

Table 4 (continued). Cancer models to be used in calculation of probability of causation. Derivation of NIOSH-IREP models is described in Section II-B. Abbreviations: MN (malignant neoplasm), CIS (carcinoma in situ), NUB (neoplasm of uncertain behavior), NUM (neoplasm of unspecified nature).

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
NUB of liver and biliary passages	235.3	Liver
NUB of retroperitoneum and peritoneum, and other and unspecified digestive organs	235.4, 235.5	All digestive
NUB of larynx, pleura, thymus, mediastinum, and other and unspecified respiratory organs	235.6, 235.8, 235.9	Other respiratory
NUB of trachea, bronchus and lung	235.7	Lung
NUB of uterus, and other and unspecified female genital organs	236.0, 236.1, 236.3	Female genitalia, less ovary
NUB of ovary	236.2	Ovary
NUB of prostate, testis and other male genital	236.4, 236.5, 236.6	All male genitalia
NUB of bladder	236.7	Bladder
NUB of other and unspecified urinary tract, and suprarenal gland	236.9, 237.2	Urinary organs less bladder
NUB of pituitary, pineal and other and unspecified endocrine glands	237.0, 237.1, 237.4	Thyroid
NUB of paraganglia, brain and spinal cord, and other nervous system	237.3, 237.5, 237.6, 237.7, 237.9	Nervous system
NUB of bone and articular cartilage	238.0	Bone
NUB of connective and other soft tissue	238.1	Connective tissue
NUB of skin	238.2	Malignant melanoma AND Non-melanoma skin-Basal cell

Table 4 (continued). Cancer models to be used in calculation of probability of causation. Derivation of NIOSH-IREP models is described in Section II-B. Abbreviations: MN (malignant neoplasm), CIS (carcinoma in situ), NUB (neoplasm of uncertain behavior), NUM (neoplasm of unspecified nature).

Primary neoplasm	ICD-9 code	NIOSH-IREP model for calculating PC
NUB of breast	238.3	Breast
NUB of other lymphatic and hematopoietic	238.5-238.7	Lymphoma and multiple myeloma
NUB of other specified and unspecified sites	238.8, 238.9	Other and ill-defined sites
Neoplasm of unspecified nature (NUN) of digestive system	239.0	All digestive
NUN of respiratory system	239.1	Lung AND Other respiratory
NUN of bone and soft tissue	239.2	Bone
NUN of skin	239.2	Non-melanoma skin-Basal cell
NUN of breast	239.3	Breast
NUN of bladder	239.4	Bladder
NUN of other genitourinary organs	239.5	Female genital less ovary AND Ovary AND All urinary organs (if female) All male genital AND All urinary organs (if male)
NUN of brain and other parts of nervous system	239.6, 239.7	Nervous system
NUN of endocrine glands	239.7	Thyroid AND Other endocrine glands
NUN of other specified or unspecified sites	239.8, 239.9	Other and ill-defined sites

Table 5A. Photons and electrons: Probability distributions of radiation effectiveness factors (REFs) to be used in estimating risks and probability of causation of cancers

Radiation type	Exposure	Probability distribution of radiation effectiveness factor (REF _r)	95% Confidence Interval
Photons	Chronic or acute ^a		2.5th 50.0th 97.5th
E > 250 keV		Single-valued at 1.0 (higher-energy photons are assumed reference radiation)	---- 1.0 ----
E = 30-250 keV		Hybrid distribution with – 25% probability assigned to value 1.0; 75% probability assigned to lognormal distribution with 95% confidence interval between 1.0 and 5.0	1.0 1.9 4.7
E < 30 keV		Product of two distributions – (1) hybrid distribution for E _γ = 30-250 keV; and (2) triangular distribution with minimum of 1.0, mode of 1.3, and maximum of 1.6	1.1 2.4 6.1
Electrons	Chronic or acute ^a		
E > 15 keV		Single-valued at 1.0 (assumed to be same as value for reference higher-energy photons)	---- 1.0 ----
E < 15 keV		Lognormal distribution with 95% confidence interval between 1.2 and 5	1.2 2.4 5.0

^aFor solid tumors, DDREF is always applied under conditions of chronic exposure. At acute doses greater than 0.2 cGy, DDREF is assumed to be 1.0. At acute doses less than 0.2 cGy, a DDREF that can exceed 1.0 is applied, and the distribution of possible values approaches the probability distribution of DDREF that applies to all chronic exposures as the dose approaches zero.

