TECHNICAL REPORT
2-75
業 績 報 告 書

FREQUENCY OF MARRIAGE AND LIVE BIRTH AMONG SURVIVORS PRENATALLY EXPOSED TO THE ATOMIC BOMB

胎 内 被 爆 者 の 結 婚 と 出 生

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ATOMIC BOMB CASUALTY COMMISSION

国立予防衛生研究所－原爆傷害調査委員会

JAPANESE NATIONAL INSTITUTE OF HEALTH OF THE MINISTRY OF HEALTH AND WELFARE

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FREQUENCY OF MARRIAGE AND LIVE BIRTH AMONG SURVIVORS PRENATALLY EXPOSED TO THE ATOMIC BOMB

胎内被爆者の結婚と出生

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SUMMARY

Frequency of marriage and birth as of 1 January 1973 was determined for persons exposed in utero to the atomic bombs in 1945 and for controls. The marriage rate was lower in persons heavily exposed in utero than in the nonexposed or lightly exposed. This difference is attributed partly to the lesser marriageability of persons with mental retardation who are significantly more numerous among the heavily exposed, and partly to unmeasured variables, possibly including social discrimination against survivors of the A-bomb. No consistent relation was observed between radiation exposure and three reproductive indices: childless marriages, number of births, and interval between marriage and first birth.

INTRODUCTION

Studies on the late effects of atomic radiation in Hiroshima and Nagasaki have uncovered no significant long-range alterations in fertility[1,2] or pregnancy termination[3] patterns of A-bomb survivors attributable to radiation. Few of the survivors followed in these studies were less than age 15 years at the time of the bomb (ATB) in 1945, and none were in utero, the period of greatest radiosensitivity in man.[4] A recent survey[5] revealed that exposure of males in utero to very high doses of atomic radiation (200-600 rad) has not induced complete sterility, but it is not yet known whether fertility after intrauterine exposure

要約

戸籍調査によって，胎内被爆者群と対照群の1972年末までの結婚率とその子供の出生率を調査した．結婚率は，非被爆者および低線量被曝者に比べ高線量被曝者において低かった．これは一部被爆に関連した社会的要因のためであり，また高線量被曝者に有意に多い知能遅滞者が結婚不可能なことも一部の原因となっていると考えられる．妊孕力の指標として，子供のない割合，出生率，結婚から初産までの期間を用いて観察したが，これらの指標と被曝線量との間には，一定の関係は見られなかった．

緒言

広島および長崎における原爆放射線の遅発性影響に関する調査では，放射線による原爆被爆者の妊孕力，[1,2] または，妊娠終結[3] に及ぼす有意な影響は認められていない．これらの調査では，調査対象の被爆者のうち1945年の原爆時に15歳以下であった者は少数であり，人間において放射線感受性が最も高いと考えられる被爆時に胎児であった者は含まれていない．[4] 最近の調査[5] では胎内で極めて多量の原爆放射線（200－600 rad）を受けた男でも完全な不妊が誘発されなかったことが認められたが，胎内被爆者に妊孕力の変化があったかどうかはまだ明ら

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has otherwise been altered. In this report the early marriage and reproductive experience of a cohort of individuals prenatally exposed to atomic radiation is examined in relation to radiation dose received.

METHODS

ABCC has conducted a mortality study on a fixed sample (the In Utero Mortality Sample) of 2756 persons in Hiroshima and Nagasaki who were in utero ATB.[6,7] The cohort consists of individuals identified from birth registrations, the 1960 prefectural supplementary censuses, and/or the ABCC Master File of A-bomb survivors, who were in utero ATB. Persons exposed at distances within 1500 m from the hypocenter were matched with respect to sex and gestational age with comparison groups of individuals prenatally exposed at greater distances and with a group not in the cities (NIC) ATB. Estimates of radiation exposure (tissue kerma in free air) have been determined for almost all pregnant mothers of members of the cohort. These dose estimates are in rad (gamma + neutron) and are based on the mother's distance and shielding from the bomb.[8] Absorbed doses to the fetus are not yet available, but may be substantially less than the maternal dose.[9]

In addition to the cohort followed for mortality, a smaller fixed sample of persons in utero ATB remained under systematic clinical observation at ABCC until 1966.[10] Head circumference measurements taken annually from 1956-65 revealed a total of 63 persons with small head circumference (head size more than 2 standard deviations below the age-, sex-, and city-specific mean head size of the unexposed) among those exposed within 2000 m.[11] Since the prevalence of small head circumference, mostly limited to those exposed before the 18th week of gestation, increased progressively with increasing dose, a large percentage of such cases were thought to be attributable to radiation. Particular attention was given to the marital and birth records of these 63 persons with small head circumference. The total number of cases of small head size in the In Utero Mortality Sample is unknown since approximately only one-third of its members were clinically observed at ABCC.

