Niedrigdosiseffekte in der Röntgendiagnostik

Ergebnisse neuer epidemiologischer Studien

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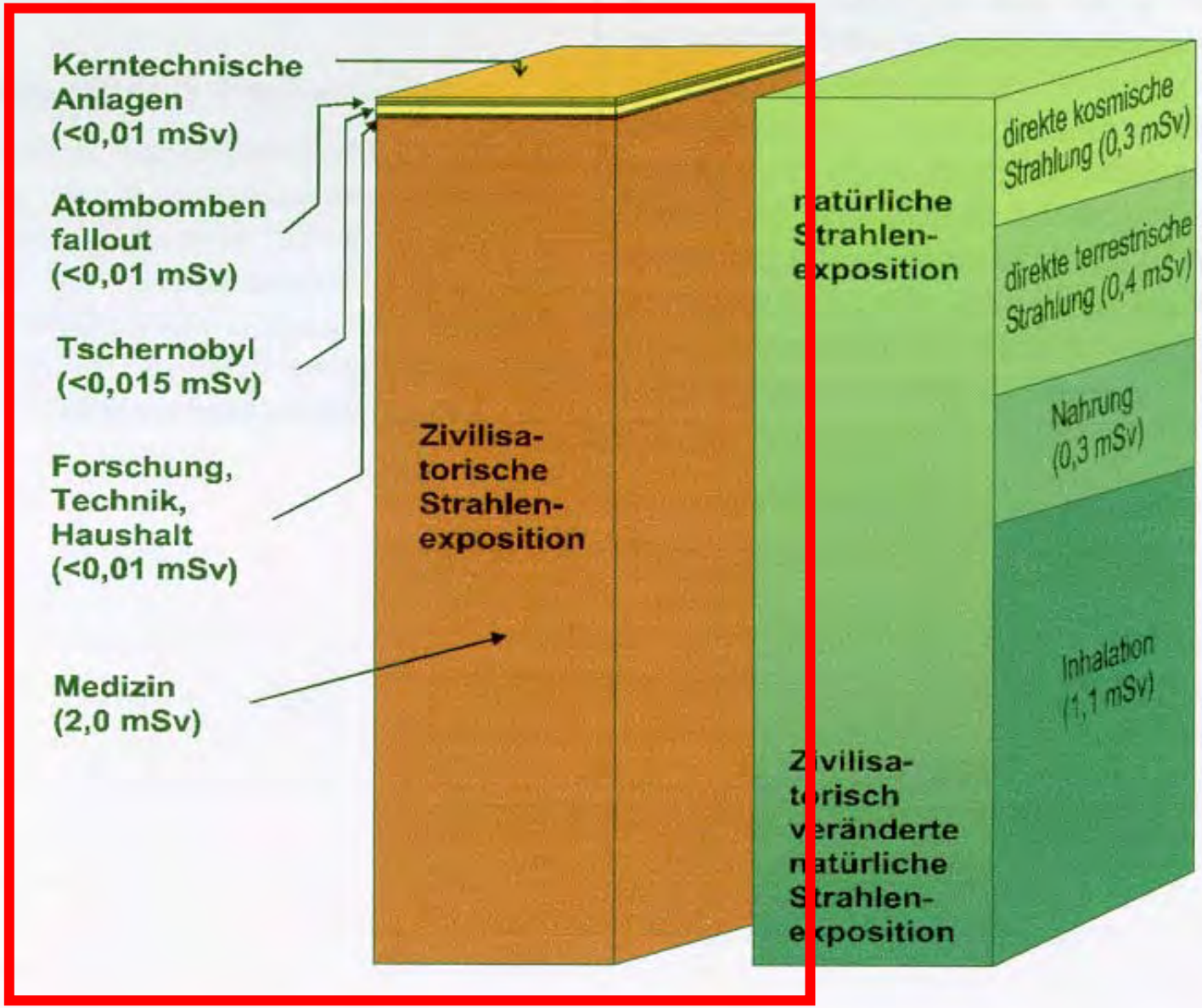
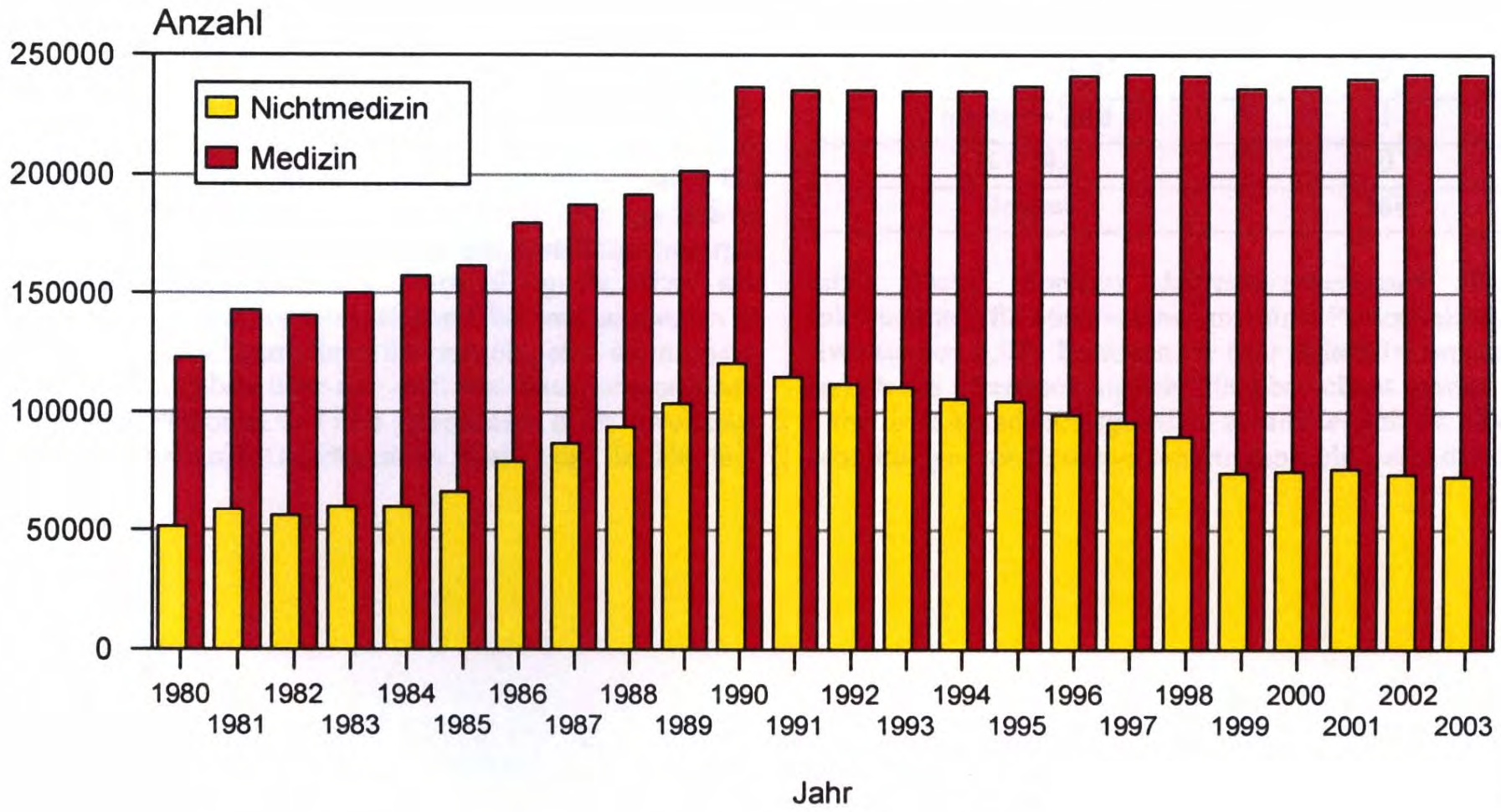
11. Fortbildungsseminar der Arbeitsgemeinschaft „Physik und Technik in der bildgebenden Diagnostik“ der Deutschen Röntgengesellschaft e.V., Bremen 22.-23.6.2007

