Supplementary Materials

Menopause age imputation

Menopause is a well-known and important breast cancer risk factor. Information about menopause status was collected in the mail surveys, but the most recent survey was in 1991. Among the 31,333 women who provided information on menopause status on at least one survey, 18% were pre-menopausal at the time of the last report, 9% reported induced menopause, and 72% reported natural menopause. The mean reported age at menopause was 48. The mean age at natural menopause was 49 while that for induced menopause was 43. Since virtually all women experience menopause by their late 50's we used a simple algorithm to impute the age at menopause for women for whom there was no survey data or who were premenopausal at the time of the last report. This method is essentially the same as the method described in more detail in the online supplement to (1).

The 31,201 women with no mail survey data on menopause status were assigned the mean reported age at menopause. The ages at menopause for the 5,761 respondents who reported being pre-menopausal at the time of their last survey were imputed as a function of their reporting age. Women who were 57 or less at the time of their last response were assigned the mean age at menopause for women who reported natural menopause with an age greater than or equal to pre-menopausal; woman's reporting age. For reporting ages between 58 and 60 the age at menopause was assumed to be less than the reporting age decreasing linearly with age from the mean menopause age for women reporting menopause between 57 and 60 (58) to the average age at natural menopause for all women (49) at age 60. For women who reported being pre-menopausal after age 60, imputed age at menopause was the average age at natural menopause.

1. Preston DL, Kitahara CM, Freedman DM, Sigurdson AJ, Simon SL, Little MP, et al. Breast cancer risk and protracted low-to-moderate dose occupational radiation exposure in the US Radiologic Technologists Cohort, 1983-2008. Br J Cancer. 2016;115(9):1105-12.

Table S1. Availability of reproductive data, body mass index, smoking history and summary statistics overall and according to three birth cohorts: female LSS solid cancer incidence cohort with known doses, 1958-2009

	Overall	Year of birth		
		<1910	1910-1929	1930-1945
Cases	1,470	216	728	526
PY	1,937,390	438,239	862,870	636,280
Age at menarche, yr				
Known (%)	47	31	56	55
Mean[a] (SD)	15 (1.7)	16 (1.6)	15 (1.7)	14 (1.6)
Number of full term pregnancies				
Known (%)	60	45	71	65
Nulliparous[a] (%)	9	12	10	6
Mean[a] (SD)	3.2 (1.9)	4.5 (2.5)	3.1 (1.6)	2.2 (0.9)
Age at first full term pregnancy, yr				
Known (%)	49	32	58	57
Mean[a] (SD)	24 (3.8)	23 (4.0)	24 (3.7)	25 (3.4)
Menopausal status				
Known (%)	50	32	60	60
Premenopausal[a] (%)	18	2	6	45
Artificial menopause[a] (%)	9	4	10	12
Natural menopause[a] (%)	72	94	84	44
Age at menopause, yr				
Reported, Mean[a] (SD)	48 (4.7)	48 (4.6)	49 (4.6)	48 (5.0)
Imputed, Mean (SD)	49 (3.1)	49 (2.6)	49 (3.4)	49 (3.1)
Body mass index, kg/m^2				
Known (%)	61	40	72	72
Mean[a] (SD)	22 (3.4)	21 (3.7)	22 (3.4)	22 (3.0)
Smoking status				
Known (%)	62	42	73	73
Never[a] (%)	82	80	82	84
Past[a] (%)	6	7	6	5
Current[a] (%)	12	13	12	11

[a] Among females with known status.

Data organization

The analyses were based on a highly stratified tables of person-time and numbers of breast cancer cases among females and males by city (Hiroshima or Nagasaki), age at exposure (14 five-year categories from 0 to 69 and one of ≥70), attained age (17 five-year categories from 10 to 84 and one of ≥85 to <110), time period (13 categories: 1958-1960, 1961-1965, 1966-1970, 1971-1975, 1976-1980, 1981-1985, 1986-1987, 1988-1990, 1991-1995, 1996-1998 [cut-off for the previous report], 1999-2000, 2001-2004, 2005-2009), NIC status (>15,000 m from the hypocenter), DS02R1 weighted absorbed breast dose (23 categories including cut points and larger: 0, 0.005, 0.02, 0.04, 0.06, 0.08, 0.1, 0.125, 0.150, 0.175, 0.2, 0.25, 0.3, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.5, 3 Gy plus an unknown dose category), and an indicator of high dose (shielded kerma >4 Gy).

