period 16-25 weeks; the regression coefficient is significant only if the mentally retarded cases are included. As mentioned above, the results of fitting a quadratic model are very similar to those derived from a linear model. When the mean squares about the regression are compared (Table 4a vs Appendix 2a, and Table 4b vs Appendix 2b), there is no evidence suggesting the superiority of a quadratic model over a linear one.

Appendixes 3a and b show the regression coefficients estimated when a linear exponential is fitted. The results are very similar to those obtained by fitting a linear model.

Findings with Respect to the Tanaka-B Test of Intelligence. As earlier noted, two tests of intelligence were routinely used in Nagasaki, namely, the Koga test, which has been the basis of the results thus far described, and the Tanaka-B. There naturally arises the question whether the two tests in Nagasaki reveal the same effect, and if not, why not. As a preliminary to a discussion of this issue, the bivariate distribution of the two intelligence test scores, the Tanaka-B and Koga, on the 739 children tested in Nagasaki is shown in Figure 4 with the 95% and 99% probability ellipses. Note that the three cases of mental retardation are identified separately in this figure, and that both tests reveal them to be below normal limits in performance. The correlation coefficient between the two tests is 0.30, and their individual means and standard deviations are 100.5 ± 12.6 (mean ± standard deviation) for the Tanaka-B and 107.3 ± 15.7 for the Koga test. The correlation in results between these tests is not particularly high, suggesting that they do not measure the same thing. Our purposes are essentially to determine the possible dependence of the results we have previously described on the measure of intelligence that is used. Unfortunately,

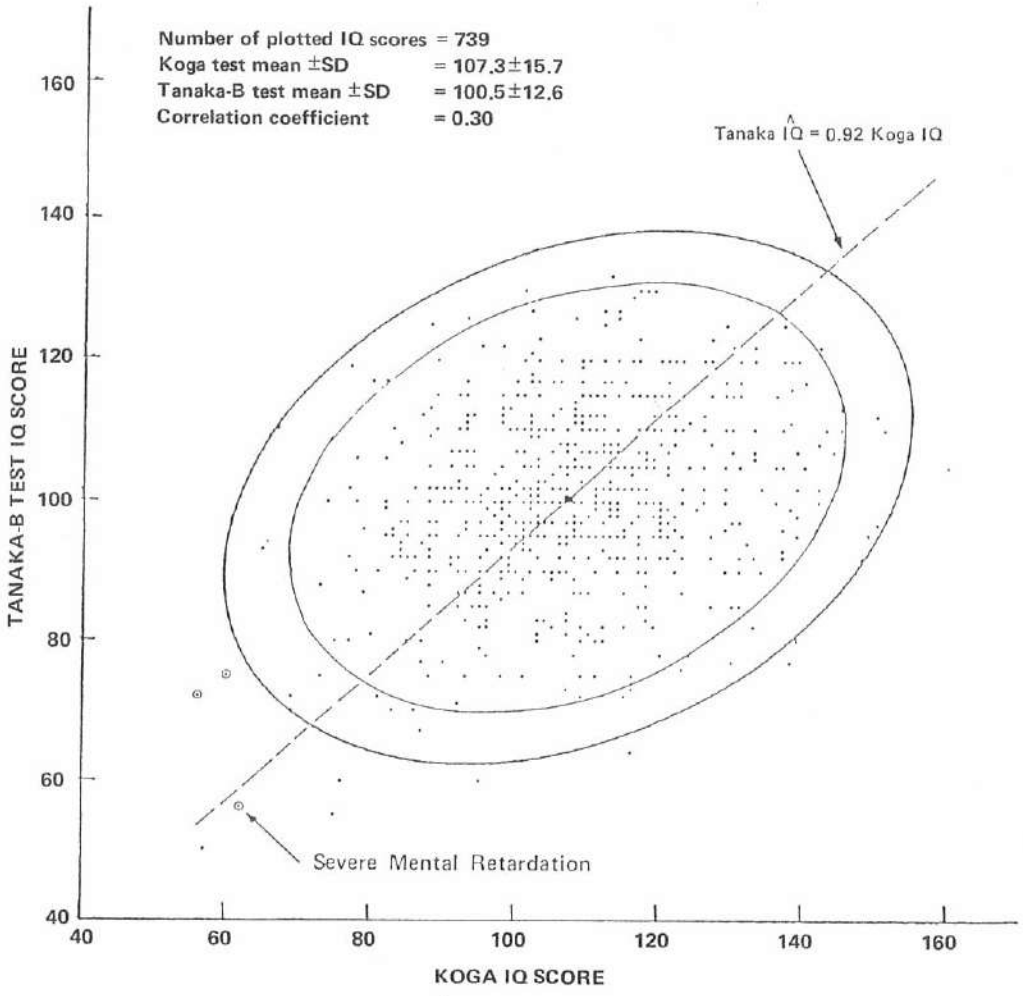
の部分集団及びPE86集団においては四つの週齢群別回帰係数間に有意な異質性を認めた．精神遅滞者8人を除外すると，8～15週齢群及び16～25週齢群の回帰係数はやはり有意ではあるがさほど顕著ではない．しかしその実際の係数値はほとんど変わらない．付表2bでもやはり，8～15週齢群で被曝した場合に有意な被曝の影響を認め，回帰係数もほとんど変わらない．しかし，16～25週齢群の結果はそれほど明瞭でなく，精神遅滞者を含めた場合にのみ回帰係数は有意である．前述のように，2次モデルを適合した結果は線形モデルを適合した結果と類似している．回帰について平均平方を比較すると（表4a対付表2a，及び表4b対付表2b），2次モデルが線形モデルよりも勝っていることを示唆する証拠はない．

付表3a及び3bには，線形指数モデルを適合した場合に推定される回帰係数を示している．その結果は線形モデルを当てはめた場合の結果と類似している．

田中B式知能検査に関する所見． 先にも述べたように，長崎では通常二つの知能検査，すなわち，これまで述べてきた結果の論拠となってきた古賀式検査と田中B式検査が用いられた．当然のことながら，長崎で用いられた二つの検査の結果が同じかどうか，また異なるとすれば，何が原因かという問題が起こってくる．この問題の検討の手始めとして，長崎の739人の児童を対象に実施した田中B式及び古賀式の両知能検査値の2変量分布を95%及び99%楕円確率を用いて図4に示した．3人の精神遅滞者はこの図では別個に確認され，3人とも両検査の検査成績は正常範囲以下であったことに留意すべきである．両検査値間の相関係数は0.30であり，個々人の平均及び標準偏差は，田中B式検査で100.5±12.6（平均±標準偏差），古賀式検査で107.3±15.7であった．これらの検査値間の結果の相関は特に高くなく，両検査の測定指標が異なることを示唆している．我々の本来の目的は，先に述べた結果が用いられた知能の測定に依存しているかどうかを決定することである．残念ながら，後にわかることだが，

FIGURE 4 RELATIOSHIP OF TANAKA-B TEST SCORE TO KOGA TEST SCORE, NAGASAKI

図4 古賀式検査値と田中B式検査値の関係，長崎



as will be seen, the extremely small number of individuals exposed prenatally to doses of 0.5 Gy or more make rigorous comparisons impossible.

The results of fitting the four different dose-response models to the data from Nagasaki are shown in Tables 6-8 and Appendixes 4 and 5. Tables 6a and b present the means and standard deviations for the two tests and for the same dose and gestational age categories. The dose and

0.5 Gy 以上の線量の胎内被爆者数が極めて少ないので正確な比較は不可能であった．

長崎のデータに四つの異なる線量反応モデルを当てはめた結果は表6～8並びに付表4及び5に示した．両検査値の平均及び標準偏差と同一線量及び週齢群に対する平均及び標準偏差を表6a及び6bに示した．古賀式検査の長崎の検査値に認められる線量及び

prenatal age dependencies seen in the Nagasaki scores for the Koga test are the same as those seen in the combined cities data with the Koga test, i.e., a significant heterogeneity among dose groups in the 8-15 and 16-25 week categories (Table 6a). However, as Table 6b illustrates, the radiation dose dependency, for the Tanaka-B test, but not the Koga test, appears restricted largely, if not exclusively, to the 16-25 week period. It is not possible to ascertain from these tables the extent to which these differences merely reflect the extremely small sample sizes involved, only five individuals at most within the seemingly sensitive periods with doses of 0.5 Gy or more. When linear, linear-quadratic, quadratic and linear exponential dose-response models are fitted to the Koga test scores, the results for Nagasaki alone (Tables 7a and b and Appendixes 4a and b) are generally similar to those when the cities are combined, namely, a significant diminution in intelligence test score occurs in the 8-15 week interval (and the 16-25) with both dosimetries and under all of the models fitted. The regression coefficients are somewhat larger with the DS86 doses than the T65DR. The results with the Tanaka-B test are less straightforward (Tables 8a and b, and Appendixes 5a and b). An effect of exposure is more consistently seen in the interval 16-25 weeks after fertilization, although significance does obtain in the 8-15 week group in the clinical subsample alone but only with the new doses. As in the examination of the means, the very small number of survivors at the higher doses makes interpretation of these apparent differences between the tests impossible. They could, of course, merely be fortuitous, but alternatively might be because the two tests are substantially different in their construction and emphases, and measure different aspects of intelligence.