Table 5B. Alpha particles: Probability distributions of radiation effectiveness factors (REFs) to be used in estimating risks and probability of causation of cancers

Cancer type	Probability distribution of radiation effectiveness factor (REF _L)	95% Confidence Interval
Leukemias		2.5th 50.0th 97.5th
All energies of alpha particles	Hybrid distribution with – 25% probability assigned to value 1.0; 50% probability assigned to lognormal distribution with 95% confidence interval between 1.0 and 15; 25% probability assigned to lognormal distribution with 95% confidence interval between 2.0 and 60 ^d	1.0 4.1 42 ^b
Solid tumors		
All energies of alpha particles	Lognormal distribution with 95% confidence interval between 3 and 80	3.4 18 101 ^b
^a Correction for inverse dose-rate effect for all exposures to alpha particles: Discrete distribution with – 70% probability assigned to value 1.0; 20% probability assigned to value 1.5; 7.5% probability assigned to value 2.0; 2.5% probability assigned to value 3.		

^aAcute exposures to alpha particles emitted by radionuclides generally should not occur; correction factor to account for inverse dose-rate effect under conditions of chronic exposure to alpha particles is applied in all cases.

^bDistribution includes the correction for inverse dose-rate effect.

Table 5C. Neutrons: Probability distributions of radiation effectiveness factors (REFs) to be used in estimating risks and probability of causation of cancers

Cancer type	Probability distribution of radiation effectiveness factor (REF _L)	Exposure	95% Confidence Interval	
Leukemia ^a			2.5th	97.5th
Neutron energies				
E = 0.1-2 MeV ^b	Lognormal distribution with 95% confidence interval between 2.0 and 60	Acute Chronic ^c	2.0 2.5	11 14 60 91
E = 10-100 keV; E = 2-20 MeV	Stepwise uniform distribution with – 30% probability assigned to values from 1.0 to 4.0; 50% probability assigned to values from 4.0 to 8.0; 20% probability assigned to values from 8.0 to 40	Acute Chronic	1.3 1.5	5.6 7.1 36 55
E < 10 keV; E > 20 MeV	Stepwise uniform distribution with – 30% probability assigned to values from 1.0 to 2.3; 50% probability assigned to values from 2.3 to 3.5; 20% probability assigned to values from 3.5 to 25	Acute Chronic	1.1 1.2	2.8 3.4 22 34

(Table is continued on following page)

Table 5C (continued). Neutrons: Probability distributions of radiation effectiveness factors

Cancer type	Probability distribution of radiation effectiveness factor (REF _H)	Exposure	95% Confidence Interval	
Solid tumors			2.5th	97.5th
Neutron energies				
E = 0.1-2 MeV ^b	Lognormal distribution with 95% confidence interval between 2.0 and 30	Acute Chronic	2.0 2.4	7.7 10 30 47
E = 10-100 keV; E = 2-20 MeV	Stepwise uniform distribution with – 30% probability assigned to values from 1.0 to 3.0; 50% probability assigned to values from 3.0 to 5.0; 20% probability assigned to values from 5.0 to 20	Acute Chronic	1.2 1.4	3.8 4.7 18 28
E < 10 keV; E > 20 MeV	Stepwise uniform distribution with – 30% probability assigned to values from 1.0 to 1.6; 50% probability assigned to values from 1.6 to 2.4; 20% probability assigned to values from 2.4 to 12	Acute Chronic	1.1 1.1	1.9 2.4 11 16
Correction for inverse dose-rate effect for chronic exposures to neutrons – Discrete distribution with – 50% probability assigned to value 1.0; 30% probability assigned to value 1.5; 15% probability assigned to value 2.0; 5% probability assigned to value 3.0				

^aAssumed probability distributions apply to leukemias, lymphomas, and lymphocytic cancers.