Marital and reproductive experience can be determined from the national family registration system in Japan (called the "koseki system").[12] In the present investigation, the koseki records of 2457 members of the In Utero Mortality Sample (299 of the 2756 sample members were excluded either because of death prior to age 16 years or because of unavailability of registration information due to migration abroad), and the 63 persons with small head circumference in the clinical sample,[10] were checked for registration

かではない．本報告では，胎内で原爆放射線に被曝した調査群の結婚状態および出生状態と被曝線量との関係について検討した．

方　法

ABCCは，原爆時胎内にいた広島・長崎両市の2756名の固定集団（胎内被爆児の死亡調査集団）について死亡調査を実施した．[6,7] 調査群は，原爆時胎内にいたもので，出生届，1960年に両県で行われた被爆者調査またはABCCの原爆被爆者に関する基本名簿で確認された人よりなる．遠距離被爆者および原爆時に市内にいなかった者の群を爆心地からの距離1500 m以内の被爆者と性および妊娠月齢について対応させた．推定被曝線量（tissue kerma in free air）は調査群に含まれている対象者のほとんどの母親について得られている．線量推定値はrad（ガンマ＋中性子）単位で示され，爆心地からの距離および遮蔽状態を基に求められている．[8] 胎児の吸収組織線量はまだ得られていないが，母親の線量よりもかなり小さいと考えられている．[9]

死亡調査の対象となっている調査群とは別に胎内被爆者の小さな固定集団についてABCCで1966年まで系統的に臨床観察が行なわれた．[10] 2000 m以内で被爆したものについての1956－65年までに毎年計測した頭囲測定値についての観察では，総計63名の頭囲の小さいもの（年齢・性・都市別にみた非被爆者の頭囲の平均よりも2標準偏差以上小さい）が認められた．[11] これら頭囲の小さな者は多くの場合，母親が妊娠第18週未満で被爆した者に限定されており，線量の増加とともに増加するので，このような症例の大部分は放射線に帰因すると考えられた．頭囲の小さなこれら63名の結婚および出生について特に注意を払った．胎内被爆者死亡調査集団の対象者の約3分の1しかABCCで臨床観察を受けていないので，小頭症例の総数は不明である．

日本では，全国的な戸籍制度があるので，結婚および出生の確認は可能である．[12] 本調査では，胎内被爆者死亡調査集団中の2457名（2756名中299名は，16歳以前に死亡したか，海外移住のため記録が入手できなくなったので除外した），および胎内被爆児の臨床調査対象の中での小頭症例63名[10]の戸籍を調べて，結婚，離婚，および死亡ならびにその子供に関する情報を得た．表1に，性，

TABLE 1 SAMPLE SIZE ACCORDING TO RADIATION DOSE, SEX, AND TRIMESTER

表1　調査対象集団—線量別・性別および妊娠期別

Trimester at Exposure	Sex	Maternal Dose (rad)						
		NIC	0	1-9	10-99	100+	Unk	Total
1	Male	115	122	52	71	19	12	391
	Female	107	139	47	63	14	9	379
	Total	222	261	99	134	33	21	770
2	Male	159	129	60	81	31	6	466
	Female	136	146	66	73	33	7	461
	Total	295	275	126	154	64	13	927
3	Male	118	91	41	54	12	4	320
	Female	154	130	55	73	23	5	440
	Total	272	221	96	127	35	9	760
Total	Male	392	342	153	206	62	22	1177
	Female	397	415	168	209	70	21	1280
	Total	789	757	321	415	132	43	2457

of marriage, divorce, and death, and for information regarding birth of their offspring. The distribution of the 2457 according to sex, trimester of gestation, and radiation exposure interval is shown in Table 1.

From the data thus collected it was possible to test for differences in marriage and fertility rates according to radiation exposure category. Three indices of reproduction were considered: the proportion of childless marriages, the number of live births per years of marriage (birth rate), and the time from marriage until first live birth.

The statistical tests for proportions were regression analyses of summary contingency tables.[13] Analyses of variance were used to compare exposure groups with respect to average time from marriage till first live birth. Because of the small number of observations, data for those with unknown dose were ignored in performing the tests.

RESULTS

Frequency of Marriage The percentage who had married at least once by 1 January 1973 (excluding 33 who died) according to sex, trimester of gestation at exposure, and exposure is shown in Table 2. By this date, 1467 cohort members, 42.2% of the males and 77.4% of the females, had married. Differences in the marriage rates between "exposed" and "not in city" showed no significance regardless of sex or trimester (Table 2). The marriage rates, however, tended to be lower with increasing dose, for both males and

母親の妊娠期(trimester)ならびに線量別に2457例の分布を示した.