Further time-dependent stratification in females was also made for reproductive variables, smoking and BMI. These were considered unknown for all females until the date at which they first provided information and as known thereafter. Reproductive variables were stratified as follows: age at menarche (6 categories with cut points at: 13, 14, 15, 16, and 17 plus an unknown age category), parity (3 categories: unknown, nulliparous, parous), number of full term pregnancies (two unknown groups: unknown, parous with unknown number of pregnancies along with 6 categories for 0, 1, 2, 3, 4-6, 7 or more pregnancies), age at first pregnancy (9 categories including an unknown group and 8 categories defined by cut points at: 18, 20, 22, 24, 26, 28, 30), reported menopausal status (4 categories: unknown, premenopausal, artificial menopause, natural menopause), imputed menopausal status (3 categories: premenopausal, natural menopause, artificial menopause), and time before and after imputed menopause (6 categories with cut-offs: >10, 5, 0 years before menopause, and 5, 10, ≥ years after menopause). Smoking status was stratified in 4 categories (unknown, never, current, or past smoker) and was considered to remain unchanged from the latest survey on which they provided information until the end of follow-up. BMI was stratified in 5 categories (unknown, <18.5, 18.5-24.9, 25.0-29.9, ≥30.0 kg/m2) with cut-offs according to the WHO classification of “underweight”, “normal weight”, “overweight” and “obese” for adults.

Background rates: birth cohort, attained age, and menopause effects

A descriptive model for the background breast cancer rates (rates in the absence of radiation exposure) was developed by considering attained age, birth cohort, city, exposure status (in-city or not in city) reproductive and gynecological factors, body mass index, and smoking. These analyses were informed by the results of other studies of breast cancer risk factors with the choice of factors to be included in the final model determined by a combination of likelihood ratio tests and AIC values. As noted in the text and described in detail in the next section, in the final model rates varied as a log-quadratic spline in log attained age with knots at ages 50 and 70 with a simple log-linear birth cohort effect, and effects of parity, menopause, menarche, and post-menopausal BMI. We think that this model captures the complex patterns of the baseline breast cancer risks quite well. In developing the model, we considered simple log-linear and log-quadratic models in log attained age, log-linear and log-quadratic splines with one or two knots (including ages 40, 50, 60, and 70) as well as a model with categorical attained age effects (6 categories). Log-linear, log-quadratic and categorical birth cohort models were also considered. When looking at menopause effects we considered simple pre- and post-menopause indicators in addition to the time-to- and time-from-menopause model that was used for the primary analyses. The background modeling was carried out in a model without dose effect and in a model with a simple linear dose effect with a high dose adjustment and attained age effect modification. Inference about baseline risk factors was little affected by "adjustment" for dose effects. The reported estimates, bounds and P-values are for the dose-adjusted model.