^bEnergy range includes spectrum of fission neutrons.

^cUnder conditions of chronic exposure only, correction factor to account for the inverse dose-rate effect is applied.

Table 6. Smoking category definitions for lung cancer claims under NIOSH-IREP

Smoking category	Definition
Never	Smoked fewer than 100 cigarettes (throughout lifetime) prior to cancer diagnosis
Former	Quit smoking five years or more before date of cancer diagnosis
Current (? cig/day)	Smoked at time of cancer diagnosis (or quit fewer than 5 years before), quantity unknown
Current (<10 cig/day)	Smoked at time of cancer diagnosis (or quit fewer than 5 years before), average of fewer than 10 cigarettes per day
Current (10-19 cig/day)	Smoked at time of cancer diagnosis (or quit fewer than 5 years before), average of 10-19 cigarettes per day
Current (20-39 cig/day)	Smoked at time of cancer diagnosis (or quit fewer than 5 years before), average of 20-39 cigarettes per day
Current (40+ cig/day)	Smoked at time of cancer diagnosis (or quit fewer than 5 years before), average of 40 or more cigarettes per day

Table 7. Primary cancers (ICD-9 codes¹) for which probability of causation is to be calculated, if only a secondary cancer site is known. “M” indicates cancer site should be used for males only, and “F” indicates cancer site should be used for females only. Whenever “173” is indicated, the “non-melanoma skin-basal cell” model should be used.

Secondary cancer	ICD-9 code of likely primary cancers
Lymph nodes of head, face and neck (196.0)	141, 142 (M), 146 (M), 149 (F), 161 (M), 162, 172, 173, 174 (F), 193 (F)
Intrathoracic lymph nodes (196.1)	150 (M), 162, 174 (F)
Intra-abdominal lymph nodes (196.2)	150 (M), 151 (M), 153, 157 (F), 162, 174 (F), 180 (F), 185 (M), 189, 202 (F)
Lymph nodes of axilla and upper limb (196.3)	162, 172, 174 (F)
Inguinal and lower limb lymph nodes (196.5)	154 (M), 162, 172, 173 (F), 187 (M)
Intrapelvic lymph nodes (196.6)	153 (M), 154 (F), 162 (M), 180 (F), 182 (F), 185 (M), 188
Lymph nodes of multiple sites (196.8)	150 (M), 151 (M), 153 (M), 162, 174 (F)
Lymph nodes, site unspecified (196.9)	150 (M), 151, 153, 162, 172, 174 (F), 185 (M)
Lung (197.0)	153, 162, 172 (M), 174 (F), 185 (M), 188 (M), 189
Mediastinum (197.1)	150 (M), 162, 174 (F)
Pleura (197.2)	150 (M), 153 (M), 162, 174 (F), 183 (F), 185 (M), 189 (M)
Other respiratory organs (197.3)	150, 153 (M), 161, 162, 173 (M), 174 (F), 185 (M), 193 (F)
Small intestine, including duodenum (197.4)	152, 153, 157, 162, 171, 172 (M), 174 (F), 183 (F), 189 (M)
Large intestine and rectum (197.5)	153, 154, 162, 174 (F), 183 (F), 185 (M)
Retroperitoneum and peritoneum (197.6)	151, 153, 154 (M), 157, 162 (M), 171, 174 (F), 182 (F), 183 (F)
Liver, specified as secondary (197.7)	151 (M), 153, 154 (M), 157, 162, 174 (F)

¹The International Classification of Diseases Clinical Modification (9th Revision) Volumes I&II. [1991] Department of Health and Human Services Publication No. (PHS) 91-1260, U.S. Government Printing Office, Washington, D.C.

Table 7 (continued). Primary cancers (ICD-9 codes) for which probability of causation is to be calculated, if on a secondary cancer site is known. “M” indicates cancer site should be used for males only, and “F” indicates cancer site should be used for females only. Whenever “173” is indicated, the “non-melanoma skin-basal cell” model should be used.