Mittlere effektive Jahresdosis durch ionisierende Strahlung im Jahr 2000 (Gemittelt über die Bevölkerung Deutschlands)

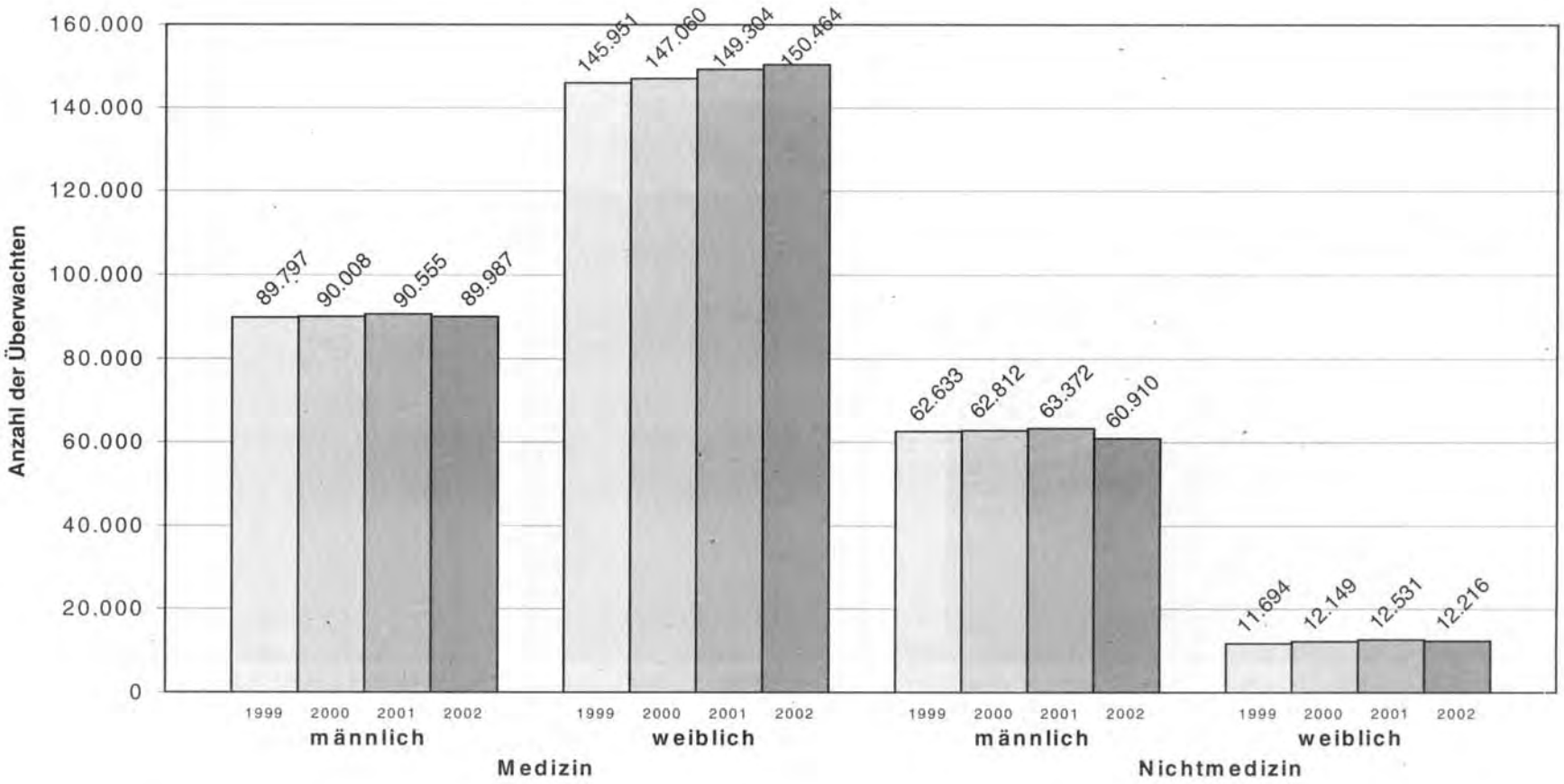


BMU: Umweltradioaktivität und Strahlenbelastung 2001

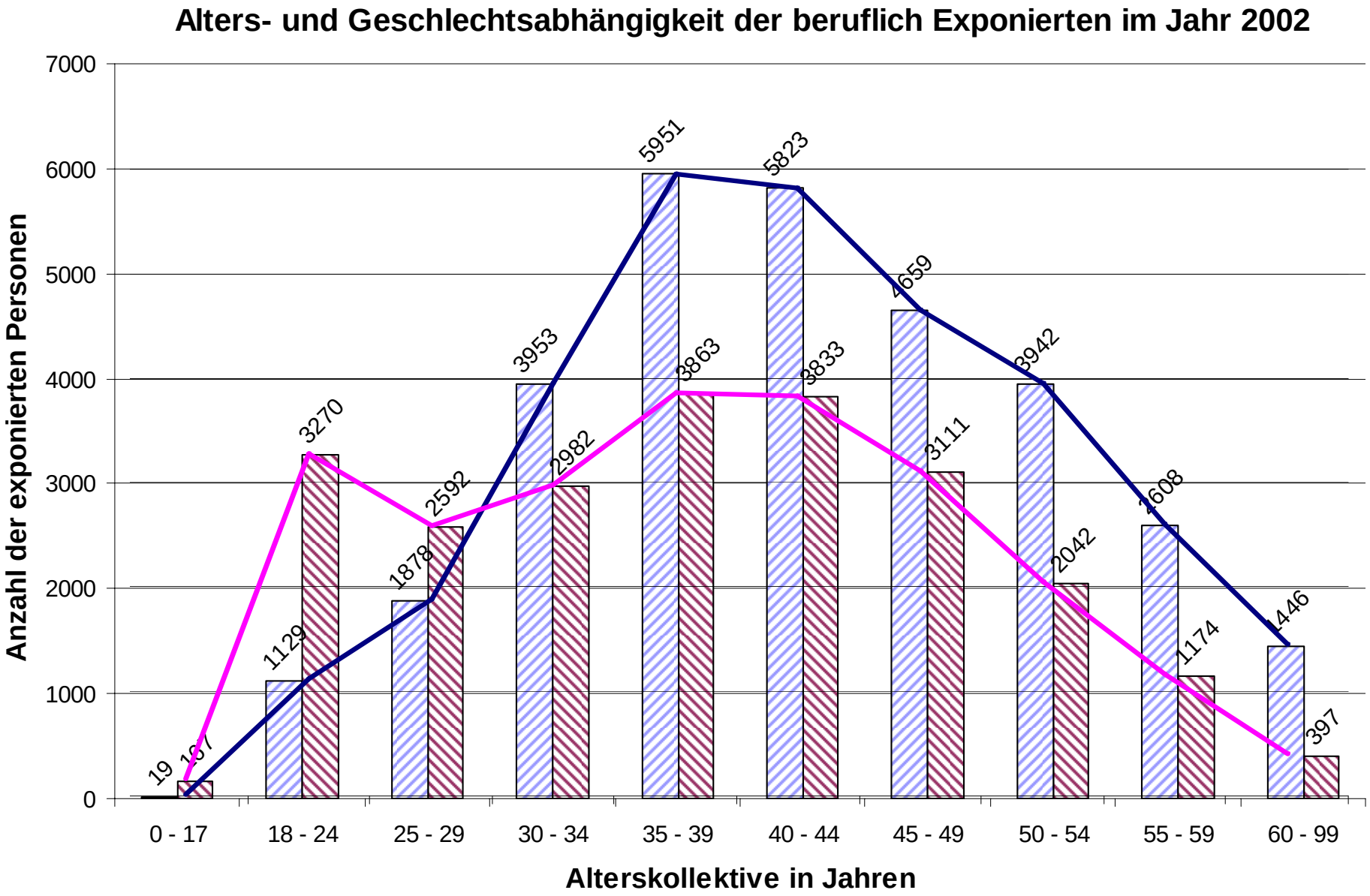
Mit Personendosimetern überwachte Personen in Deutschland
(ab 1990 einschließlich der neuen Bundesländer)



BfS: Anzahl der überwachten Personen in medizinischen und nichtmedizinischen Betrieben (1999-2002)