胎内週齢の依存性は，古賀式検査を両市合計データに用いても認められた結果と同じであった．すなわち，８～15週齢群及び16～25週齢群の線量群間に有意な異質性を認めた（表6a）．しかし，表6bが示すように，古賀式検査ではなく田中B式検査の放射線依存性を認められるのは主として16～25週齢群に限定しているようである．これらの差が0.5 Gy以上の線量に被曝した感受性の危険期に属す高々５人の被爆者という極めて小規模な集団がどの程度反映しているかをこれらの表から確認することは不可能である．古賀式検査値に線形，線形-２次，２次，及び線形指数線量反応モデルを適合すると，長崎のみの結果（表7a及び7b，並びに付表4a及び4b）は一般的に両市合計の結果と類似していた．すなわち，両線量推定方式を用いた場合及びすべての適合モデルに基づいた場合も，８～15週齢群（及び16～25週齢群）に知能検査値の有意な低下を認めた．その回帰係数は，T65DRよりもDS86線量の方が若干大きかった．田中B式検査による結果は古賀式検査結果よりもわかりにくい（表8a及び8b，並びに付表5a及び5b）．被爆の影響は，臨床検査の部分集団においてのみ，しかも新線量を用いた場合にのみ８～15週齢群が有意であったが，16～25週齢群では更に一貫して認められた．平均値を検討した場合と同様，高線量被爆者はごく少数なので，両検査間の差を説明することは不可能である．勿論，その差は単に偶然の結果かもしれないが，両検査はその構成も重点の置き方も本質的に異なり，知能の異なる面を測定することに起因しているかもしれない．

Uncertainties

These data have their share of uncertainties. These include the limited number of "heavily" exposed individuals, particularly when the mentally retarded are excluded, errors in the estimation of the tissue-absorbed doses and the prenatal ages at exposure, the biological bases of the endpoint measured, and other confounding factors in the postbomb period, including nutrition and disease. A number of these have been discussed elsewhere,[20] and we shall not repeat our remarks in detail here. However, some brief reiteration seems important.

不確定要素

これらのデータは不確定要素を共有している．特に，精神遅滞者を除外した場合の少数の「高線量」被爆者，組織吸収線量及び胎内被爆年齢の推定誤差，測定指標の生物学的根拠，並びに栄養及び疾患を含む被爆後のその他の交絡因子を含んでいる．このうちの幾つかは別報で論じており，[20] ここでは著者の見解を詳細に述べないが，簡潔に反復することは重要であるように思われる．

TABLE 6a MEAN INTELLIGENCE SCORE (KOGA) BY GESTATIONAL AGE AT EXPOSURE AND FETAL OR UTERINE ABSORBED DOSE BASED ON THE T65DR AND DS86 DOSIMETRIES IN NAGASAKI. ALL INDIVIDUALS ON WHOM INTELLIGENCE TEST DATA ARE AVAILABLE ARE TABULATED, INCLUDING THOSE DIAGNOSED AS MENTALLY RETARDED

表6a 平均知能値（古賀式），原爆時胎内週齢別並びに長崎のT65DR及びDS86線量推定方式に基づく胎児又は子宮吸収線量別．臨床的に診断された精神遅滞者を含む知能検査データの利用可能な全対象者

Gestational ages (Weeks)	Dose Categories (Gy)						F+ (df_1, df_2)	P
	<0.01	0.01-0.99	0.10-0.49	0.50-0.99	1.00+	All		
A. PE86 sample based on T65DR								
0-7 Weeks								
N	121	23	10	2	1	157	2.78	
Mean	106.0	101.5	113.1	98.5	65.0	105.4	(3,153)	0.04
SD	15.37	14.06	15.30	19.09	-	15.58		
8-15 Weeks								
N	92	30	12	2	4	140	4.77	
Mean	110.1	112.8	114.1	119.0	76.3	110.2	(4,135)	<0.01
SD	16.69	17.46	13.25	1.41	9.74	17.29		
16-25 Weeks								
N	150	45	9	6	2	212	3.64	
Mean	108.0	105.3	106.1	113.3	71.5	107.2	(4,207)	<0.01
SD	14.94	12.97	9.68	18.29	16.26	14.83		
26+ Weeks								
N	178	36	16	2	3	235	0.81	
Mean	107.3	107.6	100.3	108.0	108.0	106.9	(4,230)	0.52
SD	14.96	17.92	12.45	12.73	8.89	15.22		
All gestational ages								
N	541	134	47	12	10	744	6.12	
Mean	107.7	106.9	107.7	110.9	83.7	107.3	(4,739)	<0.01
SD	15.37	15.91	13.82	15.65	19.29	15.64		
B. Clinical Subsample based on DS86								
0-7 Weeks								
N	76	9	6	0	1	92	0.76	
Mean	105.1	108.6	104.2	-	65.0	105.0	(2,89)	0.47
SD	16.24	14.88	13.88	-	-	16.32		
8-15 Weeks								
N	52	8	7	2	2	71	3.72	
Mean	108.9	110.9	111.7	101.0	70.0	108.1	(4,66)	<0.01
SD	14.58	16.81	8.92	26.87	11.31	15.74		
16-25 Weeks								
N	89	8	11	2	1	111	1.82	
Mean	107.5	103.1	109.8	104.5	60.0	107.0	(3,107)	0.15
SD	14.37	5.17	14.97	17.68	-	14.58		
26+ Weeks								
N	88	13	14	1	2	118	1.06	
Mean	106.1	103.2	99.4	111.0	106.5	105.0	(3,114)	0.37
SD	13.80	17.62	11.89	-	12.02	13.99		
All gestational ages								
N	305	38	38	5	6	392	5.01	
Mean	106.8	106.1	105.4	104.4	79.7	106.1	(4,387)	<0.01
SD	14.72	14.78	13.29	16.59	22.37	15.04		

(Continue 続く)

TABLE 6a Continued 続き

Gestational ages (Weeks)		Dose Categories (Gy) <0.01	0.01-0.99	0.10-0.49	0.50-0.99	1.00+	All	F+ (df_1, df_2)	p
		C. PE86 sample based on DS86							
0-7	Weeks								
	N	121	25	10	0	1	157	0.48	
	Mean	106.0	102.6	109.8	-	65.0	105.4	(2,154)	0.62
	SD	15.37	14.80	15.65	-	-	15.58		
8-15	Weeks								
	N	92	30	13	2	3	140	4.05	
	Mean	110.1	112.8	114.4	101.0	74.3	110.2	(4,135)	<0.01
	SD	16.69	17.46	12.73	26.87	10.97	17.29		
16-25	Weeks								
	N	150	47	11	3	1	212	2.79	
	Mean	108.0	105.5	109.8	97.3	60.0	107.2	(3,208)	0.04
	SD	14.94	12.72	14.97	17.62	-	14.83		
26+	Weeks								
	N	178	37	17	1	2	235	0.73	
	Mean	107.3	107.2	101.6	111.0	106.5	106.9	(3,231)	0.54
	SD	14.96	17.84	12.55	-	12.02	15.22		
All gestational ages									
	N	541	139	51	6	7	744	5.82	
	Mean	107.7	107.0	108.3	100.8	80.1	107.3	(4,739)	<0.01
	SD	15.37	15.83	14.28	17.22	20.46	15.64		

+ Shows the significance of the difference among dose means within an age-group.
同一年齢群内の線量群の平均検査値間の差の有意性を示す.

The two high dose categories, 0.50-0.99 and 1.00+ Gy, have been combined because of the small numbers of individuals on whom data are available.
データのある対象者が少ないので，二つの高線量群（0.50－0.99 及び1.00＋Gy）を合計した.

TABLE 6b MEAN INTELLIGENCE SCORE (TANAKA-B) BY GESTATIONAL AGE AT EXPOSURE AND FETAL OR UTERINE ABSORBED DOSE BASED ON THE T65DR AND DS86 DOSIMETRIES IN NAGASAKI. ALL INDIVIDUALS ON WHOM INTELLIGENCE TEST DATA ARE AVAILABLE ARE TABULATED, INCLUDING THOSE DIAGNOSED AS METNALLY RETARDED

表6b 平均知能値（田中B式），原爆時胎内週齢別並びに長崎のT65DR及びDS86線量推定方式に基づく胎児又は子宮吸収線量別．臨床的に診断された精神遅滞者を含む知能検査データの利用可能な全対象者

Gestational ages (Weeks)		Dose Categories (Gy) <0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+	All	F+ (df_1, df_2)	p
		A. PE86 sample based on T65DR							
0-7	Weeks								
	N	121	23	10	2	1	157	0.02	
	Mean	95.3	94.9	95.4	95.0	93.0	95.2	(3,153)	0.99
	SD	12.12	7.05	4.93	0.00	-	11.03		
8-15	Weeks								
	N	91	30	12	2	4	139	1.40	
	Mean	100.1	98.7	104.5	94.0	87.8	99.7	(4,134)	0.24
	SD	13.36	12.25	9.55	2.83	22.81	13.17		
16-25	Weeks								
	N	150	45	9	6	2	212	2.78	
	Mean	104.3	100.6	97.6	96.8	83.5	102.8	(4,207)	0.03
	SD	12.45	13.03	9.15	16.92	12.02	12.80		
26+	Weeks								
	N	175	35	16	2	3	231	1.03	
	Mean	102.9	102.2	101.8	91.5	92.3	102.4	(4,226)	0.39
	SD	11.76	13.47	9.93	0.71	15.04	11.93		
All gestational ages									
	N	537	133	47	12	10	739	3.20	
	Mean	101.1	99.6	100.3	95.2	88.8	100.5	(4,734)	0.01
	SD	12.75	12.28	9.24	11.62	15.89	12.57		