Secondary cancer	ICD-9 code of likely primary cancers
Other digestive organs (197.8)	150 (M), 151, 153, 157, 162, 174 (F), 185 (M)
Kidney (198.0)	153, 162, 174 (F), 180 (F), 185 (M), 188, 189, 202 (F)
Other urinary organs (198.1)	153, 174 (F), 180 (F), 183 (F), 185 (M), 188, 189 (F)
Skin (198.2)	153, 162, 171 (M), 172, 173 (M), 174 (F), 189 (M)
Brain and spinal cord (198.3)	162, 172 (M), 174 (F)
Other parts of nervous system (198.4)	162, 172 (M), 174 (F), 185 (M), 202
Bone and bone marrow (198.5)	162, 174 (F), 185 (M)
Ovary (198.6)	153 (F), 174 (F), 183 (F)
Suprarenal gland (198.7)	153 (F), 162, 174 (F)
Other specified sites (198.8)	153, 162, 172 (M), 174 (F), 183 (F), 185 (M), 188 (M)

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Appendix I: NIOSH-IREP program output

**NIOSH-Interactive RadioEpidemiological Program
Probability of Causation Results**

Date of Run: 06/12/2002	DOL District Office: DE
Time of Run: 12:00:05 PM	NIOSH-IREP version: 5.2
NIOSH ID #: 123456	Claimant SSN: 123-45-6789
Claimant Name: John Q. Doe	

Claimant Cancer Diagnoses:

Primary Cancer #1: Prostate (ICD-9 185)	Date of Diagnosis: 10/20/1988
Primary Cancer #2: N/A	Date of Diagnosis: N/A
Primary Cancer #3: N/A	Date of Diagnosis: N/A
Secondary Cancer #1: Lung (ICD-9 197.0)	Date of Diagnosis: 03/13/1994
Secondary Cancer #2: N/A	Date of Diagnosis: N/A
Secondary Cancer #3: N/A	Date of Diagnosis: N/A

Claimant Information Used In Probability of Causation Calculation:

Gender: Male	Race (skin cancer only): N/A
Birth Year: 1920	Year of Diagnosis: 1988
Cancer Model: All Male Genitalia (185-187)	
Should alternate cancer model be run?: No	
Smoking history (trachea, bronchus, or lung cancer only): N/A	

NIOSH-IREP Assumptions and Settings:

User Defined Uncertainty Distribution: Lognormal (1,1)
Number of Iterations: 2000
Random Number Seed: 99

Appendix I (continued): NIOSH-IREP program output**GENERAL EXPOSURE INFORMATION:**

Exposure #	Exposure Year	Organ Dose (cSv)	Exposure Rate	Radiation Type
1	1955	Lognormal (0.5,1.8)	acute	photons E=30-250keV
2	1955	Lognormal (0.7,1.8)	acute	photons E>250keV
3	1956	Lognormal (0.1,1.8)	chronic	neutrons E=100keV-2MeV
4	1956	Lognormal (0.4,2.5)	acute	photons E>250keV
5	1957	Uniform (0.1,4)	chronic	alpha
6	1957	Lognormal (1.3,1.8)	acute	photons E>250keV
7	1958	Uniform (0.05,5.6)	chronic	alpha
8	1958	Lognormal (0.2,1.8)	acute	photons E>250keV
9	1959	Lognormal (0.5,2.5)	chronic	neutrons E=100keV-2MeV
10	1959	Lognormal (0.1,1.8)	acute	photons E>250keV
11	1960	Lognormal (0.5,1.8)	acute	photons E>250keV
12	1960	Lognormal (0.1,2.5)	chronic	neutrons E=100keV-2MeV
13	1961	Lognormal (0.3,1.8)	acute	photons E>250keV
14	1961	Lognormal (0.2,2.5)	chronic	neutrons E=100keV-2MeV
15	1962	Lognormal (0.1,1.8)	acute	photons E>250keV

Radon Exposure Information:

N/A (applies only to cases of Lung Cancer with Radon Exposures)

Appendix I (continued): NIOSH-IREP program output**Results of NIOSH-IREP
Probability of Causation:**