このようにして収集した資料から，線量別に結婚率および妊孕力の差について観察した．この調査では，3つの妊孕力の指標について検討した．すなわち，結婚しているが子供のない割合，結婚年数当たりの出生児の数(出生率)および結婚より最初の出生までの期間，である．

統計的検定方法として主に分割表についての回帰解析を用いた.[13] また，結婚から最初の出生までの期間についての被曝線量群間の比較には，分散分析を用いた．線量不明の者については例数が少ないので除外して，検討を行った．

結　果

結婚の頻度　表2に，1972年12月までに少なくとも1回結婚した者(死亡者33名は除く)の割合を，性別，妊娠期別，および被曝状態別に示した．この時期までに調査群のうち1467人すなわち男の42.2%，女の77.4%が結婚していた．"被爆者"と"市内不在者"との間の結婚率には性別または妊娠期に関係なく有意な差は認められなかった(表2)．しかしながら，妊娠期について訂正した場合，結婚率は男女双方とも線量の増加に伴って下降する傾向

TABLE 2 PERCENTAGE OF THOSE MARRIED ACCORDING TO RADIATION DOSE, SEX, AND TRIMESTER

表2　既婚者の割合—線量別・性別および妊娠期別

Trimester	Sex	Maternal Dose (rad)							χ^2 test†		
		NIC	0	1-9	10-99	100+	Unk.	Total	Total	Exp-NIC	L
1	Male	39.6	43.7	33.3	31.9	21.1	25.0	37.3	NS	NS	*
	Female	75.2	82.0	84.8	71.0	64.3	77.8	77.9	NS	NS	*
2	Male	41.8	45.3	48.3	40.7	37.9	50.0	43.3	NS	NS	NS
	Female	80.7	82.9	72.7	77.8	62.5	71.4	78.4	Sug	NS	*
3	Male	44.4	55.6	42.5	37.0	41.7	75.0	46.4	NS	NS	Sug
	Female	77.0	74.2	80.0	75.0	69.6	80.0	75.9	NS	NS	NS
Total	Male	42.0	47.5	41.7	36.8	33.3	40.9	42.2	Sug	NS	**
	Female	77.8	80.0	78.4	74.8	65.2	76.2	77.4	Sug	NS	**

†Exp-NIC: Nonhomogeneity of "Exposed" vs "Not-in-City" (two-tailed)
L: Linear decrease with dose (one-tailed)
***: Statistically significant at 0.1% level ($P < .001$)
**: Statistically significant at 1% level ($P < .01$)
*: Statistically significant at 5% level ($.01 < P < .05$)
Sug: Suggestive ($.05 < P < .10$)
NS: Not significant ($.10 < P$)

females when adjusted over trimester ($P<.01$). For each sex-trimester combination except males exposed in the third trimester, marriage rates were lowest among those whose mothers were exposed to 100+rad. The percentages marrying before attaining a certain age are shown in Figure 1. The cumulative rates, for all ages for males and ages above 23 for females, were lowest among those in the 100+rad dose group.

The total number of cases of mental retardation among members of the In Utero Mortality Sample is unknown, however 21 cases have been identified among persons in the clinic sample who were exposed to 1 or more rad.[14] All but one were also in the In Utero Mortality Sample. After excluding 5 who had died by 1973, the remaining 15 were distributed by dose group as follows: 3 in the 1-9 rad group; 2 in the 10-99 rad group; and 10 in the 100+rad group. If these cases are excluded from consideration the marriage rates become 42.0, 36.9, and 35.8 for males and 79.4, 75.1, and 68.2 for females respectively in these three dose groups. The linear decrease in marriage rate with increasing dose remains significant ($P<.05$).

Of the 63 persons in the clinic sample who were proximally exposed and had small head circumference, 4 had died by 1 January 1973 (2 of the 4 were mentally retarded) and 2 were listed as foreigners and thus not included in the koseki registration. Of the remaining 57 persons, 24 had married (Table 3). Eight of 25 (32%) males and 15 of 20 (75%) females with small head circumference but without mental