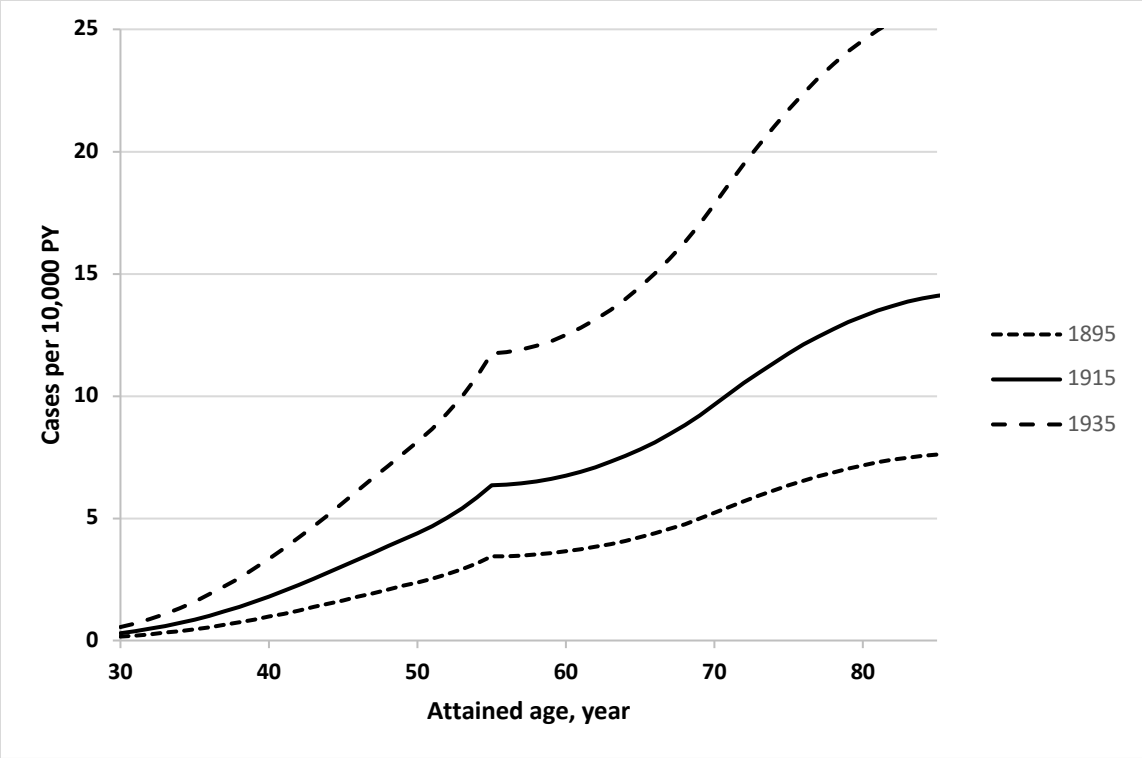

Figure S1. Fitted background breast cancer incidence rates by attained age and year of birth (1895 – long dash curve, 1915 – solid curve, 1935 – short dash curve) for females in the LSS solid cancer incidence cohort with known dose, 1958-2009. The model includes effects for birth cohort, attained age, city, NIC, and nulliparous indicator, age at menarche, number of full term pregnancies, years to and from menopause, and BMI in postmenopausal females. The rates are for females with menarche age 15 years, two children, and menopause age 55 years

Table S2. Modeling of background rates of incident breast cancer in relation to attained age: female LSS solid cancer incidence cohort with known doses, 1958-2009

Attained age[a]	**Number of age parameters**	**Deviance**	**AIC**
Log(age/70)	1	15642.192	15676.192
Log(age/70) + Log(age/70)^2	2	15642.066	15678.066
Log(age/70) + Log(age/70)^2 + Log(age/70)^2*I(age>70)	3	15638.66	15676.66
Log(age/70) + Log(age/70)^2 + Log(age/70)^2*I(age>70) + Log(age/50)^2*I(age<50)	4	15604.524	15644.524
I(age<40) + I(age<50) + I(age<60) + I(age<70) + I(age<80) + I(age≥80)	6	15610.137	15652.137

[a] In addition to attained age each background model includes effects of birth cohort, city, NIC, nulliparous indicator, age at menarche, number of full term pregnancies, years to and from menopause, and BMI in postmenopausal females and is adjusted for the effect of dose and modifying effects of attained age and high dose

Preferred ERR model parameter estimates

Our preferred ERR model has the form:

$$\exp\left(\begin{array}{l}\beta_0+\beta_1 I(Naga)+\beta_2 I(NIC)+\beta_3(byr-1915)/10+\beta_4\log(age/70)+\beta_5\log(age/70)\,\hat{}\,2+\\ \beta_6\log(age/70)^2 I(age>70)+\beta_7\log(age/50)^2 I(age<50)+\beta_8(mna\_age-14)+\\ \beta_9 I(unk\ mna\_age)+\beta_{10} I(nulliparous)+\beta_{11}(prgno-1)I(prgno>0)+\\ \beta_{12} I(unk\ prgno)+\beta_{13} I(unk\ BMI)+\beta_{14} I(postmenop\ \&\ BMI\geq 25)+\\ \beta_{15} I(premenop)(age-menop\_age)+\beta_{16} I(postmenop)(age-menop\_age)\end{array}\right)*$$

$$\left[1+\beta_{17}\,dose\,\exp\left(\begin{array}{l}\beta_{18}\log(age/70)\_+\beta_{19}(mna\_age-14)+\\ \beta_{19}(agex-mna-age)I(agex<mna\_age)/10+\\ \beta_{20}(agex-mna-age)I(agex\geq mna\_age)/10+\\ \beta_{21} I(high\_dose)\end{array}\right)\right]$$

where:

I(x)	indicator function that has the value 0 of *x* is true and 0 if it is false.
byr	year of birth
age	attained age
mna_age	age at menarche
unk mna_age	unknown age at menarche
nulliparous	no full-term pregnancies
prgno	number of full term pregnancies
unk_prgno	number of full term pregnancies unknown
BMI	body mass index
unk_BMI	unknown BMI
menop_age	age at menopause (imputed if unknown)
agex	age at exposure
premenop	pre-menopausal*;*
postmenop	post-menopausal
high_dose	shielded kerma truncated to 4Gy

Table S3. Parameter estimates and 95% likelihood based confidence intervals for the preferred excess relative risk (ERR) model: female LSS solid cancer incidence cohort with known doses, 1958-2009

Risk factor	Effect estimate	95% CI
Baseline rates		
Cases per 10,000 PY (age 70 born 1915) e^{β_0}	19.0	(12.7 to 28.6)
Nagasaki: Hiroshima ratio e^{β_1}	0.89	(0.78 to 1.00)
NIC:in-city ratio e^{β_2}	0.97	(0.85 to 1.11)
Year of birth (% change per decade) $100(e^{\beta_3}-1)$ [a]	36%	(29% to 44%)
Attained age		
Attained age power β_4	5.9	(4.2 to 7.6)
log(age/70)^2 β_5	7.8	(4.5 to 11.1)
log(age/70) quadratic spline after 70 β_6	-13.5	(-22.6 to -4.7)
log(age/50) quadratic spline before 50 β_7	-13.2	(-18.3 to -8.4)
Age at menarche (% change per year) $100(e^{\beta_8}-1)$ [a]	-4%	(-9% to 1%)
Unknown menarche: age 15 menarche ratio e^{β_9}	1.1	(0.9 to 1.2)
Nulliparous: 1 pregnancy ratio $e^{\beta_{10}}$	1.37	(0.99 to 1.61)
% change per pregnancy $100(e^{\beta_{11}}-1)$ [a]	-12.3%	(-17.0% to -7.5%)
Unknown number of full-term pregnancies: 1 pregnancy ratio $e^{\beta_{12}}$	1.21	(0.96 to 1.51)
Unknown BMI: known BMI ratio $e^{\beta_{13}}$	0.65	(0.52 to 0.81)
High postmenopause BMI:low postmenopause ratio $e^{\beta_{14}}$	1.70	(1.45 to 1.98)
Time to menopause (% change per year closer to menopause given age) $100(e^{\beta_{15}}-1)$ [a]	4.9%	(0.5% to 9.3%)
Time from menopause (% change per year further from menopause given age) $100(e^{\beta_{16}}-1)$ [a]	-3.6%	(-5.3% to -1.8%)

Risk factor	Effect estimate	95% CI
Radiation parameters		
Dose ERR per Gy at age 70 and menarche and exposure at age 15 β_{17}	1.40	(0.85 to 2.15)
Attained age power β_{18}	-1.46	(-2.52 to -0.42)
Age at menarche % change per year $100(e^{\beta_{19}}-1)$ [a]	-24%	(-37% to -8%)
Age at exposure		
Before menarche % change per decade $100(e^{\beta_{20}}-1)$ [a]	67%	(-2% to 214%)
After menarche % change per decade $100(e^{\beta_{21}}-1)$ [a]	-18%	(-43% to 10%)
High dose (truncated shielded kerma:linear ERR ratio) $e^{\beta_{21}}$	0.86	(0.38 to 1.62)

Note. 95% CI, 95% confidence interval. PY, person-years. NIC, not in Hiroshima or Nagasaki city at the time of the bombings. BMI, body mass index.