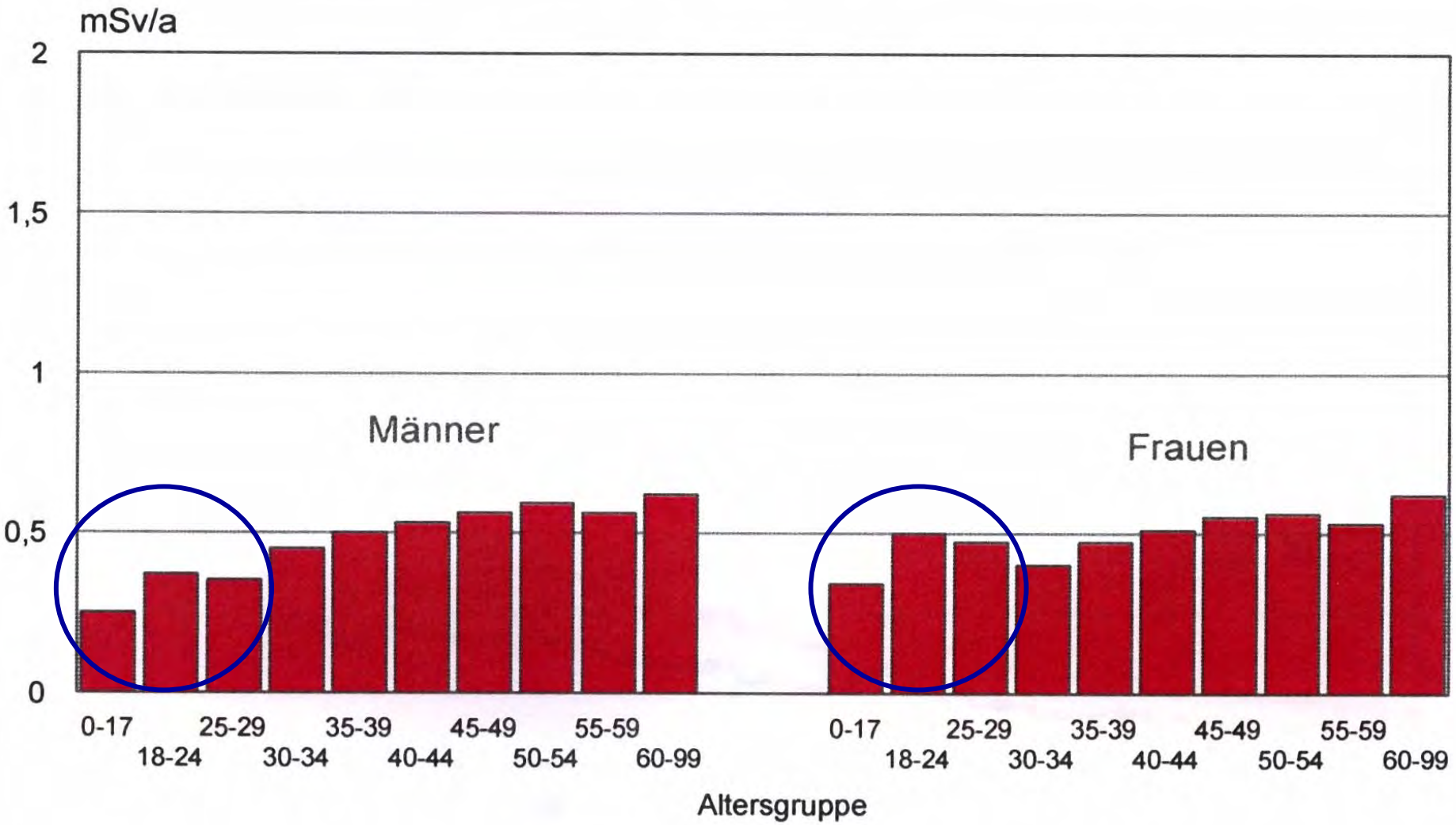


Frasch et al. (2003) Bericht des Strahlenschutzregisters. BfS, Abb. 4, p 29



Alters- und Geschlechtsabhängigkeit der beruflich Strahlenexponierten im Jahr 2002 [BFS 2004]

Mittlere Ganzkörperjahresdosis exponierter Personen im medizinischen Bereich im Jahr 2003



BfS Umweltradioaktivität und Strahlenbelastung 2003 (2005)

Quantifizierung des Strahlenrisikos

- (DNA-)Biochemie ?
- Zellkultur ?
- Tierversuch ?
- Fallberichte ?

→ **Epidemiologie !**

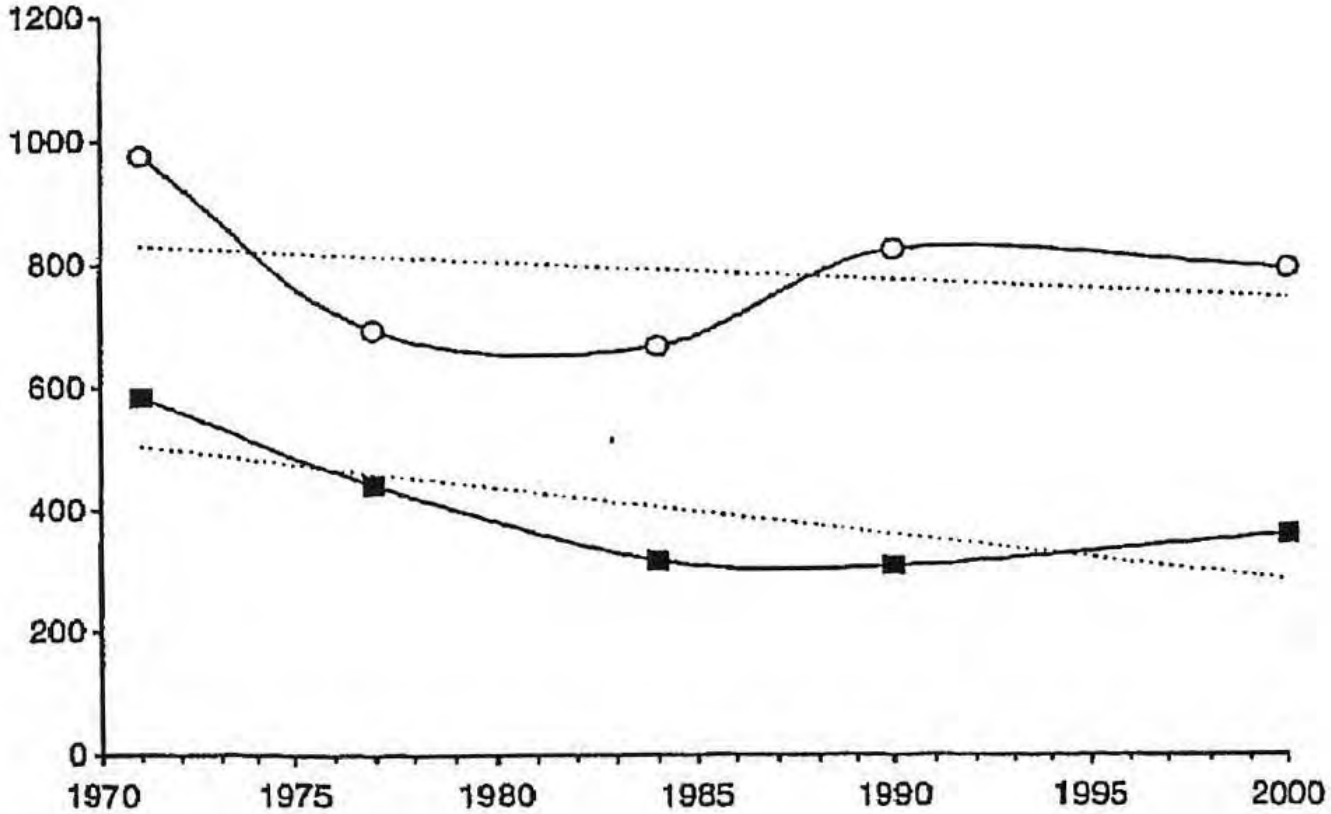


Figure 1. Storks and the birth rate in Lower Saxony, Germany (1971–2000). Open circles show yearly birthrates in hundreds in Lower Saxony. Full squares show numbers pairs of storks in Lower Saxony. Dotted lines represent linear regression trend ($y = mx + b$).

Quelle: Höfer,T. et al.,New evidence for the Theory of the Stork, Paediatric and Perinatal Epidemiology 2004, 18, p.90