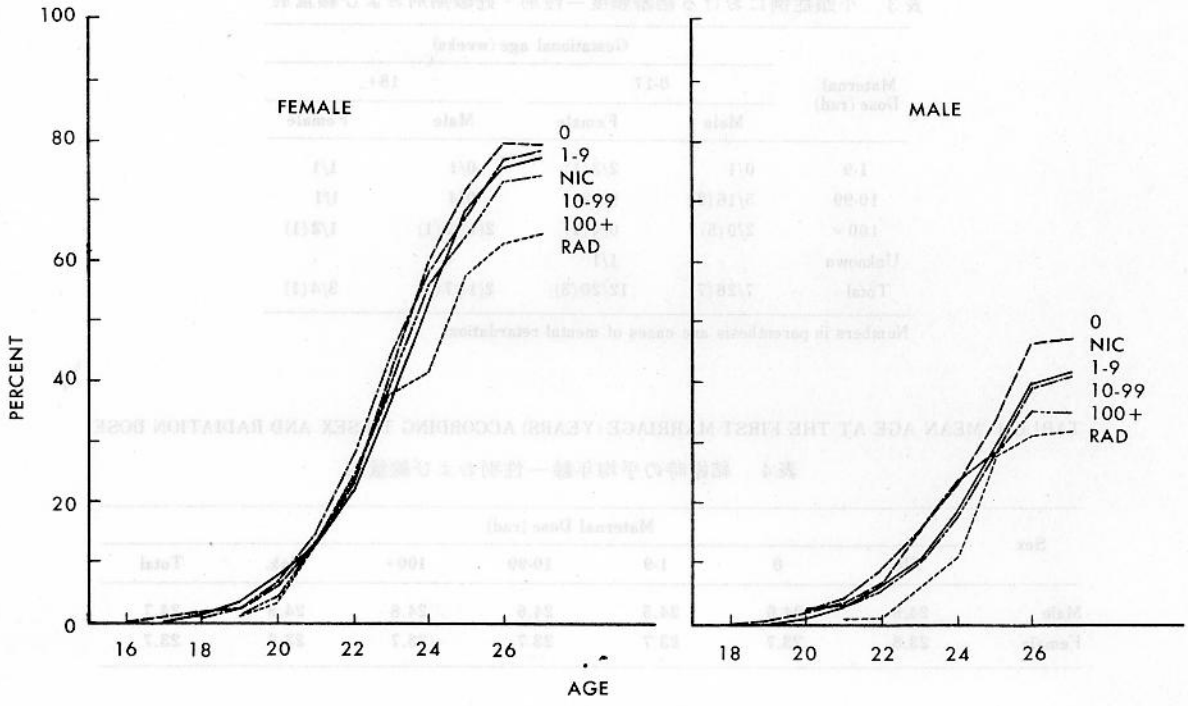
が認められた（$P < .01$）．第3妊娠期における男を除き，両性ならびに各妊娠期とも母親が100 rad以上の線量を受けた者の結婚率は最低であった．図1に，特定の年齢に達する以前の結婚率を示した．全年齢の男と23歳以上の女についての累積結婚率は100 rad以上の線量群において最低であった．

胎内被爆者死亡調査集団中の知能遅滞例の総数は不明であるが，1 rad以上の線量を受けた臨床調査対象者中には21例が確認されている．[14] 1例を除き全例とも胎内被爆者死亡調査集団に含まれていた．1972年までに死亡した5例を除いた残り15例は線量群別に次のように分布していた．1－9 rad群に3例，10－99 rad群に2例，100 rad以上の群に10例．もしこれらの遅滞例を除外すれば，結婚率は3つの線量群で，男は42.0，36.9および35.8，女では79.4，75.1および68.2となる．結婚率は，線量の増加とともに直線的に減少し，依然として有意である（$P < .05$）．

近距離で被爆し小頭症であった臨床調査対象者63名中，1972年12月までに4名が死亡し（この4名中2名は知能遅滞）さらに2名は外人として登録されていたため戸籍には含まれていなかった．残りの57名中，24名は結婚していた（表3）．小頭症ではあるが知能遅滞のなかった男25名中8名（32%）および女20名中15名（75%）が1972年

FIGURE 1 CUMULATIVE MARRIAGE RATES BY SEX AND EXPOSURE GROUP

図1　累積結婚率—性別および被曝群別



retardation had married by 1 January 1973. Three of the five males and one of the three females in the 100+rad dose group with small head size but normal intelligence were married. Elimination of these cases from consideration does not greatly alter the pattern of declining marriage rate with increasing dose.

Among those who ever married, no significant differences in age at marriage were evident among the radiation exposure groups (Table 4).

Frequency of Live Birth A total of 1505 children were born to the cohort members. Of these, eight were children born of women recorded as unmarried on the koseki. In constructing birth rates these children were excluded from the number of children (numerator), and their mothers (5 in number: 4 in NIC group, 1 in 10-99 rad group) were not included in the number of eligible mothers (denominator). There were only four couples where both the husband and the wife were members of the study cohort, and these couples had borne six children. In three, both partners were unexposed: (either not in city ATB or else in the city but receiving zero exposure). For the fourth couple, the husband was exposed to 10 rad, the wife unexposed. This latter couple had one child.