(Continue 続く)

TABLE 6b Continued 続き

Gestational ages (Weeks)		Dose Categories (Gy) <0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+	All	F+ (df_1, df_2)	p
				B. Clinical Subsample based on DS86					
0-7	Weeks								
	N	76	9	6	0	1	92	0.44	
	Mean	95.3	91.2	94.5	-	93.0	94.8	(2,89)	0.64
	SD	13.13	6.53	5.24	-	-	12.20		
8-15	Weeks								
	N	52	8	7	2	2	71	2.57	
	Mean	101.3	104.1	99.1	95.5	73.0	100.4	(4,66)	0.05
	SD	13.89	7.47	5.79	0.71	24.04	13.48		
16-25	Weeks								
	N	89	8	11	2	1	111	4.30	
	Mean	105.4	94.3	98.9	92.5	75.0	103.3	(3,107)	<0.01
	SD	12.42	15.15	13.48	3.54	-	13.24		
26+	Weeks								
	N	87	12	14	1	2	116	2.74	
	Mean	103.9	107.8	98.0	75.0	101.0	103.3	(3,112)	0.05
	SD	11.52	10.18	8.91	-	1.41	11.45		
All gestational ages									
	N	304	37	38	5	6	390	3.77	
	Mean	101.7	100.1	97.9	90.2	86.0	100.8	(4,385)	<0.01
	SD	13.17	12.15	9.41	8.82	17.54	12.97		
				C. PE86 sample based on DS86					
0-7	Weeks								
	N	121	25	10	0	1	157	0.01	
	Mean	95.3	94.9	95.3	-	93.0	95.2	(2,154)	0.99
	SD	12.12	6.76	4.88	-	-	11.02		
8-15	Weeks								
	N	91	30	13	2	3	139	1.29	
	Mean	100.1	98.7	103.5	95.5	85.3	99.7	(4,134)	0.28
	SD	13.36	12.25	9.78	0.71	27.30	13.17		
16-25	Weeks								
	N	150	47	11	3	1	212	3.54	
	Mean	104.3	100.3	98.9	92.3	75.0	102.8	(3,208)	0.02
	SD	12.45	12.97	13.48	2.52	-	12.80		
26+	Weeks								
	N	175	36	17	1	2	231	0.92	
	Mean	102.9	102.1	100.6	75.0	101.0	102.4	(3,227)	0.43
	SD	11.76	13.28	10.20	-	1.41	11.93		
All gestational ages									
	N	537	138	51	6	7	739	2.89	
	Mean	101.1	99.4	100.0	90.5	89.4	100.5	(4,734)	0.02
	SD	12.75	12.14	10.25	7.92	18.40	12.57		

See footnotes of Table 6a.
表 6a の脚注参照.

TABLE 7a THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR MODEL OF IQ (KOGA) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

表7a 個人の胎児又は子宮吸収線量に対するIQ値(古賀式)への線形モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	b	S_b	
All cases included					
A. PE86 sample based on T65DR					
0-7	106.0	1.272	-0.1595Sug	0.0848	238.8
8-15	111.5	1.465	-0.1496**	0.0446	278.5
16-25	107.9	1.040	-0.1271**	0.0488	214.1
26+	107.1	1.026	-0.0422	0.0646	232.3
All	107.9	0.585	-0.1181**	0.0273	239.0
Heterogeneity χ^2(df=3)			2.11	P=0.55	
B. Clinical subsample based on DS86					
0-7	105.9	1.714	-0.2587*	0.1116	254.0
8-15	110.0	1.841	-0.2321**	0.0703	217.0
16-25	108.0	1.411	-0.1651*	0.0662	202.9
26+	105.2	1.356	-0.0320	0.0806	197.2
All	107.0	0.776	-0.1651**	0.0391	216.9
Heterogeneity χ^2(df=3)			4.34	P=0.23	
C. PE86 sample based on DS86					
0-7	106.0	1.263	-0.2287*	0.1053	237.0
8-15	111.4	1.465	-0.1811**	0.0564	280.2
16-25	107.9	1.031	-0.1830**	0.0628	212.4
26+	107.0	1.025	-0.0514	0.0850	232.4
All	107.9	0.582	-0.1563**	0.0348	238.5
Heterogeneity χ^2(df=3)			2.32	P=0.51	
After exclusion of the controls					
A. PE86 sample based on T65DR					
0-7	106.2	3.100	-0.1622	0.0989	255.2
8-15	114.9	2.677	-0.1777**	0.0477	270.6
16-25	107.4	2.012	-0.1210*	0.0510	194.5
26+	106.0	2.486	-0.0259	0.0771	263.3
All	108.6	1.250	-0.1265**	0.0305	247.4
Heterogeneity χ^2(df=3)			2.95	P=0.40	
B. Clinical subsample based on DS86					
0-7	111.8	4.271	-0.3522**	0.1160	191.2
8-15	114.7	4.317	-0.2883**	0.0852	223.7
16-25	110.9	3.831	-0.2049*	0.0800	190.0
26+	101.0	3.316	0.0429	0.0994	210.9
All	108.6	1.984	-0.1877**	0.0471	218.1
Heterogeneity χ^2(df=3)			8.77	P=0.03	
C. PE86 sample based on DS86					
0-7	106.4	2.989	-0.2355Sug	0.1193	247.1
8-15	114.5	2.683	-0.2117**	0.0605	278.1
16-25	107.5	1.947	-0.1770**	0.0641	188.8
26+	106.0	2.476	-0.0292	0.1011	263.4
All	108.6	1.230	-0.1658**	0.0384	245.8
Heterogeneity χ^2(df=3)			2.71	P=0.44	

See the footnote in Table 4a.
表4aの脚注参照.

TABLE 7b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR-QUADRATIC MODEL OF IQ (KOGA) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

表7b 個人の胎児又は子宮吸収線量に対するIQ値(古賀式)への線形-2次モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients						Mean Squares about Regression
	a	S_a	b	S_b	c	S_c	
All cases included							
A. PE86 sample based on T65DR							
0-7	105.3	1.288	0.3441	0.2307	-0.005170*	0.002208	232.1
8-15	111.3	1.528	-0.0954	0.1386	-0.000285	0.000689	280.1
16-25	107.3	1.056	0.1299	0.1175	-0.001831*	0.000764	209.4
26+	107.3	1.057	-0.2047	0.1822	0.001573	0.001649	232.4
All	107.6	0.598	0.0001	0.0656	-0.000781*	0.000394	238.0
Heterogeneity χ^2(df=3)			5.05	P=0.17	8.26	P=0.04	
B. Clinical subsample based on DS86							
0-7	105.5	1.750	0.0884	0.2962	-0.003499	0.002767	252.4
8-15	109.5	1.896	-0.0259	0.2146	-0.001795	0.001765	216.9
16-25	107.1	1.432	0.1338	0.1482	-0.002215*	0.000987	195.6
26+	105.6	1.406	-0.2573	0.2181	0.002578	0.002319	196.8
All	106.6	0.793	0.0318	0.0929	-0.001738*	0.000745	214.5
Heterogeneity χ^2(df=3)			2.30	P=0.52	4.10	P=0.25	
C. PE86 sample based on DS86							
0-7	105.5	1.290	0.1923	0.2596	-0.004381Sug	0.002473	233.8
8-15	111.4	1.516	-0.1665	0.1614	-0.000092	0.000953	282.2
16-25	107.5	1.050	0.0434	0.1393	-0.001776Sug	0.000977	210.1
26+	107.3	1.056	-0.2475	0.2203	0.002306	0.002390	232.4
All	107.7	0.596	-0.0476	0.0807	-0.000829	0.000556	238.1
Heterogeneity χ^2(df=3)			2.65	P=0.45	5.30	P=0.15	
After exclusion of the controls							
A. PE86 sample based on T65DR							
0-7	101.1	3.361	0.5695*	0.2775	-0.006816**	0.002444	212.8
8-15	115.4	3.144	-0.2216	0.1623	0.000217	0.000765	276.2
16-25	104.4	2.123	0.2298Sug	0.1247	-0.002307**	0.000757	170.9
26+	107.3	2.979	-0.2019	0.2440	0.001553	0.002042	265.3
All	107.4	1.402	0.0067	0.0784	-0.000810Sug	0.000440	244.5
Heterogeneity χ^2(df=3)			9.34	P=0.02	12.66	P<0.01	
B. Clinical subsample based on DS86							
0-7	109.4	5.564	-0.1033	0.3717	-0.002163	0.003062	198.3
8-15	113.4	5.316	-0.1695	0.2884	-0.000926	0.002143	235.0
16-25	101.8	4.757	0.3251	0.2093	-0.003140*	0.001168	144.9
26+	101.8	4.348	-0.0506	0.3220	0.000928	0.003034	218.0
All	105.5	2.388	0.0749	0.1253	-0.001983*	0.000880	208.1
Heterogeneity χ^2(df=3)			2.53	P=0.47	2.06	P=0.56	
C. PE86 sample based on DS86							
0-7	102.7	3.407	0.3634	0.3207	-0.005633Sug	0.002818	227.1
8-15	115.1	3.032	-0.2934	0.1843	0.000487	0.001037	282.8
16-25	105.5	2.090	0.1237	0.1474	-0.002184*	0.000971	176.8
26+	107.2	2.954	-0.2390	0.2947	0.002236	0.002947	265.5
All	107.8	1.373	-0.0498	0.0954	-0.000818	0.000616	244.9
Heterogeneity χ^2(df=3)			5.13	P=0.16	7.45	P=0.06	

See the footnote in Table 4a.
表4aの脚注参照.