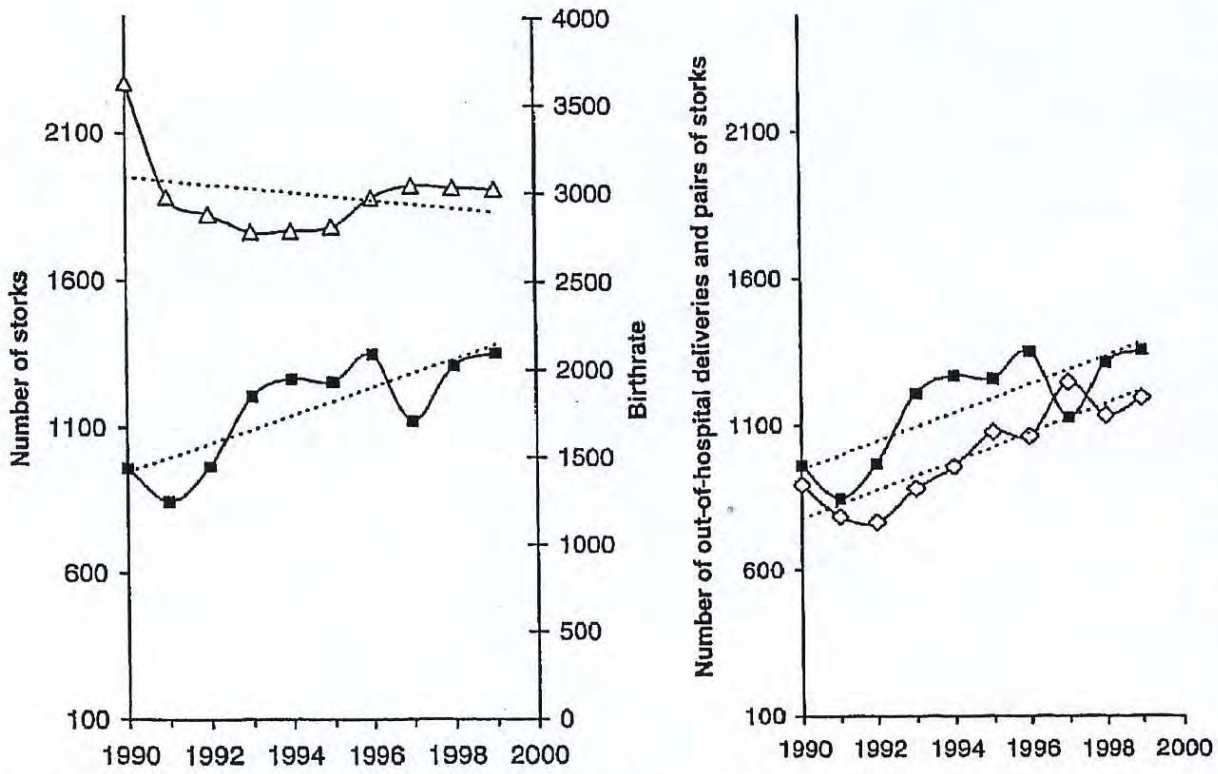


Figure 2. Storks in Brandenburg and the birthrates in Berlin, Germany (1990–99). Open triangles show number of clinical deliveries per year in Berlin. Open diamonds show number of out-of-hospital deliveries per year in Berlin. Number of pairs of storks are shown as full squares. Dotted lines represent linear regression trend ($y = mx + b$). For the convenience of the readers, two figures are presented. Left graph shows clinical deliveries against pairs of storks using two scalings, right graph shows numbers of out-of-hospital deliveries and pairs of storks both on the same scale. In both figures, data are from the years 1990–2000.

Quelle: Höfer,T. et al.,New evidence for the Theory of the Stork, Paediatric and Perinatal Epidemiology 2004, 18, p.91

(Clinical births) **(out-of-hospital births)**

Was ist ein „Risiko“

Prävalenz von Risikofaktoren bei der Basisuntersuchung sowie Hazard Rate Ratios (HRR) und Rate Advancement Periods (RAP) für inzidente Herzinfarkte bei Männern (N = 1012)

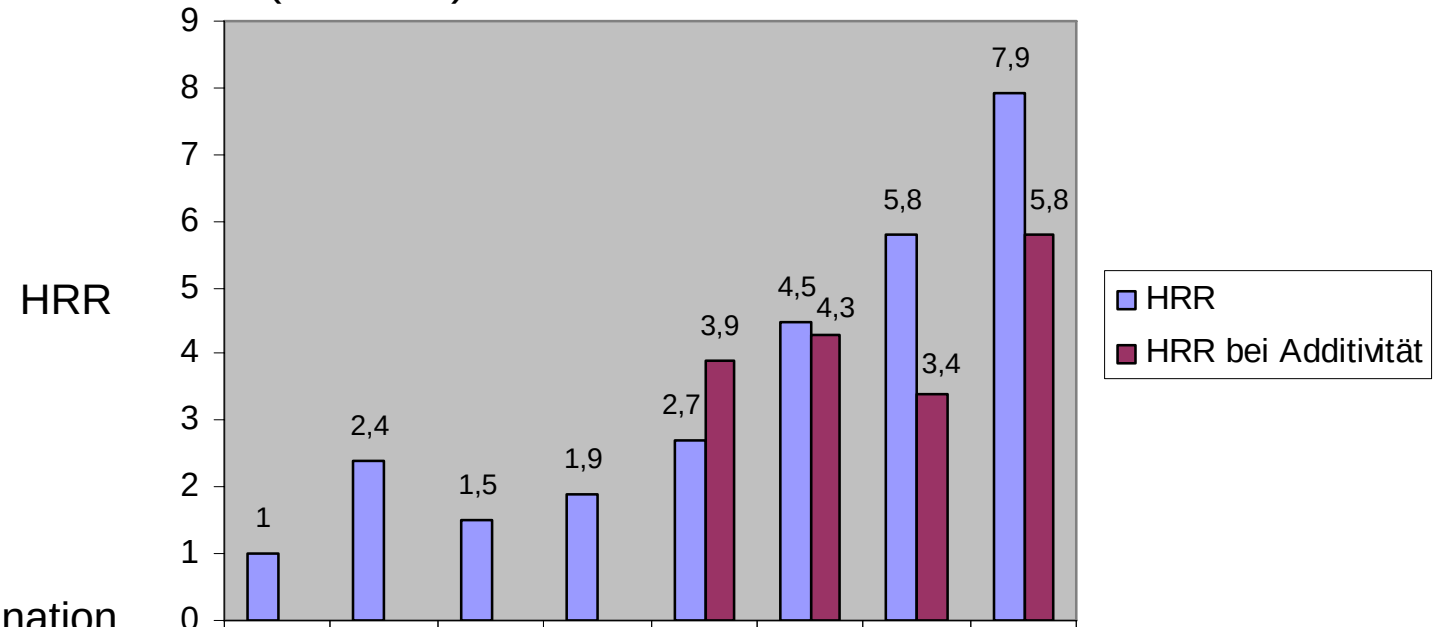
	Prävalenz	HRR	95 % KI	RAP	95 % KI
Hypertonie Grad I	24,4	1,1	0,7-1,8	1,0	-4,9-8,1
Hypertonie Grad II und III	16,5	1,1	0,6-2,0	1,5	-5,7-9,5
Behandelte Hypertonie	8,3	2,4	1,3-4,3	10,5	2,9-22,2
Gesamtcholesterin/HDL-Cholesterin	35,7	1,6	1,1-2,5	5,8	0,6-13,4
Ex-Raucher	41,2	1,4	0,7-2,7	4,0	-3,5-14,5
Raucher (1-19 Zig/Tag)	16,8	2,6	1,4-5,2	11,4	3,3-25,2
Raucher (≥ 20 Zig/Tag)	16,5	3,8	1,9-7,6	15,8	7,3-31,6

Hypertonie Grad I: systolischer Blutdruck 140-159 mmHg
Hypertonie Grad II oder III: systolischer Blutdruck >160 mmHg
Hypercholesterinämie: Gesamtcholesterin/HDL-Cholesterin ≥ 5,5

J. Heidrich et al. (2003). Z Kardiol 92:445-454.

Was ist ein Risiko ?