12月までに結婚していた．100 rad 以上の線量群において小頭症ではあったが正常の知能を有していた男5名中3名および女3名中1名が結婚していた．これらの例を除外しても，線量の増加とともに結婚率が下降するという傾向は大きくは変わらない．

結婚した者の間の放射線量群別における結婚時年齢には有意な差は認められなかった（表4）．

出生の頻度　調査対象には1505名の子供が生まれた．このうち戸籍上では未婚となっている婦人に生まれた子供が8名いた．出生率を算出するに当たり，これらの子供は除外され（分子），その母親（5人：市内不在者群4，10－99 rad 群1）は既婚の母親の数（分母）には含めなかった．調査群に夫婦共含まれていたものは4組だけであり，そのものには計6名の子供があった．3組では夫婦共非被爆（原爆時市内不在かまたは市内にはいたが，被曝線量0）であった．4組目の夫婦では，夫が線量10 rad を受け，妻は非被爆者であった．この夫婦には子供が1名いた．

TABLE 3 FREQUENCY OF MARRIAGE AMONG SMALL HEAD CIRCUMFERENCE CASES ACCORDING TO SEX, GESTATIONAL AGE, AND RADIATION DOSE

表3　小頭症例における結婚頻度—性別・妊娠期別および線量別

Maternal Dose (rad)	Gestational age (weeks)			
	0-17		18+	
	Male	Female	Male	Female
1-9	0/1	2/3(1)	0/1	1/1
10-99	5/16(2)	9/12	0/4	1/1
100+	2/9(5)	0/4(2)	2(1)/2(1)	1/2(1)
Unknown	-	1/1	-	-
Total	7/26(7)	12/20(3)	2(1)/7(1)	3/4(1)

Numbers in parenthesis are cases of mental retardation.

TABLE 4 MEAN AGE AT THE FIRST MARRIAGE (YEARS) ACCORDING TO SEX AND RADIATION DOSE

表4　結婚時の平均年齢—性別および線量別

Sex	Maternal Dose (rad)						
	NIC	0	1-9	10-99	100+	Unk.	Total
Male	24.8	24.6	24.5	24.6	24.8	24.8	24.7
Female	23.8	23.7	23.7	23.7	23.7	23.6	23.7

The percentage of the married who were childless is shown in Table 5 according to dose interval, sex, and age at marriage. For males there was a highly significant (P<.01) difference between the NIC and the radiation-exposed groups as to the percentage who were childless. However, the rates for the four exposure-dose groups did not differ significantly. No consistent differences were evident among the exposure groups in the proportion of childless marriages among females.

Birth rates for each exposure group are shown in Table 6 according to sex and age at marriage. The rates were computed by dividing the total number of births by the aggregate years of marriage (based on koseki dates of marriage, divorce, remarriage, and death for each individual) for each exposure group. No significant differences in the exposure groups were found. The 100+rad dose group rates were at intermediate levels for both males and females.

The average interval between marriage and birth of the first child of those with children is shown in Table 7 according to exposure group, sex, and age at first marriage. Excluded were 192 births in which the interval was less than 29 weeks. The tabulation thus included a total of 893 parents.

表5に，既婚者で子供のない人の割合を線量別，性別および結婚時年齢別に示した．男では，市内不在者群と被爆群との間に極めて有意な差（P＜.01）があった．しかし，4つの被曝線量群においては有意な差はなかった．女では線量群別に一定の差は認められなかった．

表6に，各被曝線量群における性別および結婚時年齢別出生率を示した．出生率の算定は線量群毎に総出生数を結婚年数（各人については戸籍上の結婚，離婚，再婚および死亡年月日を基に計算された）で割って行った．線量群間に有意の差はなかった．100 rad 以上の群における出生率は，特に低くなく男女双方とも平均に近い値を示した．

表7に，結婚から第1子の出生までの平均期間を線量群別，性別および初婚時年齢別に示した．期間が29週以下であった192の出生例は除外し，総数893名について集計した．

TABLE 5 PERCENTAGE OF CHILDLESS MARRIAGES ACCORDING TO RADIATION DOSE, SEX, AND AGE AT MARRIAGE

表5 既婚者の子供のない者の割合—線量別・性別および結婚時年齢別

Age at marriage	Sex	Maternal Dose (rad)							χ^2 test†		
		NIC	0	1-9	10-99	100+	Unk.	Total	Total	Exp-NIC	L
<25	Male	16.7 (72)	10.5 (76)	2.9 (35)	18.4 (38)	14.3 (7)	50.0 (4)	13.4(232)	NS	NS	NS
	Female	10.0(209)	14.1(248)	11.3 (97)	10.4(115)	10.3(29)	20.0(10)	11.9(708)	NS	NS	NS
25+	Male	68.9 (90)	47.6 (84)	42.9 (28)	56.8 (37)	38.5(13)	60.0 (5)	55.6(257)	*	***	NS
	Female	44.8 (96)	36.7 (79)	64.7 (34)	64.1 (39)	43.8(16)	50.0 (6)	47.8(270)	*	NS	NS
Total	Male	45.7(162)	30.0(160)	20.6 (63)	37.3 (75)	30.0(20)	55.6 (9)	35.6(489)	**	***	NS
	Female	21.0(305)	19.6(327)	24.4(131)	24.0(154)	22.2(45)	31.3(16)	21.7(978)	NS	NS	NS

Numbers in parenthesis are married persons.
†See footnotes Table 2.