TABLE 8a THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR MODEL OF IQ (TANAKA-B) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

表8a 個人の胎児又は子宮吸収線量に対するIQ値（田中B式）への線形モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	b	S_b	
All cases included					
A. PE86 sample based on T65DR					
0-7	95.3	0.910	-0.0175	0.0607	122.2
8-15	100.0	1.160	-0.0369	0.0352	173.3
16-25	103.5	0.892	-0.1259**	0.0419	157.7
26+	102.8	0.806	-0.0954Sug	0.0503	140.8
All	100.9	0.474	-0.0682**	0.0221	156.3
Heterogeneity χ^2 (df=3)			3.67	P=0.30	
B. Clinical subsample based on DS86					
0-7	94.9	1.319	-0.0229	0.0859	150.4
8-15	101.8	1.610	-0.1706**	0.0614	165.9
16-25	104.5	1.262	-0.1853**	0.0592	162.4
26+	103.9	1.102	-0.1276Sug	0.0650	127.8
All	101.6	0.672	-0.1371**	0.0338	161.8
Heterogeneity χ^2 (df=3)			2.72	P=0.44	
C. PE86 sample based on DS86					
0-7	95.3	0.907	-0.0211	0.0756	122.2
8-15	100.0	1.157	-0.0445	0.0444	173.4
16-25	103.5	0.887	-0.1701**	0.0540	157.1
26+	102.7	0.808	-0.0954	0.0664	141.7
All	100.8	0.473	-0.0830**	0.0282	156.5
Heterogeneity χ^2 (df=3)			4.06	P=0.25	
After exclusion of the controls					
A. PE86 sample based on T65DR					
0-7	95.3	1.204	-0.0172	0.0384	38.5
8-15	100.0	2.104	-0.0363	0.0375	167.2
16-25	101.0	1.830	-0.0962*	0.0464	161.0
26+	102.7	1.908	-0.0932	0.0586	151.5
All	100.1	0.942	-0.0597**	0.0229	139.9
Heterogeneity χ^2 (df=3)			2.40	P=0.50	
B. Clinical subsample based on DS86					
0-7	92.1	1.867	0.0215	0.0507	36.5
8-15	104.2	2.728	-0.1992**	0.0539	89.4
16-25	98.9	3.758	-0.1101	0.0785	182.8
26+	104.2	2.534	-0.1327Sug	0.0747	117.0
All	100.8	1.493	-0.1259**	0.0352	121.4
Heterogeneity χ^2 (df=3)			9.31	P=0.03	
C. PE86 sample based on DS86					
0-7	95.2	1.180	-0.0202	0.0471	38.5
8-15	99.9	2.082	-0.0430	0.0469	167.5
16-25	101.1	1.785	-0.1345*	0.0588	158.6
26+	102.2	1.922	-0.0845	0.0778	155.2
All	100.0	0.932	-0.0712*	0.0290	140.4
Heterogeneity χ^2 (df=3)			2.55	P=0.47	

See the footnote in Table 4a.
表4aの脚注参照.

TABLE 8b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR-QUADRATIC MODEL OR IQ (TANAKA-B) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

表8b 個人の胎児又は子宮吸収線量に対するIQ値（田中B式）への線形-2次モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients						Mean Squares about Regression
	a	S_a	b	S_b	c	S_c	
All cases included							
A. PE86 sample based on T65DR							
0-7	95.3	0.938	-0.0413	0.1680	0.000244	0.001607	123.0
8-15	100.2	1.210	-0.0993	0.1093	0.000328	0.000543	174.1
16-25	103.5	0.918	-0.1295	0.1023	0.000026	0.000665	158.5
26+	103.0	0.832	-0.1840	0.1421	0.000857	0.001286	141.2
All	101.0	0.487	-0.1143*	0.0532	0.000304	0.000320	156.3
Heterogeneity χ^2(df=3)			0.47	P=0.92	0.35	P=0.95	
B. Clinical subsample based on DS86							
0-7	94.9	1.358	-0.0698	0.2299	0.000473	0.002147	152.0
8-15	101.8	1.670	-0.1503	0.1890	-0.000177	0.001555	168.3
16-25	104.7	1.308	-0.2595Sug	0.1354	0.000550	0.000902	163.3
26+	104.6	1.128	-0.4646**	0.1734	0.003854*	0.001843	124.2
All	101.7	0.691	-0.1723*	0.0808	0.000310	0.000647	162.1
Heterogeneity χ^2(df=3)			2.41	P=0.49	3.23	P=0.36	
C. PE86 sample based on DS86							
0-7	95.3	0.936	-0.0356	0.1883	0.000151	0.001794	123.0
8-15	100.3	1.192	-0.1770	0.1264	0.000836	0.000747	173.1
16-25	103.6	0.910	-0.2154Sug	0.1207	0.000356	0.000847	157.7
26+	103.0	0.831	-0.3004Sug	0.1719	0.002411	0.001864	141.3
All	101.0	0.484	-0.1677*	0.0654	0.000646	0.000450	156.3
Heterogeneity χ^2(df=3)			1.14	P=0.77	1.13	P=0.77	
After exclusion of the controls							
A. PE86 sample based on T65DR							
0-7	95.5	1.450	-0.0509	0.1196	0.000314	0.001054	39.5
8-15	100.8	2.462	-0.1166	0.1271	0.000397	0.000599	169.3
16-25	100.4	2.071	-0.0229	0.1216	-0.000482	0.000738	162.5
26+	103.6	2.297	-0.2164	0.1863	0.001085	0.001556	152.9
All	100.5	1.066	-0.0975	0.0595	0.000230	0.000333	140.2
Heterogeneity χ^2(df=3)			0.90	P=0.83	1.29	P=0.74	
B. Clinical subsample based on DS86							
0-7	91.2	2.443	0.1164	0.1632	-0.000824	0.001344	38.2
8-15	105.0	3.363	-0.2672	0.1825	0.000530	0.001356	94.0
16-25	96.2	5.410	0.0489	0.2380	-0.000941	0.001329	187.5
26+	110.2	2.843	-0.7765**	0.2065	0.006341**	0.001934	86.0
All	101.1	1.858	-0.1511	0.0968	0.000190	0.000679	122.7
Heterogeneity χ^2(df=3)			12.78	P<0.01	11.27	P=0.01	
C. PE86 sample based on DS86							
0-7	95.3	1.424	-0.0385	0.1341	0.000173	0.001178	39.7
8-15	101.1	2.322	-0.2039	0.1412	0.000959	0.000794	165.9
16-25	100.9	1.996	-0.1088	0.1407	-0.000186	0.000927	161.2
26+	103.7	2.280	-0.3498	0.2253	0.002821	0.002249	153.6
All	100.5	1.042	-0.1505*	0.0722	0.000559	0.000466	140.1
Heterogeneity χ^2(df=3)			1.69	P=0.64	2.02	P=0.57	

See the footnote in Table 4a.
表4aの脚注参照.

The Nature of the Study Group. It must be borne in mind that these observations are based on a sample, and not a full birth cohort in the usual sense. The number of individuals at risk is known to be incomplete for at least two reasons. First, the primary source of ascertainment of the sample was through births registered in Hiroshima or Nagasaki. Prenatally exposed survivors whose births were registered elsewhere are not included. Second, presence in the study sample entailed residence within contact areas (essentially the limits of the two cities), and thus migrants from the contact areas after birth are not included.

調査集団の特性. これらの観察は，通常の意味での完全な出生コホート集団ではないことを銘記しなければならない．観察対象者数は少なくとも二つの理由から不完全なものである．まず第一は，対象者の主要な確認源は広島又は長崎の出生届であった．両市以外で出生届を出した胎内被爆者は含まれていない．第二に，調査集団は連絡区域内（本来，両市内）に居住することを条件としているので，出生後連絡区域から転出した者は含まれていない．

Errors in the Estimation of Fetal Absorbed dose. The doses to the survivors of the A-bombing that are used are subject to at least three sources of error, i.e., those that stem from a) the estimated free-in-air kerma, b) the attenuation factors for tissues, materials, positions, and the like, and c) the assertions of the survivors as to their locations. The probable magnitude of these errors is poorly known; however, it is clear that they can affect inferences on the overall shape of the dose-response relationship as well as parameter values defining that shape. If such errors are random, the effect is to underestimate the slope of the dose-response relationship, and to suggest a curvilinearity in response that does not, in fact, obtain.[27–29]

胎児吸収線量の推定誤差. 用いる原爆被曝線量は，a）推定空中カーマ，b）組織，材料，位置などによる減弱率，並びに c）被爆者の被爆位置に関する本人の回答に由来する少なくともこれら三つの誤差が考えられる．これらの誤差の程度は余りよく知られていないが，線量反応関係の全体的形状並びにその形状を決定するパラメータの推定値に影響を及ぼすことは明らかである．もしそのような誤差が確率的なものだとすれば，その影響は線量反応関係の勾配を過小評価し，また実際に認められない反応の曲線性を示唆することになろう．[27-29]