1 st percentile	0.0%
5 th percentile	0.0%
50 th percentile	0.81%
95 th percentile	5.29%
99th percentile	10.22%

Name of Analyst:

Title:

Signature:

Date:

Name of Reviewer:

Title:

Signature:

Date:

Appendix II: Glossary of ICD-9 codes and their cancer descriptions¹

ICD-9 code	Cancer description
140	Malignant neoplasm of lip
141	Malignant neoplasm of tongue
142	Malignant neoplasm of major salivary glands
143	Malignant neoplasm of gum
144	Malignant neoplasm of floor of mouth
145	Malignant neoplasm of other and unspecified parts of mouth
146	Malignant of neoplasm of oropharynx
147	Malignant neoplasm of nasopharynx
148	Malignant of neoplasm of hypopharynx
149	Malignant of neoplasm other and ill-defined sites within the lip, oral cavity, and pharynx
150	Malignant of neoplasm of esophagus
151	Malignant of neoplasm of stomach
152	Malignant of neoplasm of small intestine, including duodenum
153	Malignant of neoplasm of colon
154	Malignant of neoplasm of rectum, rectosigmoid junction, and anus
155	Malignant neoplasm of liver and intrahepatic bile ducts
156	Malignant neoplasm of gall bladder and extrahepatic bile ducts
157	Malignant neoplasm of pancreas
158	Malignant neoplasm of retroperitoneum and peritoneum
159	Malignant neoplasm of other and ill-defined sites within the digestive organs and peritoneum

¹The International Classification of Diseases Clinical Modification (9th Revision) Volumes I&II. [1991] Department of Health and Human Services Publication No. (PHS) 91-1260, U.S. Government Printing Office, Washington, D.C.

Appendix II (continued): Glossary of ICD-9 codes and their cancer descriptions

ICD-9 code	Cancer description
160	Malignant neoplasm of nasal cavities, middle ear, an accessory sinuses
161	Malignant neoplasm of larynx
162	Malignant neoplasm of trachea, bronchus an lung
163	Malignant neoplasm of pleura
164	Malignant neoplasm of thymus, heart, and mediastinum
165	Malignant neoplasm of other and ill-defined sites within the respiratory system and intrathoracic organs
170	Malignant neoplasm of bone and articular cartilage
171	Malignant neoplasm of connective and other soft tissue
172	Malignant melanoma of skin
173	Other malignant neoplasm of skin
174	Malignant neoplasm of female breast
175	Malignant neoplasm of male breast
179	Malignant neoplasm of uterus, not otherwise specified
180	Malignant neoplasm of uterine cervix
181	Malignant neoplasm of placenta
182	Malignant neoplasm of uterine corpus (body of uterus)
183	Malignant neoplasm of ovary and other uterine adnexa
184	Malignant neoplasm of other and unspecified female genital organs
185	Malignant neoplasm of prostate
186	Malignant neoplasm of testis
187	Malignant neoplasm of penis and other male genital organs
188	Malignant neoplasm of urinary bladder
189	Malignant neoplasm of kidney and other and unspecified urinary organs
190	Malignant neoplasm of eye

Appendix II (continued): Glossary of ICD-9 codes and their cancer descriptions

ICD-9 code	Cancer description
191	Malignant neoplasm of brain
192	Malignant neoplasm of other an unspecified parts of nervous system
193	Malignant neoplasm of thyroid gland
194	Malignant neoplasm of other endocrine glands and related structures
195	Malignant neoplasm of other and ill-defined sites
196	Secondary and unspecified neoplasms of the lymph nodes
197	Secondary neoplasms of the respiratory and digestive organs
198	Secondary neoplasms of other tissue and organs
199	Malignant neoplasm without specification of site
200	<i>Lymphosarcoma and reticulosarcoma</i>
201	Hodgkin's disease
202	Other malignant neoplasms of lymphoid and histiocytic tissue
203	Multiple myeloma and other immunoproliferative diseases
204	Lymphoid leukemia
205	Myeloid leukemia
206	<i>Monocytic leukemia</i>
207	Other specified leukemia
208	Leukemia of unspecified cell type