TABLE 6 BIRTH RATES (NUMBER OF CHILDREN/YEARS OF MARRIAGE) ACCORDING TO RADIATION DOSE, SEX, AND AGE AT MARRIAGE

表6 出生率(子供数／結婚年数)—線量別・性別および結婚時年齢別

Age at marriage	Sex	Maternal Dose (rad)							χ^2 test†		
		NIC	0	1-9	10-99	100+	Unk.	Total	Total	Exp-NIC	L
<25	Male	0.32	0.35	0.39	0.33	0.42	0.18	0.34	NS	NS	NS
	Female	0.33	0.33	0.32	0.36	0.32	0.30	0.33	NS	NS	NS
25+	Male	0.32	0.53	0.67	0.45	0.41	0.31	0.43	NS	*	NS
	Female	0.46	0.54	0.42	0.36	0.45	0.57	0.47	NS	NS	NS
Total	Male	0.32	0.39	0.43	0.36	0.42	0.23	0.37	NS	*	NS
	Female	0.35	0.35	0.32	0.36	0.34	0.33	0.35	NS	NS	NS

†See footnotes Table 2.

TABLE 7 AVERAGE DURATION BETWEEN MARRIAGE AND FIRST BIRTH (WEEKS) ACCORDING TO RADIATION DOSE, SEX, AND AGE AT MARRIAGE

表7 結婚と第1子出生との間の平均期間(週間)—線量別・性別および結婚時年齢別

Age at Marriage	Sex	Maternal Dose (rad)						
		NIC	0	1-9	10-99	100+	Unk.	Total
<25	Male	71.0 (44)	65.0 (50)	63.6(19)	78.6 (20)	56.5 (4)	83.0(2)	68.9(139)
	Female	72.0(158)	65.8(182)	74.3(76)	59.6 (92)	73.5(21)	85.6(7)	68.3(536)
25+	Male	51.7 (20)	45.6 (41)	39.4(12)	53.0 (14)	55.6 (8)	42.5(2)	47.9 (97)
	Female	49.4 (43)	48.3 (48)	47.8(10)	52.3 (12)	59.0 (6)	40.0(2)	49.4(121)
Total	Male	64.9 (64)	56.3 (91)	54.2(31)	68.1 (34)	59.3(12)	62.8(4)	60.3(236)
	Female	67.1(201)	62.2(230)	71.2(86)	58.8(104)	70.3(27)	75.4(9)	64.9(657)

Numbers in parentheses are first births.

TABLE 8 FREQUENCY OF CHILDBEARING MARRIAGES AMONG SMALL HEAD CIRCUMFERENCE CASES ACCORDING TO SEX AND RADIATION DOSE

表8　小頭症例の既婚者における子供のある者の頻度—性別および線量別

Maternal Dose (rad)	Male	Female
1-9	-	3/3
10-99	2/5	6/10
100+	2/4	1/1
Unknown		1/1
Total	4/9	11/15

The average interval between marriage and birth of first child did not differ significantly according to exposure group as judged by an analysis of variance. Although not shown in Tables 5-7, no differences existed according to trimester.

Table 8 lists the number among those with small head size who were married and who have borne at least one child. Four of the 9 (44%) males and 11 of the 15 (73%) females had children. Both of these rates are somewhat lower, but insignificantly so, than the NIC and zero dose rates given in Table 5. Of the five males without offspring, two have been married for less than 9 months, two for less than 16 months, and one for 4 years. One of the four married women without a child has been married for less than 9 months, the others for 1, 2, and 2½ years. Hence, over 71% (15 of 21) of those "eligible" had conceived and delivered at least one live birth by 1 January 1973; and those eligible but without children have been married for an average of 2 years. The aggregate birth rate for the nine married males was .24, and for the married females was .36.

Among the 63 persons with small head size, there were 6 persons with head circumference averaging more than 3 standard deviations below the control average but without mental retardation. Five of the six were living by age 27, and three were married (1 of 2 males and 2 of 3 females). Two of the three married, both females, had borne children.