Errors in the Estimation of Prenatal Age at Exposure. The apparent timing of vulnerable events in development can be affected by errors in the determination of prenatal age, and possibly seriously so in specific cases. Postovulatory age is usually estimated from the onset of the last menstrual period, and adjustment is then made for the difference between that date and the probable date of fertilization (usually taken to be two weeks later). Women with irregular menstrual cycles or who miss a menstrual period for any of several reasons, notably lactational amenorrhea, illness or malnutrition, or postovulatory bleeding, could erroneously identify the onset of their last cycle. All of these possible sources of error were present immediately prior to and following the cessation of hostilities in Japan. Their impact on the estimated ages is impossible to assess. An equally important contributor to uncertainty is the normal variability in developmental age, the critical measure of vulnerability, for fixed intervals of time after fertilization. Embryos or fetuses of the same

被爆時胎内週齢の推定誤差. 発達過程に影響を受けやすい事象が起こる時期は胎内週齢の推定誤差によって誤って推定される可能性があり，恐らく特定の症例についてはその可能性が大である．胎内週齢は普通，最終月経期の開始日から推定され，その開始日と推定受胎日（普通2週間後とみなされている）の差を補正する．月経周期が不規則な女性，又は授乳期無月経，疾病，栄養失調などの何らかの理由により月経が飛んでいる場合，あるいは受胎後出血がある場合は最終月経の開始日を誤認する可能性がある．終戦直前及び直後の日本にはこのような誤差源となりうる要素が多く存在していた．これらの誤差が推定胎内週齢に及ぼす影響を評価することは不可能である．誤差源同様に重要な他の不確定要因は受胎後の一定の期間において感受性の重要な尺度である発達胎齢が普通変動することである．同じ胎齢の胎芽又は胎児でも発達段階においては数日あるい

chronological age can differ by days, possibly a week or more in their developmental stage.

Intelligence Test Scores as a Measure of Brain Damage. Intuitively, achievement on intelligence tests must be related to the quality of brain function, but the biological basis of this relationship is far from clear. Obviously, motivation, socialization at home and in school, physical impairment (vision or hearing, for example), and other factors can affect performance on intelligence tests. Of necessity, these extraneous sources of variability are assumed to be part of the random error in the analyses discussed above, but the possibility that they are systematic cannot be excluded.

DISCUSSION

Recently, Otake et al[20] have reexamined the data on the frequency of occurrence of severe mental retardation among the prenatally exposed, comparing the dose-response estimates based on the DS86 doses with those derived from the earlier T65DR dosimetry. They observed: The highest risk of radiation damage to the embryonic and fetal brain occurs 8-15 weeks after fertilization under both dosimetric systems. Although other dose-response models will fit the data, damage to the 8-15 week old fetus expressed as the frequency of severe mental retardation appears adequately described by a simple linear model without a threshold. However, somewhat more evidence exists under the DS86 system of a threshold to the dose-response relationship in the 8-15 week interval than existed with the T65DR doses. But the location and reality of the threshold are difficult to assess. The threshold estimate varies substantially with the model fitted and whether five cases of mental retardation with probable nonradiation-related etiologies are or are not included. Damage to the fetus 16-25 weeks after fertilization seems linear-quadratically or quadratically related to dose, especially in the DS86 sample, and suggests a threshold.

In this context, it is interesting to note that insofar as the Koga test is concerned, evidence of a radiation-related effect is confined to the same two age-groups where severe mental retardation is increased, that is, 8-15 and 16-25 weeks after fertilization. This suggests that the findings with respect to one measure may be intimately related to the other. Alternatively put, both are products of a common kind of brain damage.

は1週間以上の差が認められることがある.

脳障害の尺度としての知能検査値. 直観的に, 知能検査成績は脳機能と質的に関連しているはずであるが, この関連性の生物学的根拠は全くはっきりしていない. 明らかに, 動機づけ, 学校・家庭での社会活動, 身体的障害(例えば, 視力又は聴力)及び他の要因が知能検査成績に影響を及ぼすことは明白である. 当然, これらの外的変動源は前述した解析においては確率的誤差とみなされるが, 系統的誤差である可能性も考慮しないわけにはいかない.

考　察

最近, 大竹ら[20]は, DS86線量に基づく線量反応推定値を, 初期のT65DR線量推定方式から得た推定値と比較して, 胎内被爆者の重度精神遅滞発生頻度に関するデータを再検討した. その観察によると, 胎芽及び胎児の放射線脳障害のリスクは, どちらの線量推定方式でも, 受胎後8～15週齢群が最も高いことを確認した. 他の線量反応モデルもデータに適合したが, 重度精神遅滞頻度として示された8～15週齢群の胎児への脳障害は, 閾値をもたない簡単な線形モデルによって適切に説明されるように思われる. しかし, 8～15週齢群の線量反応関係に対する閾値の存在はT65DR線量を用いたときよりもDS86線量推定方式の方が若干はっきりした証拠を認める. しかし閾値の位置設定及び実在を評価するのは難しい. 閾値の推定値は, 適合するモデルや恐らく放射線以外の原因による精神遅滞者5人を含めるか含めないかによって大きく変わる. 受胎後16～25週齢群の胎児に対する障害は, 特にDS86集団において線量に対して線形-2次関係又は2次関係を示し, 閾値を示唆している.

これに関連して, 古賀式検査に関する限り, 放射線の影響が認められるのは, 重度精神遅滞が増加する二つの同じ週齢群, すなわち受胎後8～15週齢群及び16～25週齢群に限定されている点に注目され, 興味深いことである. このことは, ある尺度に関する所見は他の尺度に関する所見と直接関係があるかもしれないことを示唆している. 換言すれば, 両方とも共通の脳障害の結果である.

As has been seen, the periods of vulnerability come either during or immediately following a rapid increase in the number of neurons and their migration to their final developmental sites. Concurrent with these events the neurons lose their capacity to divide, becoming perennial cells. Thus the cells at risk are not replaceable, and any that are lost (either through death or incapacitation) are irretrievably so. A priori two different conjectures about the radiosensitivity of these cells, or a combination of the two, can be made. There could exist a relatively small number of individuals whose neurons are disproportionately sensitive to radiation damage, and the effects that are seen are confined largely, if not exclusively to these individuals. It is also conceivable, indeed more likely in our view, that the neurons of all embryos and fetuses are similarly, if not identically, sensitive to ionizing radiation. We have sought, but failed to find evidence of different radiosensitivities, but the data pertinent to this notion are admittedly limited. Accordingly, we are inclined to view both the decrement in intelligence test score and the increase in frequency of mental retardation as products of a common process or processes, one ultimately referable to the number of neurons lost, incapacitated, or faultily situated with exposure to ionizing radiation. The severity of the effect depends upon the number of cells involved, and where in the continuum of brain function the exposed individual would have been in the absence of exposure, for it is important to bear in mind that there is no single state of normality in brain function.

これまでに認められてきたように，危険期は，ニューロン数が急増し，最終的な発達部位に移動する期間中かその期間の直後にくる．これらの事象と同時に，ニューロンはその分裂の特性を失って非分裂細胞になる．したがって，この非分裂細胞は取り換え不可能であり，（細胞死又は活動不能により）喪失された細胞は決して補充できない．これらの細胞の放射線感受性について先験的な二つの異なる推測又はその二つを組み合わせた推測ができる．すなわち，ニューロンの放射線障害に対する感受性が不相応な対象者が比較的に少数存在し，被爆影響を認めるのは主にこれらの対象者に限定されているという可能性である．もう一つは，すべての胎芽及び胎児のニューロンの電離放射線に対する感受性は，全く同一でないにしても，類以していると考えられることである．実際に我々の見解ではこちらの可能性が大きい．著者らは，放射線感受性が異なる証拠を見つけることに失敗したが，この見解に関連するデータは明らかに少ない．したがって，知能検査値の減少及び精神遅滞頻度の増加は，電離放射線被曝によるニューロンの喪失，活動不能，配置ミスなどのニューロン数が究極原因である共通の過程あるいは幾つかの過程の結果であると考えたい．脳機能における単一の正常態はないということを銘記することは重要である．このことは，対象となる細胞数と，被爆対象者が被曝していなかったとすれば脳機能連続体のどの段階であったかということが，影響の程度を左右することを示す．

Patently these notions would be more compelling if specific biological processes could be incriminated. However, the biological bases of the effects we describe remain elusive. Elsewhere we have suggested that mismanaged neuronal migration could be a significant contributor, but there are numerous other candidates including impaired neuronal proliferation, aggregation and cytodifferentiation, the growth of specific cell connections, neuronal death and neurite consolidation. Brain development and function depend upon all of these, and their occurrence in a temporally and spatially coordinated manner. Any disturbance of this sequence, however transitory, could lead to abnormality, for proper neuronal function depends upon the proper number and situating of the neuronal cells. There is now, for example, a substantial and growing literature, largely based on magnetic resonance imaging of

特定の生物学的過程を原因としてあげることができれば，明らかにこれらの考え方はもっと説得力のあるものであろう．しかし，ここに示す影響の生物学的根拠は確認しにくいものである．著者は別報で，ニューロンの遊走ミスが重大な原因であることを示唆したが，その他にも障害を受けたニューロンの増殖，集合及び細胞分化，特定の細胞間の線維連絡の成長，細胞死，並びに神経突起の分枝の固質化などの幾つかの原因が考えられる．脳の発達及び機能はこれらの一連の事象に左右され，それは時間的にも空間的にも統合されなければならない．この順序に変調が起こると，それが一過性であろうと異常が起こり得る．なぜならば，ニューロンが正常に機能するためにはニューロン数と移動位置が適切であるかどうかに

the living brain, that demonstrates that mismanaged migration is associated with mental retardation. These studies unfortunately do not illuminate the basis for the present findings for at least two reasons. First, they have focused on individuals who have been previously diagnosed clinically as mentally retarded; to our knowledge, there are no epidemiologically based studies that have examined the brains of individuals of normal, but lower intelligence exposed to radiation or other possible teratogens. Second, there are limitations to the present magnetic resonance imaging techniques. They cannot, for instance, reveal modest, but potentially functionally important errors in migration that involve a few critically disposed cells, nor can they disclose errors in connectedness within the brain. The latter may be especially important in view of the differences in findings in Nagasaki with regard to the Koga and Tanaka tests. One of these, the Koga, places greater emphasis upon the perception of spatial relationships; whereas the other, the Tanaka, emphasizes word-sense, arithmetic abilities, and the like which are probably associated with the more subtle processing of visual clues than their simple recognition, and could, therefore, depend more upon connectedness. Be this as it may, what is now needed is more new evidence and a lesser dependence upon reanalysis of the old.