Hazard Rate Ratios (HRR) für Risikofaktor-Kombinationen hinsichtlich der Inzidenz von Herzinfarkten bei Männern (N=1012)



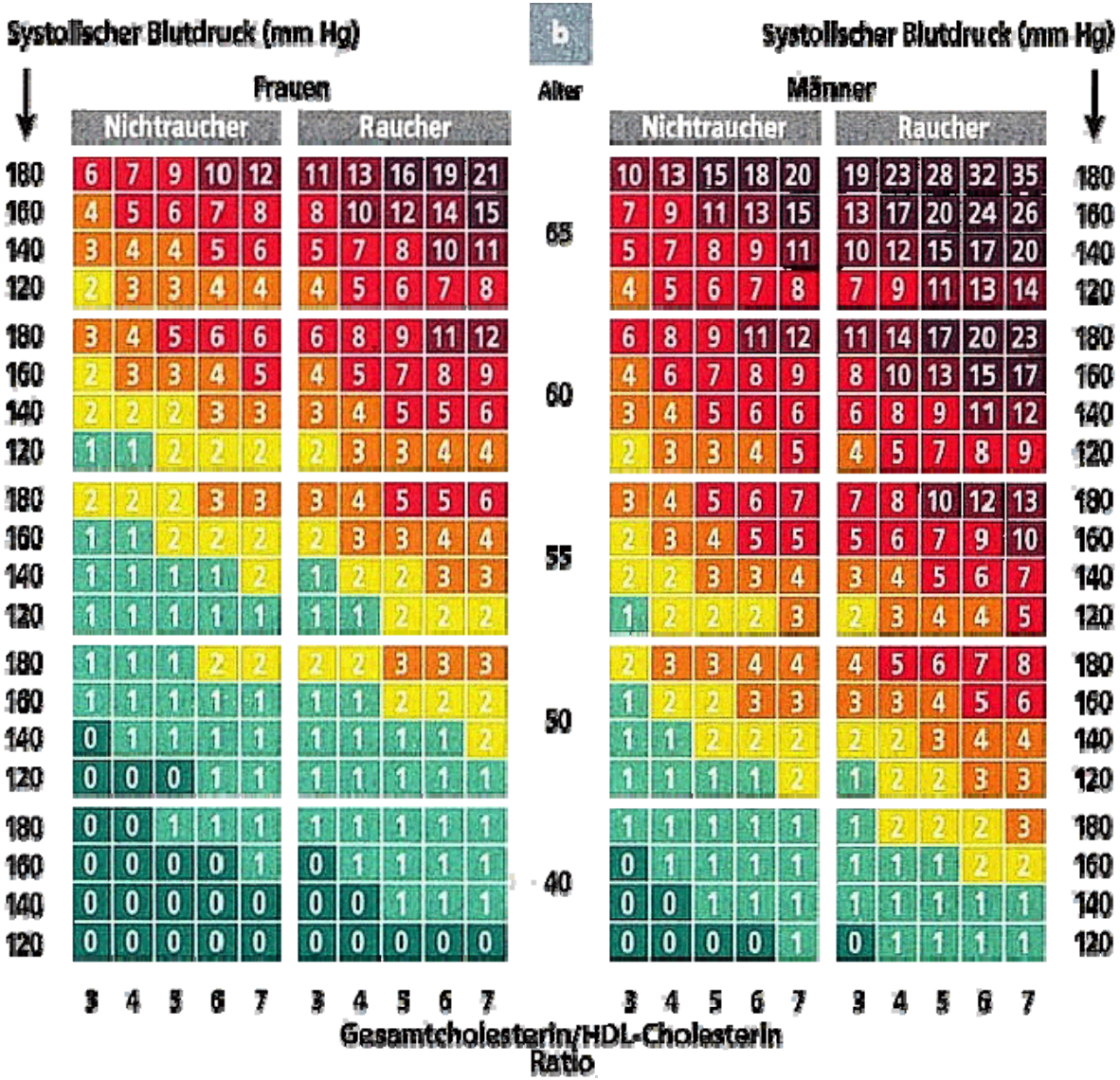
Risikofaktoren-Kombination								
Art. Hypertonie (≥160/95 mm Hg)	0	0	0	1	0	1	1	1
Gesamtcholesterin/HDL-Cholesterin ≥5,5	0	0	1	0	1	0	1	1
Rauchen (≥1 Zigarette am Tag)	0	1	0	0	1	1	0	1
Herzinfarktrate/ N Probanden	19/373	14/133	9/110	14/148	10/73	6/35	25/107	10/33

J. Heidrich et al. (2003). Z Kardiol 92:445-454.

SCORE – Beteiligte Kohorten

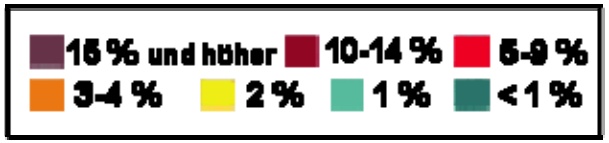
Land	Teilnehmerzahl	Altersspanne	Beobachtungs-zeiträume	Teilnehmerrate
Finnland	37 296	24-64	1972/1977 1982/1987	80 %
Russland	3325	37-62	1975-77	70 %
Norwegen	48 425	35-49	1947-78	88 %
Großbritannien Schottland	7292 12 285	38-61 25-66	1978-80 1984-87	78 % 64 %
Dänemark	9945	29-80	1977-91	74 %
Schweden	7435	47-56	1970-73	75 %
Belgien	10 641	25-75	1980-84	36 %
Deutschland	3968	25-65	1984-85	79 %
Italien	53 439	19-80	1978-87	? %
Frankreich	7337	43-53	1967-72	80 %
Spanien	4701	25-68	1968-88 1974-77 1980-82	75 % 77 % 83 %