[a] Positive values are percent increases and negative values are percent decreases.

Table S4. Parameter estimates and 95% likelihood based confidence intervals for the excess relative risk (ERR) model with effect modification by attained age and age at exposure: female LSS solid cancer incidence cohort with known doses, 1958-2009

Risk factor	Effect estimate	95% CI
Baseline rates		
Cases per 10,000 PY (age 70 born 1915) e^{β_0}	18.9	(12.7 to 28.6)
Nagasaki: Hiroshima ratio e^{β_1}	0.90	(0.80 to 1.01)
NIC:in-city ratio e^{β_2}	0.98	(0.85 to 1.12)
Year of birth (% change per decade) $100(e^{\beta_3}-1)$ [a]	35%	(28% to 43%)
Attained age		
Attained age power β_4	5.9	(4.2 to 7.7)
log(age/70)^2 β_5	7.9	(4.6 to 11.2)
log(age/70) quadratic spline after 70 β_6	-13.9	(-23.0 to -5.12)
log(age/50) quadratic spline before 50 β_7	-13.6	(-18.6 to -8.8)
Age at menarche (% change per year) $100(e^{\beta_8}-1)$ [a]	-7%	(-11% to -3%)
Unknown menarche: age 15 menarche ratio e^{β_9}	1.0	(0.9 to 1.2)
Nulliparous: 1 pregnancy ratio $e^{\beta_{10}}$	1.27	(1.00 to 1.61)
% change per pregnancy $100(e^{\beta_{11}}-1)$ [a]	-12.4%	(-17.1% to -7.6%)
Unknown number of full-term pregnancies: 1 pregnancy ratio $e^{\beta_{12}}$	1.19	(0.95 to 1.49)
Unknown BMI: known BMI ratio $e^{\beta_{13}}$	0.66	(0.53 to 0.82)
High postmenopause BMI:low postmenopause ratio $e^{\beta_{14}}$	1.71	(1.45 to 1.99)
Time to menopause (% change per year closer to menopause given age) $100(e^{\beta_{15}}-1)$ [a]	4.9%	(0.5% to 9.3%)
Time from menopause (% change per year further from menopause given age) $100(e^{\beta_{16}}-1)$ [a]	-3.5%	(-5.3% to -1.8%)

Risk factor	Effect estimate	95% CI
Radiation parameters		
Dose ERR per Gy at age 70 and exposure at age 30 β_{17}	1.12	(0.73 to 1.59)
Attained age power β_{18}	-1.5	(-2.6 to -0.4)
Age at exposure		
% change per decade $100(e^{\beta 19}-1)$ [a]	-5%	(-23% to 15%)
High dose (truncated shielded kerma:linear ERR ratio) β_{20}	0.84	(0.37 to 1.59)

Note. 95% CI, 95% confidence interval. PY, person-years. NIC, not in Hiroshima or Nagasaki city at the time of the bombings. BMI, body mass index.

[a] Positive values are percent increases and negative values are percent decreases.

Table S5. Female breast cancer radiation risk parameter estimates based on Preston et al. 2007 model fit to the current data

Model	Risk per 1 Gy	Age at exposure[a] (% change per decade increase)	Attained age[a] (power)
Deviance = 15750.409, 13 parameters			
ERR	1.06	-6.34	-1.61
	(0.69 to 1.51)	(-24.17 to 14.49)	(-2.73 to -0.53)
Deviance = 15761.229, 13 parameters			
EAR	9.59[c]	-36.87	1.64
	(6.92 to 12.55)	(-47.79 to -24.50)	(0.96 to 2.36)

Note. ERR, excess relative risk. EAR, excess absolute risk.

[a] Dose-response models include modifying effects of both age at exposure and attained age, while the background includes effects of city, NIC by city, attained age modeled as a quadratic spline in log attained age with knots at 50 and 70, and birth cohort modeled as a log-linear-log-quadratic function of year of birth.

[b] 95% confidence interval.

[c] Excess cases per 10,000 PY Gy.