依存するからである．例えば，現在，主として生きた脳の磁気共鳴画像に基づいた大量かつ多数の文献は，遊走ミスが精神遅滞と関連することを立証している．あいにく，これらの研究は少なくとも二つの理由から現在の所見の論拠を明確にしていない．まず第一に，いずれの研究も以前臨床的に精神遅滞者と診断された人のみを対象としている．著者の知る限りでは，放射線又は他の催奇物質に被曝した正常で，しかも知能の低い対象者の脳を検査した疫学研究はない．第二に，現在の磁気共鳴画像技法には限度がある．例えば，この技法では，危機的状態に配列された細胞を幾つか含む，些細ではあるが潜在的に機能上重要な遊走ミスを明らかにすることはできないし，脳内の連結異常を明示することもできない．後者は，長崎の所見が古賀式と田中式の検査で異なる点からみて特に重要であるかもしれない．古賀式検査では空間関係の認知に重点が置かれているが，もう一つの田中式検査では語感や計算能力並びに単純認知よりも微妙な視覚的処理に関するものに重点を置いているので，脳内連結に対する依存性が古賀式検査より大きくなる．いずれにせよ，現在必要なことは，更に多くの新しい証拠を探究することであり，余り古い所見の再解析のみに頼らないことであろう．

APPENDIX TABLE 1 THE DISTRIBUTION OF DS86 UTERINE DOSE ESTIMATES BY DOSE GROUPS AND THE METHOD OF DOSE ESTIMATION

付表1 DS86子宮線量推定値分布，線量群並びに線量推定法別

Method of estimation	DS86 Dose Category (Gy)				
	<0.01	0.01-0.09	0.10-0.49	0.50-0.99	1.00+
Direct	1	124	119	26	15
Indirect	269	49	3		1
Total	270	173	122	26	16

APPENDIX 2a THE REGRESSION COEFFICIENTS OBTAINED WHEN A QUADRATIC MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE

付表2a 個人の胎児又は子宮吸収線量に対する知能検査値への2次モデルを利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	c	S_c	
All cases included					
A. PE86 sample based on T65DR					
0-7	106.1	0.925	-0.000376	0.000495	226.3
8-15	108.2	0.910	-0.000851**	0.000220	285.0
16-25	109.6	0.731	-0.001526**	0.000324	251.6
26+	107.3	0.660	-0.000062	0.000563	246.1
All	108.0	0.392	-0.000897**	0.000159	254.0
Heterogeneity χ^2(df=3)			7.12	P=0.07	
B. Clinical subsample based on DS86					
0-7	105.8	1.149	0.000121	0.000255	233.4
8-15	107.2	0.964	-0.002272**	0.000355	227.9
16-25	110.5	0.854	-0.001955**	0.000386	247.7
26+	107.2	0.771	-0.000318	0.000556	238.6
All	107.8	0.459	-0.000922**	0.000177	247.0
Heterogeneity χ^2(df=3)			39.53	P<0.01	
C. PE86 sample based on DS86					
0-7	106.0	0.922	0.000125	0.000251	226.5
8-15	108.5	0.898	-0.001463**	0.000273	274.5
16-25	109.8	0.730	-0.002043**	0.000377	248.0
26+	107.4	0.663	-0.000336	0.000562	245.9
All	108.0	0.393	-0.000889**	0.000161	254.1
Heterogeneity χ^2(df=3)			30.98	P<0.01	
After exclusion of clinically diagnosed cases of retardation					
A. PE86 sample based on T65DR					
0-7	106.1	0.925	-0.000376	0.000495	226.3
8-15	108.6	0.882	-0.000680**	0.000218	265.8
16-25	109.8	0.730	-0.001563*	0.000617	246.8
26+	107.4	0.656	-0.000071	0.000559	242.6
All	108.1	0.388	-0.000652**	0.000176	247.0
Heterogeneity χ^2(df=3)			3.59	P=0.31	
B. Clinical subsample based on DS86					
0-7	105.8	1.149	0.000121	0.000255	233.4
8-15	107.5	0.946	-0.002164**	0.000493	217.0
16-25	110.4	0.865	-0.001440Sug	0.000846	245.4
26+	107.3	0.764	-0.000333	0.000550	233.7
All	107.9	0.451	-0.000422*	0.000206	238.2
Heterogeneity χ^2(df=3)			18.49	P<0.01	
C. PE86 sample based on DS86					
0-7	106.0	0.922	0.000125	0.000251	226.5
8-15	108.7	0.880	-0.001133**	0.000308	262.9
16-25	109.9	0.737	-0.001987**	0.000768	246.7
26+	107.4	0.659	-0.000347	0.000558	242.4
All	108.1	0.389	-0.000506**	0.000181	247.9
Heterogeneity χ^2(df=3)			14.20	P<0.01	

See the footnote in Table 4a.
表4aの脚注参照.

APPENDIX 2b THE REGRESSION COEFFICIENTS OBTAINED WHEN A QUADRATIC MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA EXCLUDING THE CONTROL CASES

付表2b 個人の胎児又は子宮吸収線量に対する知能検査値への2次モデルを対照例を除く利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	c	S_c	
All cases except the controls included					
A. PE86 sample based on T65DR					
0-7	103.6	2.025	-0.000201	0.000550	265.3
8-15	107.7	1.763	-0.000836**	0.000250	357.4
16-25	106.8	1.438	-0.001350**	0.000343	267.9
26+	104.2	1.404	0.000276	0.000593	258.7
All	105.9	0.806	-0.000795**	0.000173	289.7
Heterogeneity χ^2 (df=3)			7.07	P=0.07	
B. Clinical subsample based on DS86					
0-7	104.2	2.929	0.000161	0.000296	299.0
8-15	107.0	1.877	-0.002254**	0.000398	262.4
16-25	108.8	1.825	-0.001815**	0.000438	289.4
26+	104.1	1.550	0.000081	0.000591	246.2
All	105.7	0.972	-0.000797**	0.000199	291.4
Heterogeneity χ^2 (df=3)			31.44	P<0.01	
C. PE86 sample based on DS86					
0-7	104.4	2.006	0.000166	0.000284	284.4
8-15	108.7	1.609	-0.001473**	0.000300	317.7
16-25	107.8	1.385	-0.001863**	0.000404	266.5
26+	104.9	1.333	-0.000009	0.000595	257.7
All	106.4	0.773	-0.000803**	0.000175	290.9
Heterogeneity χ^2 (df=3)			25.29	P<0.01	
After exclusion of clinically diagnosed cases of retardation and the controls					
A. PE86 sample based on T65DR					
0-7	103.6	2.025	-0.000201	0.000550	265.3
8-15	108.5	1.691	-0.000677**	0.000244	323.9
16-25	107.1	1.441	-0.001184Sugg	0.000650	253.5
26+	104.2	1.404	0.000276	0.000593	258.7
All	106.1	0.789	-0.000550**	0.000190	275.8
Heterogeneity χ^2 (df=3)			3.56	P=0.31	
B. Clinical subsample based on DS86					
0-7	104.2	2.929	0.000161	0.000296	299.0
8-15	107.2	1.891	-0.002134**	0.000562	259.7
16-25	108.4	1.934	-0.000962	0.000993	281.5
26+	104.1	1.550	0.000081	0.000591	246.2
All	105.7	0.945	-0.000279	0.000227	274.0
Heterogeneity χ^2 (df=3)			13.93	P<0.01	
C. PE86 sample based on DS86					
0-7	104.4	2.006	0.000166	0.000284	284.4
8-15	108.9	1.585	-0.001142**	0.000338	306.6
16-25	107.8	1.441	-0.001503Sug	0.000841	262.8
26+	104.9	1.333	-0.000009	0.000595	257.7
All	106.4	0.759	-0.000413*	0.000195	279.9
Heterogeneity χ^2 (df=3)			10.94	P=0.01	

See the footnote in Table 4a.
表4aの脚注参照.