SCORE-Deutschland

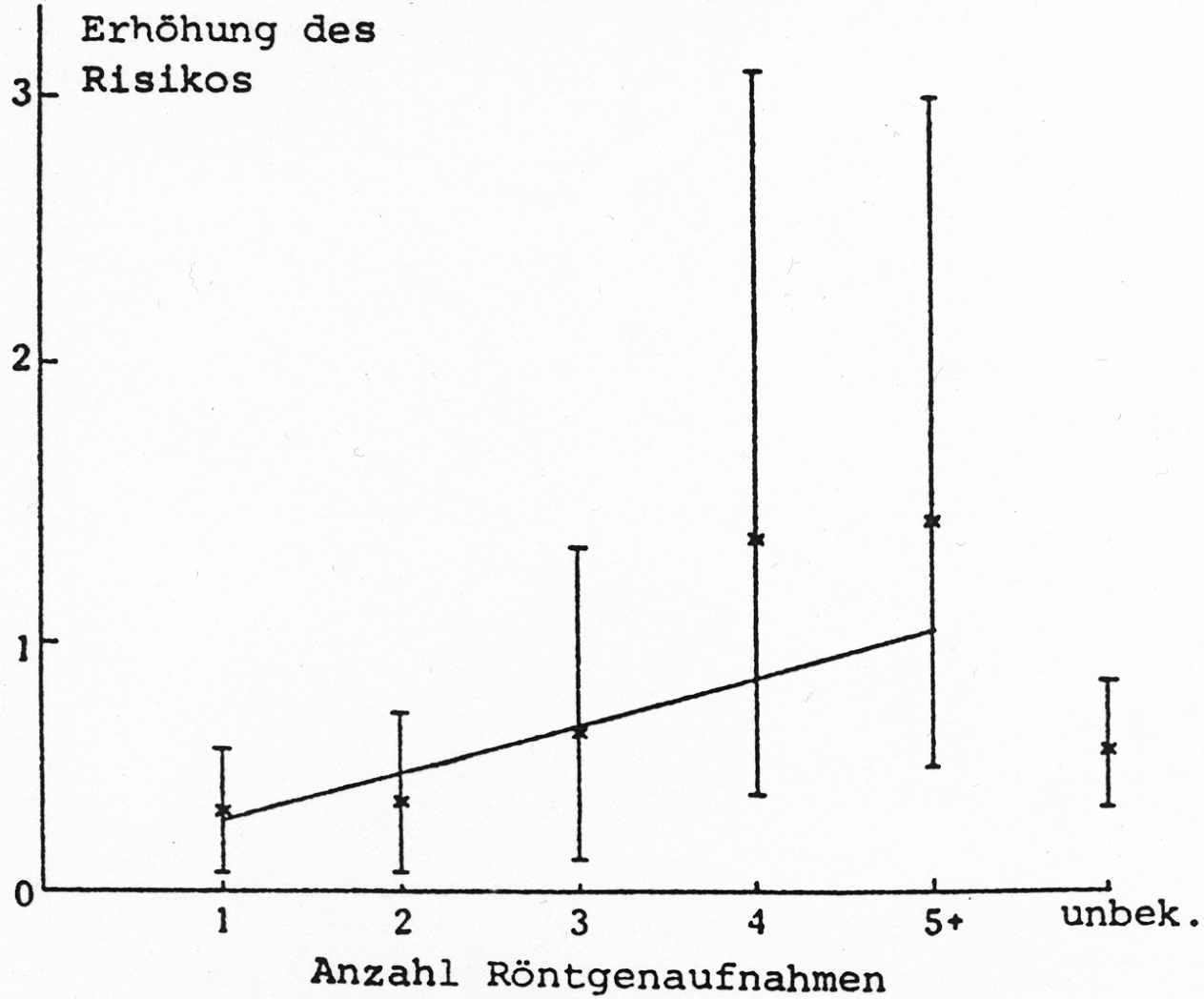


10-Jahres-Risiko für eine tödliche Herz-Kreislauf-Erkrankung

- **nach Geschlecht,**
- **Alter,**
- **systolischem Blutdruck,**
- **<u>Gesamtcholesterin/HDL-Cholesterin Verhältnis</u>,**
- **Raucherstatus**



Krebs im Kindesalter (<15 J.) nach vorgeburtlicher Bestrahlung



Quelle: *Bithell, J. F., A. M. Stewart*, Pre-natal irradiation and childhood malignancy, in: British Journal of Cancer 31, 1975, S. 271 ff.