Table S6. Estimated dose coefficients in linear and linear-quadratic excess relative risk models over selected dose ranges: female LSS solid cancer incidence cohort with known doses, 1958-2009

Dose range, Gy	Linear model[a]	Linear-quadratic model		
	Linear dose coefficient	Linear dose coefficient	Quadratic dose coefficient	Pcurv[b]
Full Range	1.40	1.80	-0.21	0.096
	(0.85 to 2.15)	(1.03 to 2.86)	(NE to 0.04)	
0 – 2.00	1.59	2.18	-0.48	0.152
	(0.96 to 2.44)	(1.14 to 3.68)	(-1.28 to 0.18)	
0 – 1.00	1.77	1.51	0.35	0.678
	(1.02 to 2.81)	(0.33 to 3.28)	(-1.43 to 2.04)	
0 - 0.50	1.74	0.38	3.67	0.168
	(0.84 to 3.13)	(-1.50 to 2.77)	(-1.67 to 9.59)	
0 - 0.25	1.29	-1.23	13.10	0.131
	(0.15 to 3.11)	(NE to 2.49)	(NE to 33.30)	
0 - 0.15	0.015	-1.64	13.75	0.614
	(NE to 2.05)	(-NE to 3.96)	(NE to 59.36)	

[a] Preferred ERR model described in Supplemental Table 3.
[b] LRT for quadratic departure from linearity.

Table S7. Modification of ERR for incident breast cancer by reproductive characteristics and body mass index: female LSS solid cancer incidence cohort with known doses, 1958-2009

	Modifying effect estimate [a]	P[b]
Age at menarche (% per year)	-23%	0.007
Nulliparous (vs. females with one live birth)	0.63	0.290
Number of full term pregnancies (% per pregnancy)	12%	0.183
Age at first full term pregnancy (% per year)	5%	0.181
Premenopausal (vs. postmenopausal females)	1.18	0.630
Age at menopause (% per year)	5%	0.145
Time to menopause (% per year closer to menopause)	-2%	0.583
Time from menopause (% per year farther from menopause)	-1%	0.578
Years of ovarian function (% per year)[c]	5%	0.099
Years of ovarian function after radiation exposure (% per year)[d]	2%	0.118
High BMI post-menopause (≥25 vs. <25 kg/m^2)	0.39	0.059

Note. BMI, body mass index.
[a] Positive values are percent increases and negative values are percent decreases.
[b] Test of departure from multiplicative interaction with radiation.
[c] Number of years between age at menopause and age at menarche.
[d] Number of years between age at menopause and largest of age at exposure and age at menarche.

Preferred excess rate (EAR) model parameter estimates

Our preferred ERR model has the form:

$$\exp\left(\begin{array}{l}\beta_0+\beta_1 I(Naga)+\beta_2 I(NIC)+\beta_3 (byr-1915)/10+\beta_4 \log(age/70)+\\ \beta_5 \log(age/70)\text{ ^ }2+\ \beta_6 \log(age/70)^2 I(age>70)+\\ \beta_7 \log(age/50)^2 I(age<50)+\beta_8 (mna\_age-14)+\beta_9 I(unk\ mna\_age)+\\ \beta_{10} I(nulliparous)+\beta_{11} (prgno-1) I(prgno>0)\ +\\ \beta_{12} I(unk\ prgno)+\beta_{13} I(unk\ BMI)+\beta_{14} I(postmenop\ \&\ BMI\geq 25)+\\ \beta_{15} I(premenop)(age-menop\_age)+\beta_{16} I(postmenop)(age-menop\_age)\end{array}\right)+$$

$$\beta_{17}\, dose\, \exp\left(\begin{array}{l}\beta_{18} \log(age/70)\ +\beta_{19} \log(age/70)^2\ +\beta_{20} (mna\_age-14)+\\ \beta_{21} (agex-mna-age) I(agex<mna\_age)/10+\\ \beta_{22} (agex-mna-age) I(agex\geq mna\_age)/10\ +\\ \beta_{23} I(high\_dose)\end{array}\right)$$

where:

I(x)	indicator function that has the value 0 of *x* is true and 0 if it is false.
byr	year of birth
age	attained age
mna_age	age at menarche
unk mna_age	unknown age at menarche
nulliparous	no full-term pregnancies
prgno	number of full term pregnancies
unk_prgno	number of full term pregnancies unknown
BMI	body mass index
unk_BMI	unknown BMI
menop_age	age at menopause (imputed if unknown)
agex	age at exposure
premenop	pre-menopausal
postmenop	post-menopausal
high_dose	shielded kerma truncated to 4Gy

Table S8. Parameter estimates and 95% likelihood based confidence intervals for preferred excess rate (EAR) model: female LSS solid cancer incidence cohort with known doses, 1958-2009

Risk factor	Effect estimate	95% CI
Baseline rates		
Cases per 10,000 PY (age 70 born 1915) e^{β_0}	18.7	(11.8 to 29.7)
Nagasaki: Hiroshima ratio e^{β_1}	0.86	(0.75 to 0.99)
NIC:in-city ratio e^{β_2}	0.96	(0.84 to 1.10)
Year of birth (% change per decade) $100(e^{\beta_3}-1)$ [a]	36%	(28% to 44%)
Attained age		
(age/70) power β_4	6.0	(4.0 to 8.0)
log(age/70)^2 β_5	8.6	(4.8 to 12.4)
log(age/70) quadratic spline after 70 β_6	-14.7	(-24.5 to -5.0)
log(age/50) quadratic spline before 50 β_7	-14.5	(-21.6 to -8.1)
Age at menarche (% change per year) $100(e^{\beta_9}-1)$ [a]	-4%	(-9% to 1%)
Unknown menarche: age 15 menarche ratio e^{β_8}	1.02	(0.85 to 1.21)
Nulliparous: 1 pregnancy ratio $e^{\beta_{10}}$	1.33	(1.02 to 1.74)
% change per pregnancy $100(e^{\beta_{11}}-1)$ [a]	-13%	(-19% to -8%)
Unknown number of full-term pregnancies: 1 pregnancy ratio $e^{\beta_{12}}$	1.24	(0.96 to 1.59)
Unknown BMI: known BMI ratio $e^{\beta_{13}}$	0.66	(0.51 to 0.84)
High postmenopause BMI:low postmenopause ratio $e^{\beta_{14}}$	1.83	(1.54 to 2.17)
Time to menopause (% change per year closer to menopause given age) $100(e^{\beta_{15}}-1)$ [a]	6.2%	(0.6% to 11.8%)
Time from menopause (% change per year further from menopause given age) $100(e^{\beta_{16}}-1)$ [a]	-3.5%	(-5.5% to -1.5%)

Risk factor	Effect estimate	95% CI
Radiation parameters		
Dose ERR per Gy at age 70 and menarche and exposure at age 15 β_{17}	19.3	(11.9 to 29.0)
Attained age		
Attained age power β_{18}	0.68	(0.08 to 3.80)
Log(age/70)^2 β_{19}	-2.52	(-5.35 to -0.39)
Age at menarche % change per year $100(e^{\beta_{20}}-1)$ [a]	-29%	(-40% to -15%)
Age at exposure		
Before menarche % change per decade $100(e^{\beta_{21}}-1)$ [a]	31%	(-24% to 153%)
After menarche % change per decade $100(e^{\beta_{22}}-1)$ [a]	-46%	(-63% to -27%)
High dose (truncated shielded kerma: linear ERR ratio) $e^{\beta_{23}}$	0.87	(0.38 to 1.65)

Note. 95% CI, 95% confidence interval. PY, person-years. NIC, not in Hiroshima or Nagasaki city at the time of the bombings. BMI, body mass index.

[a] Positive values are percent increases and negative values are percent decreases.

Table S9. Variation in ERR per Gy according to indicator of unknown vs. known reproductive history, body mass index, and smoking history: female LSS solid cancer incidence cohort with known doses, 1958-2009

Unknown vs. known indicator	Modifying parameter estimate	P[a]
Age at menarche	-0.096	0.681
Number of full term pregnancies	-0.328	0.181
Age at first full term pregnancy	0.220	0.575
BMI	-0.439	0.089
Smoking	-0.410	0.100

Note. BMI, body mass index.
[a] Test of departure from multiplicative interaction with radiation.