APPENDIX 3a THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR EXPONENTIAL MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE

付表3a 個人の胎児又は子宮吸収線量に対する知能検査値への線形指数モデルを利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Deviance
	a	S_a	b(Gy)	S_b(Gy)	
All cases included					
A. PE86 sample based on T65DR					
0-7	4.656	0.00919	-0.07395	0.05976	5.74
8-15	4.680	0.00897	-0.22970**	0.03481	9.08
16-25	4.692	0.00716	-0.23090**	0.04032	10.86
26+	4.666	0.00642	-0.02793	0.05201	12.67
All	4.675	0.00386	-0.17100**	0.02245	38.87
Heterogeneity χ^2 (df=3)			15.24	P<0.01	
B. Clinical subsample based on DS86					
0-7	4.653	0.01150	-0.03928	0.05176	3.99
8-15	4.676	0.00968	-0.32540**	0.04124	5.42
16-25	4.701	0.00858	-0.22770**	0.04241	8.12
26+	4.665	0.00765	-0.04159	0.04835	9.10
All	4.676	0.00458	-0.17780**	0.02297	27.52
Heterogeneity χ^2 (df=3)			29.28	P<0.01	
C. PE86 sample based on DS86					
0-7	4.655	0.00919	-0.02984	0.04981	5.77
8-15	4.685	0.00888	-0.27770**	0.03834	8.70
16-25	4.694	0.00721	-0.23730**	0.03965	10.79
26+	4.666	0.00647	-0.04596	0.04775	12.66
All	4.677	0.00388	-0.17500**	0.02151	38.68
Heterogeneity χ^2 (df=3)			25.43	P<0.01	
After exclusion of clinically diagnosed cases of retardation					
A. PE86 sample based on T65DR					
0-7	4.656	0.00919	-0.07395	0.05976	5.74
8-15	4.682	0.00858	-0.17290**	0.03958	8.18
16-25	4.690	0.00711	-0.13470**	0.04997	10.45
26+	4.667	0.00635	-0.03010	0.05138	12.34
All	4.675	0.00378	-0.11570**	0.02410	37.05
Heterogeneity χ^2 (df=3)			5.50	P=0.14	
B. Clinical subsample based on DS86					
0-7	4.653	0.01150	-0.03928	0.05176	3.99
8-15	4.676	0.00933	-0.26270**	0.04852	4.86
16-25	4.696	0.00851	-0.09363Sug	0.05391	7.71
26+	4.667	0.00763	-0.04159	0.04753	8.78
All	4.675	0.00448	-0.10730**	0.02534	25.87
Heterogeneity χ^2 (df=3)			13.75	P<0.01	
C. PE86 sample based on DS86					
0-7	4.655	0.00919	-0.02984	0.04981	5.77
8-15	4.686	0.00863	-0.21670**	0.04291	8.04
16-25	4.691	0.00719	-0.13180**	0.04932	10.46
26+	4.668	0.00640	-0.04823	0.04717	12.33
All	4.676	0.00382	-0.11440**	0.02352	37.03
Heterogeneity χ^2 (df=3)			10.66	P=0.01	

The coefficients are expressed as change in the logarithm of IQ points per 1.0 Gy of exposure.
各係数は1.0 Gy 当たりのIQ値の対数変化を示す.

** Significant at <0.01 level, * at < 0.05 level, and Sug at <0.10 level.
< 0.01水準で有意, * < 0.05水準で有意, Sug < 0.10水準で示唆的

APPENDIX 3b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR EXPONENTIAL MODEL OF INTELLIGENCE TEST SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA EXCLUDING THE CONTROL CASES

付表3b 個人の胎児又は子宮吸収線量に対する知能検査値への線形指数モデルを対照例を除く全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Deviance
	a	S_a	b(Gy)	S_b(Gy)	
All cases except the controls included					
A. PE86 sample based on T65DR					
0-7	4.631	0.02184	-0.03626	0.07190	1.74
8-15	4.693	0.01819	-0.24510**	0.04579	3.75
16-25	4.678	0.01637	-0.20830**	0.04961	3.75
26+	4.631	0.01522	0.04214	0.06113	3.37
All	4.664	0.00882	-0.15410**	0.02721	13.14
Heterogeneity χ^2(df=3)			18.06	P<0.01	
B. Clinical subsample based on DS86					
0-7	4.643	0.03196	-0.02932	0.06540	1.02
8-15	4.705	0.02008	-0.36750**	0.04929	1.89
16-25	4.703	0.02246	-0.23080**	0.05885	3.02
26+	4.631	0.01734	0.02438	0.05793	2.66
All	4.672	0.01109	-0.17140**	0.02947	9.44
Heterogeneity χ^2(df=3)			32.96	P<0.01	
C. PE86 sample based on DS86					
0-7	4.639	0.02140	-0.01046	0.06043	1.95
8-15	4.710	0.01650	-0.30980**	0.04375	3.51
16-25	4.687	0.01587	-0.22490**	0.04929	4.10
26+	4.640	0.01459	0.00997	0.05662	3.77
All	4.673	0.00843	-0.16890**	0.02601	14.10
Heterogeneity χ^2(df=3)			28.51	P<0.01	
After exclusion of clinically diagnosed cases of retardation and the controls					
A. PE86 sample based on T65DR					
0-7	4.631	0.02184	-0.03626	0.07190	1.74
8-15	4.693	0.01726	-0.18590**	0.04649	3.28
16-25	4.667	0.01614	-0.08665	0.06061	3.31
26+	4.631	0.01522	0.04214	0.06113	3.37
All	4.660	0.00857	-0.09074**	0.02881	12.04
Heterogeneity χ^2(df=3)			9.49	P=0.02	
B. Clinical subsample based on DS86					
0-7	4.643	0.03196	-0.02932	0.06540	1.02
8-15	4.698	0.02045	-0.29980**	0.06067	1.78
16-25	4.675	0.02263	-0.04752	0.07515	2.59
26+	4.631	0.01734	0.02438	0.05793	2.66
All	4.661	0.01083	-0.08299*	0.03227	8.50
Heterogeneity χ^2(df=3)			17.04	P<0.01	
C. PE86 sample based on DS86					
0-7	4.639	0.02140	-0.01046	0.06043	1.95
8-15	4.704	0.01637	-0.24500**	0.04973	3.30
16-25	4.672	0.01594	-0.08900	0.06134	3.72
26+	4.640	0.01459	0.00997	0.05662	3.77
All	4.666	0.00830	-0.09710**	0.02834	13.18
Heterogeneity χ^2(df=3)			14.49	P<0.01	

See the footnote in Appendix 3a.
付表3aの脚注参照.

APPENDIX 4a THE REGRESSION COEFFICIENTS OBTAINED WHEN A QUADRATIC MODEL OF IQ (KOGA) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

付表4a 個人の胎児又は子宮吸収線量に対するIQ値（古賀式）への2次モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	c	S_c	
All cases included					
A. PE86 sample based on T65DR					
0-7	105.9	1.234	-0.002101**	0.000803	233.9
8-15	111.0	1.432	-0.000734**	0.000222	279.1
16-25	107.7	1.004	-0.001061**	0.000314	209.6
26+	106.9	1.006	-0.000159	0.000585	232.6
All	107.6	0.570	-0.000780**	0.000163	237.7
Heterogeneity χ^2 (df=3)			4.54	P=0.21	
B. Clinical subsample based on DS86					
0-7	105.6	1.666	-0.002734**	0.001034	249.8
8-15	109.5	1.779	-0.001996**	0.000574	213.8
16-25	107.6	1.341	-0.001414**	0.000432	195.3
26+	105.0	1.316	0.000035	0.000858	197.5
All	106.7	0.749	-0.001507**	0.000311	214.0
Heterogeneity χ^2 (df=3)			5.41	P=0.14	
C. PE86 sample based on DS86					
0-7	105.8	1.227	-0.002704**	0.000994	233.1
8-15	110.9	1.438	-0.001013**	0.000334	282.4
16-25	107.6	1.000	-0.001504**	0.000437	209.2
26+	106.9	1.004	-0.000171	0.000923	232.7
All	107.6	0.570	-0.001125**	0.000239	237.9
Heterogeneity χ^2 (df=3)			4.33	P=0.23	
After exclusion of the controls					
A. PE86 sample based on T65DR					
0-7	105.6	2.672	-0.002073*	0.000833	232.9
8-15	112.8	2.526	-0.000781**	0.000229	281.3
16-25	106.7	1.755	-0.001018**	0.000296	177.8
26+	105.6	2.254	-0.000049	0.000646	263.8
All	107.5	1.131	-0.000775**	0.000169	243.3
Heterogeneity χ^2 (df=3)			4.10	P=0.25	
B. Clinical subsample based on DS86					
0-7	108.2	3.634	-0.002970**	0.000941	185.3
8-15	111.3	3.815	-0.002127**	0.000636	225.9
16-25	107.9	2.813	-0.001429**	0.000404	155.2
26+	101.3	2.846	0.000475	0.000935	210.4
All	106.5	1.643	-0.001494**	0.000322	206.6
Heterogeneity χ^2 (df=3)			7.88	P=0.05	
C. PE86 sample based on DS86					
0-7	105.2	2.600	-0.002650*	0.001009	229.0
8-15	112.4	2.561	-0.001070**	0.000349	292.3
16-25	106.4	1.726	-0.001445**	0.000408	175.9
26+	105.6	2.235	-0.000009	0.001012	263.8
All	107.3	1.125	-0.001112**	0.000247	244.0
Heterogeneity χ^2 (df=3)			3.92	P=0.27	

See the footnote in Table 4a.
表4aの脚注参照.