DISCUSSION

Irradiation of the human fetus has long been known to induce marked effects. A study reported in 1929 found over 50% of the offspring of women exposed to therapeutic (high dose) irradiation during early pregnancy to have central nervous system impairment.[15] Previous studies among survivors prenatally

結婚から第1子の出生までの期間の平均は，分散分析から判定できるように線量群別には有意な差はなかった．表5－7には示していないが，妊娠期別にも差はなかった．

表8に，小頭症例で結婚して少なくとも一人の子供を産んだ者の数を示した．男9例中4例(44%)，女15例中11例(73%)に子供があった．これらの率は，表5に示した市内不在者および被曝線量0の者に比べて多少低いが，統計的には有意ではない．子供のない男5名中2名は結婚期間が9ヵ月未満であり，2名は16ヵ月未満そして1名は4ヵ年であった．既婚の子供のない女4名中1名は結婚して9ヵ月未満，その他の者は1年，2年および2年半であった．したがって，結婚後9ヵ月以上経過した者の71%(21名中15名)に1972年12月までに少なくとも1名の出生があった．結婚後9ヵ月以上経過しながら子供のなかった者は，結婚して平均2年経過していた．既婚の男9名の出生率は0.24で，既婚の女では0.36であった．

小頭症例63名中，対照例の平均より3標準偏差以上も小さくて知能遅滞のなかった者は6名あった．6名中5名は27歳現在生存しており，3名は結婚していた(男2名中1名，女3名中2名)．既婚者3名中2名(共に女)に子供があった．

考　察

人間の胎児に放射線を照射した場合，著明な影響を誘発することは以前から知られている．妊娠初期に高線量の治療用放射線照射を受けた婦人の子供の50%以上に中枢神経系損傷のあったことが1929年に報告された．[15] 妊娠

exposed in early pregnancy to the A-bomb have shown sharp rises in the percentage of children with small head circumference and mental retardation with increasing exposure dose.[11,14] The largest of a number of studies examining childhood mortality from leukemia has found increases in mortality among children whose mothers were exposed to diagnostic (low dose) radiology during pregnancy.[16-18] The radiosensitivity of germ cells may differ considerably from neuronal or other cell types, nevertheless the evidence from studies such as these, as well as from animal experimentation,[19-22] indicated that a large radiation-induced alteration in fertility was a possibility. Even though the cohort under observation was still within the early stages of marriage and child-bearing, it was felt that the koseki records should be examined so that early differential fertility patterns might be identified and described.

All information relating to vital events was obtained from the family registration (koseki) records. Registration of marriages in the koseki is occasionally inaccurate, the inaccuracy usually being a recorded date later than the actual marriage date. Nonetheless utilization of the koseki system is advantageous since births and deaths are completely registered, investigation is easy, and complete information can be obtained regardless of the location of the present address if the address in the koseki is shown.[23] The koseki does not provide information on periods of marital separation, practice of contraception, or any outcome of pregnancy except live birth, so that more precise measures of fecundity than the birth rate could not be determined.

The information collected did show significant decreases in the marriage rate as radiation dose increased. The lower marriage rates among the highly exposed may be attributable, at least in part, to social pressures. Apprehension over possible delayed physical or genetic radiation-induced effects is still prevalent in Japan more than 25 years following the A-bombs. It is widely assumed that survivors suffered damage whether or not overt signs or symptoms of injury were identified following exposure. A study of absenteeism in 1968-71 among ABCC employees revealed excess annual and sickness leave among employees carrying A-bomb handbooks identifying them as survivors.[24] The differences in leave-taking patterns were considered due to behavioral causes.

Among those married, no consistent differences in percentages of childless marriages and no consistent differences in birth rates were observed according to dose. It has previously been reported[5] that complete sterility did not occur among males prenatally exposed in Hiroshima and Nagasaki to

初期の胎内被爆者に関する以前の調査では，被曝線量の増加に伴い，小頭症と知能遅滞の見られる子供の有病率が著しく上昇している.[11,14] 小児の白血病による死亡率を検討した多くの調査の中で最も大きい調査では，妊娠期間中に診断用(低線量)放射線に被曝した母親の子供の死亡率に増加が認められている.[16-18] 生殖細胞の放射線感受性は神経細胞またはその他の細胞とは相当異なるかも知れないが，このような調査並びに動物実験より得た所見では，[19-22] 妊孕力に大きな放射線誘発性変化の起こる可能性のあることが分かった．観察中の調査群がまだ結婚または生殖初期の段階にあるとしても，早期における妊孕力の特質を確認するために，戸籍を検討する必要があると考える．

人口動態に関する資料はいずれも戸籍から入手した．戸籍における結婚の記述は時として不正確であるが，その不正確な箇所は多くの場合記載されている年月日が実際の結婚年月日よりも遅くなっていることである．しかし，出生と死亡に関する記述は完全になされており，調査は容易であり，現住所のいかんにかかわらず，完全な資料を入手することができる点から戸籍制度の利用には利点がある.[23] 戸籍には，別居期間，避妊の実施または出生以外の死産，流産に関して資料はないので，妊孕力について，出生率よりも正確な測定の方法は得られなかった．