APPENDIX 4b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR EXPONENTIAL MODEL OF IQ (KOGA) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

付表4b 個人の胎児又は子宮吸収線量に対するIQ値（古賀式）への線形指数モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Deviance
	a	S_a	b(Gy)	S_b(Gy)	
All cases included					
A. PE86 sample based on T65DR					
0-7	4.653	0.01235	-0.18460*	0.08232	3.49
8-15	4.702	0.01439	-0.15710**	0.04384	3.71
16-25	4.637	0.00989	-0.15040**	0.04642	4.07
26+	4.663	0.00947	-0.03377	0.05962	4.61
All	4.671	0.00558	-0.13000**	0.02601	16.14
Heterogeneity χ^2(df=3)			3.61	P=0.31	
B. Clinical subsample based on DS86					
0-7	4.652	0.01668	-0.29510**	0.10860	2.17
8-15	4.692	0.01877	-0.25640**	0.07163	1.56
16-25	4.675	0.01366	-0.20360**	0.06409	2.07
26+	4.647	0.01286	-0.12530	0.07643	2.06
All	4.665	0.00757	-0.18930**	0.03816	8.06
Heterogeneity χ^2(df=3)			6.47	P=0.09	
C. PE86 sample based on DS86					
0-7	4.654	0.01224	-0.26680**	0.10200	3.45
8-15	4.701	0.01439	-0.19140**	0.05537	3.73
16-25	4.673	0.09792	-0.21610**	0.05963	4.02
26+	4.663	0.00946	-0.04181	0.07845	4.61
All	4.671	0.00555	-0.17380**	0.03316	16.09
Heterogeneity χ^2(df=3)			4.24	P=0.24	
After exclusion of the controls					
A. PE86 sample based on T65DR					
0-7	4.658	0.03082	-0.19240	0.09834	0.86
8-15	4.736	0.02519	-0.18490**	0.04494	1.10
16-25	4.673	0.01953	-0.15100**	0.04956	1.10
26+	4.651	0.02290	-0.01463	0.07100	1.23
All	4.680	0.01192	-0.14010**	0.02906	4.53
Heterogeneity χ^2(df=3)			4.41	P=0.22	
B. Clinical subsample based on DS86					
0-7	4.719	0.04099	-0.40120**	0.11300	0.25
8-15	4.742	0.04306	-0.31660**	0.08499	0.38
16-25	4.720	0.03671	-0.26350**	0.07666	0.35
26+	4.605	0.03106	0.05016	0.09308	0.52
All	4.687	0.01941	-0.22090**	0.04608	1.78
Heterogeneity χ^2(df=3)			12.65	P<0.01	
C. PE86 sample based on DS86					
0-7	4.661	0.02948	-0.28050**	0.11770	0.82
8-15	4.732	0.02527	-0.22170**	0.05690	1.14
16-25	4.675	0.01876	-0.21810**	0.06178	1.05
26+	4.651	0.02281	-0.01631	0.09313	1.23
All	4.680	0.01170	-0.18550**	0.03652	4.48
Heterogeneity χ^2(df=3)			4.57	P=0.21	

See the footnote in Appendix 3a.
付表3aの脚注参照.

APPENDIX 5a THE REGRESSION COEFFICIENTS OBTAINED WHEN A QUADRATIC MODEL OF IQ (TANAKA-B) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

付表5a 個人の胎児又は子宮吸収線量に対するIQ値（田中B式）への2次モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Mean Squares about Regression
	a	S_a	c	S_c	
All cases included					
A. PE86 sample based on T65DR					
0-7	95.2	0.892	-0.000124	0.000581	122.3
8-15	99.9	1.135	-0.000139	0.000175	173.9
16-25	103.2	0.875	-0.000742**	0.000273	158.9
26+	102.6	0.792	-0.000699	0.000457	141.6
All	100.6	0.465	-0.000321*	0.000133	157.1
Heterogeneity χ^2(df=3)			4.24	P=0.24	
B. Clinical subsample based on DS86					
0-7	94.8	1.293	-0.000131	0.000803	150.5
8-15	101.4	1.574	-0.001345**	0.000508	167.4
16-25	103.9	1.241	-0.001003*	0.000400	167.3
26+	103.5	1.081	-0.000735	0.000698	130.9
All	101.2	0.657	-0.000944**	0.000272	163.6
Heterogeneity χ^2(df=3)			1.76	P=0.63	
C. PE86 sample based on DS86					
0-7	95.2	0.889	-0.000159	0.000720	122.3
8-15	99.8	1.134	-0.000143	0.000263	174.3
16-25	103.1	0.873	-0.000995**	0.000381	159.4
26+	102.5	0.793	-0.000595	0.000723	142.6
All	100.6	0.465	-0.000396*	0.000195	157.4
Heterogeneity χ^2(df=3)			3.58	P=0.31	
After exclusion of the controls					
A. PE86 sample based on T65DR					
0-7	95.1	1.088	-0.000110	0.000339	38.6
8-15	99.4	1.956	-0.000128	0.000178	168.7
16-25	100.2	1.664	-0.000610*	0.000281	159.9
26+	101.8	1.738	-0.000630	0.000494	153.9
All	99.4	0.865	-0.000275*	0.000129	141.4
Heterogeneity χ^2(df=3)			2.85	P=0.42	
B. Clinical subsample based on DS86					
0-7	92.5	1.622	0.000085	0.000420	36.9
8-15	101.6	2.543	-0.001362**	0.000424	100.4
16-25	97.1	3.016	-0.000684	0.000434	178.5
26+	102.1	2.262	-0.000572	0.000731	127.8
All	99.0	1.286	-0.000795**	0.000250	124.8
Heterogeneity χ^2(df=3)			5.90	P=0.11	
C. PE86 sample based on DS86					
0-7	95.1	1.068	-0.000144	0.000414	38.6
8-15	99.3	1.952	-0.000124	0.000266	169.8
16-25	100.0	1.647	-0.000837*	0.000389	160.1
26+	101.4	1.744	-0.000460	0.000783	157.6
All	99.3	0.862	-0.000331Sug	0.000189	142.4
Heterogeneity χ^2(df=3)			2.52	P=0.47	

See the footnote in Table 4a.
表4aの脚注参照.

APPENDIX 5b THE REGRESSION COEFFICIENTS OBTAINED WHEN A LINEAR EXPONENTIAL MODEL OF IQ (TANAKA-B) SCORE ON INDIVIDUAL FETAL OR UTERINE ABSORBED DOSE IS FITTED TO ALL OF THE DATA AVAILABLE IN NAGASAKI

付表5b 個人の胎児又は子宮吸収線量に対するIQ値（田中B式）への線形指数モデルを長崎の利用可能な全データに当てはめて得られた回帰係数

Gestational Ages (Weeks)	Regression Coefficients				Deviance
	a	S_a	b(Gy)	S_b(Gy)	
All cases included					
A. PE86 sample based on T65DR					
0-7	4.549	0.00981	-0.00832	0.06536	2.20
8-15	4.596	0.01299	-0.04487	0.03942	2.98
16-25	4.632	0.00899	-0.13290**	0.04170	3.29
26+	4.626	0.00829	-0.09535Sug	0.05174	3.41
All	4.606	0.00496	-0.07309**	0.02307	12.60
Heterogeneity χ^2(df=3)			3.69	P=0.30	
B. Clinical subsample based on DS86					
0-7	4.544	0.01424	-0.01142	0.09276	1.58
8-15	4.616	0.01759	-0.19710**	0.06710	1.37
16-25	4.642	0.01258	-0.19640**	0.05900	1.76
26+	4.638	0.01091	-0.12550Sug	0.06427	1.43
All	4.613	0.00695	-0.14700**	0.03495	6.72
Heterogeneity χ^2(df=3)			3.49	P=0.32	
C. PE86 sample based on DS86					
0-7	4.549	0.00978	-0.01037	0.08149	2.20
8-15	4.596	0.01295	-0.05652	0.04964	2.98
16-25	4.632	0.00883	-0.17960**	0.05377	3.27
26+	4.625	0.00831	-0.09245	0.06830	3.43
All	4.605	0.00495	-0.08980**	0.02946	12.61
Heterogeneity χ^2(df=3)			4.16	P=0.24	
After exclusion of the controls					
A. PE86 sample based on T65DR					
0-7	4.554	0.01283	-0.01586	0.04095	0.15
8-15	4.597	0.02407	-0.04576	0.04293	1.01
16-25	4.608	0.01881	-0.10400*	0.04772	1.02
26+	4.624	0.01957	-0.09234	0.06015	0.86
All	4.600	0.00998	-0.06629**	0.02425	3.14
Heterogeneity χ^2(df=3)			2.39	P=0.50	
B. Clinical subsample based on DS86					
0-7	4.520	0.02044	0.02579	0.05550	0.06
8-15	4.650	0.03363	-0.23790**	0.06637	1.23
16-25	4.587	0.04029	-0.12220	0.08412	0.42
26+	4.641	0.02535	-0.13150Sug	0.07470	0.32
All	4.609	0.01609	-0.14190**	0.03798	1.18
Heterogeneity χ^2(df=3)			9.70	P=0.02	
C. PE86 sample based on DS86					
0-7	4.554	0.01257	-0.01872	0.05019	0.15
8-15	4.597	0.02380	-0.05715	0.05362	1.01
16-25	4.608	0.01833	-0.14500*	0.06037	1.00
26+	4.619	0.01973	-0.07985	0.07984	0.88
All	4.598	0.00987	-0.08020**	0.03070	3.15
Heterogeneity χ^2(df=3)			2.65	P=0.45	

See the footnote in Appendix 3a.
付表3aの脚注参照.

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