収集された資料からは放射線量が増加するにつれて結婚率に有意な下降が認められた．高線量被曝者における低い結婚率は少なくとも一部社会的要因によるものかも知れない．原爆投下後25年以上経過しているが，日本においては，依然として放射線による身体的または遺伝的影響の可能性に対しての不安感がある．被爆後，放射線による明らかな症状がなくても，被爆者は放射線の影響を受けていると広く一般には考えられている．1968－71年におけるABCC従業員の欠勤率調査では，原爆手帳を有する被爆者に年次有給および病気休暇をとる者が極端に多かったことを示した.[24] 休暇のとり方にみられる差は，個人的態度によるものと考えられた．

出生率および結婚して子供のない者の割合には，線量に関して一定した差は認められなかった．広島および長崎における高線量(200－600 rad)胎内被爆者の男には，

very high doses (200-600 rad), as observed in animal experimentation.[19-21,26] From the present study it can be said that to date no marked reduction in fertility among the highly exposed has resulted either. A recent prospective epidemiological study among young (age 18-23) women prenatally exposed to diagnostic radiation and matched controls has shown small (10%-15%) but significant increases in fertility among the exposed which could not be explained by any of several influences considered except radiation.[27] The exact fetal doses received were unknown, but generally considered to fall within the range 1-5 rad. A parallel finding exists in animal experimentation involving low level prenatal exposure to ionizing radiation, where accelerated ovulation and fertility have occurred in early adulthood. The increases have been temporary, generally followed by reduced fertility or sterility.[28-30] The direction of differences among females exposed to 1-9 rad and higher levels of atomic radiation fail to confirm these findings. The members of the cohort of A-bomb exposed and controls began cohabitation at an average age some 5 years older than the women in the aforementioned study, perhaps beyond the age of the postulated increase in likelihood of conception.

There was an increase in Hiroshima in the frequency of small head size at low doses (10-19 rad), a progressive increase with dose, and an excess of mental retardation at high doses.[11] These findings led to the suggestion that head size, brain growth, and intelligence are related in these individuals and that even small amounts of in utero irradiation may deprive the individual of some intelligence.[11] The results presented have shown persons with small head circumference but without mental retardation to have lower marriage rates than the unexposed. However among those with small head circumference married for at least 9 months, including those for whom the abnormality was severe, most had given birth to live offspring. Hence the abnormality, in terms of the social behavior attendant to marriage, has had an effect far short of preventing marriage and childbirth. This is not unexpected since moderate reduction in head size by radiation is not deforming, and may in fact go unnoticed. It is too early for an adequate determination of fertility among those with small head circumference since only 2 of the 63 have been married for as long as 5 years.

動物実験において観察された[19-21,26]ような完全不妊症は起こらなかったことが先に報告されている.[5] また，本調査結果から，高線量被曝者中，妊孕力に著しい減少が今日までのところ観察されなかったということができる．診断用放射線に胎内被曝した若い婦人（18歳－23歳）およびその対照者について最近実施されたプロスペクティブ（前向き）な疫学的調査では，わずか（10%－15%）ではあるが，有意の妊孕力の促進を認めたが，これは放射線以外には他のどのような影響によっても説明することはできなかった.[27] 胎児が受けた正確な線量は不明であったが，一般に1－5 radの範囲であると考えられた．同じような所見が胎内で低電離放射線量に被曝した動物の実験においても認められ，この実験では成熟初期において排卵および妊孕力は促進された．この増加は一時的であり，通常，妊孕力の減少または不妊症がそれに続いた.[28-30] 1－9 radおよびそれより多量の放射線に被曝した女性間の差の方向からはこれらの所見を確認することはできなかった．被爆調査群および対照群は，前述の調査における婦人よりも結婚生活に入った平均年齢が約5歳年上であり，妊娠の可能性が増加するとされている年齢を過ぎていたためと考えられる．

広島においては，低線量（10－19 rad）で小頭症者の出現頻度に増加があり，それも線量の増加に伴って増加し，また，高線量では知能遅滞者数が極端に多かった.[11] これらの所見から，これらの者においては頭囲，脳の成長および知能の程度は関係があり，低線量の胎内被曝によっても，知能遅滞がみられるかも知れないということが示唆された.[11] 調査結果からは，頭囲が小さくても知能遅滞のない者の結婚率は非被爆者よりも幾分低率であることを示した．しかし，小頭症で，少なくとも9か月結婚していた者（異常の程度が重かった者を含めて）の間ではその大部分には，子供の出生がみられた．したがって，結婚に付随する社会的行動の面からは，結婚や出生の妨げとなる程の影響はほとんどなかったようである．中等程度に頭囲が小さいのは醜いほどではなく，場合によっては気付かれないことすらあるので，上記の所見は予期されないことではない．63名中2名のみが結婚して5年を経過しているに過ぎないので，小頭症例の妊孕力を十分に確定するには時期尚早である．

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