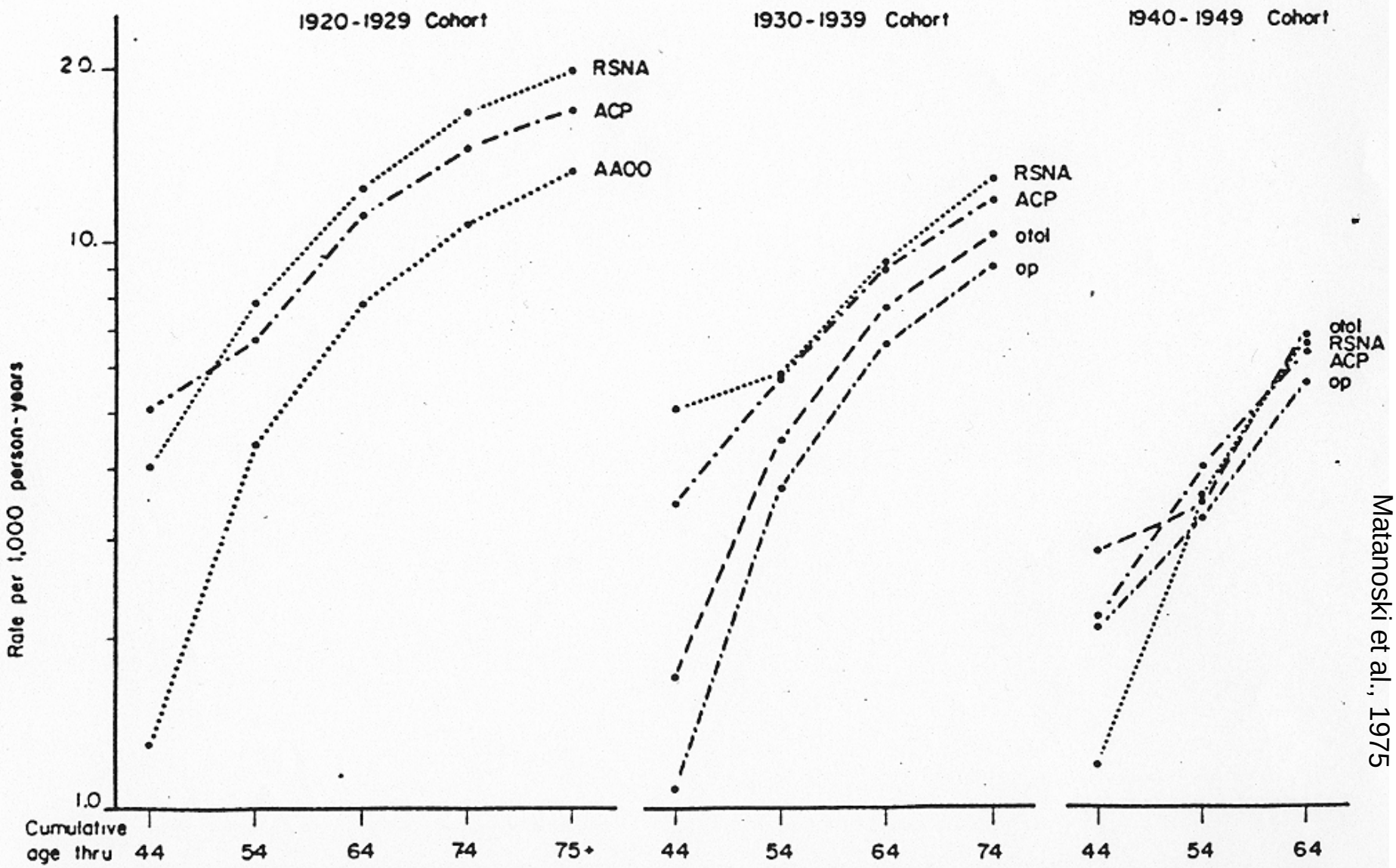


FIGURE 1. Age- and time-adjusted death rates for all-cause mortality by society and by cohort. Limited by age. RSNA, Radiological Society of North America; ACP, American College of Physicians, AAOO, American Academy of Ophthalmology and Otolaryngology; op, ophthalmologists; otol, otolaryngologists.

Matanoski et al., 1975

Epidemiologie: ”Klassische” Kollektive

Arbeiter in der Atomindustrie (I)

Studie: Arbeiter am Oak Ridge National Laboratory
(Wing et al. JAMA 1991)

N = 8318 (Einstellungen 1943-1972)

Mittlere Dosis (externe γ-Dosis):1,4 mSv

Ergebnisse:

- Anstieg erst nach 20 Jahren Exposition
- RF (alle Krebsarten, Mortalität, 20 yr lag):
  $\approx$ 385 / 1.000.000 * mSv (nur Leukämie, 10 yr: 37,2)
- RF 10fach größer als Life Span Study (LSS)

BMJ, Volume 331, 9 July 2005, 77-80

Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries

E Cardis, M Vrijheid, M Blettner, E Gilbert, M Hakama, C Hill, G Howe, J Kaldor, C R Muirhead, M Schubauer-Berigan, T Yoshimura, F Bermann, G Cowper, J Fix, C Hacker, B Heinmiller, M Marshall, I Thierry-Chef, D Utterback, Y-O Ahn, E Amoros, P Ashmore, A Auvinen, J-M Bae, J Bernar Solano, A Biau, E Combalot, P Deboodt, A Diez Sacristan, M Eklof, H Engels, G Engholm, G Gulis, R Habib, K Holan, H Hyvonen, A Kerekes, J Kurtinaitis, H Malker, M Martuzzi, A Mastauskas, A Monnet, M Moser, M S Pearce, D B Richardson, F Rodriguez-Artalejo, A Rogel, H Tardy, M Telle-Lamberton, I Turai, M Usel, K Veress

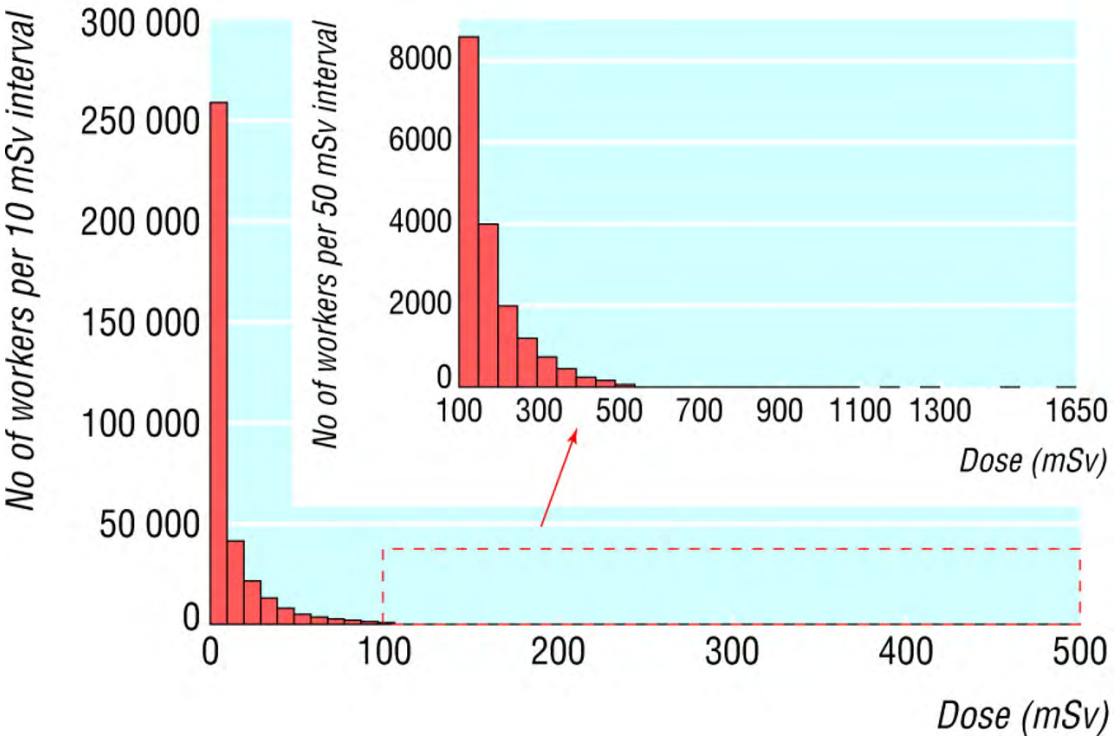


Fig 1 Distribution of cumulative radiation doses among workers included in the analyses

(N= 407,591; 5.2 mio. person years)

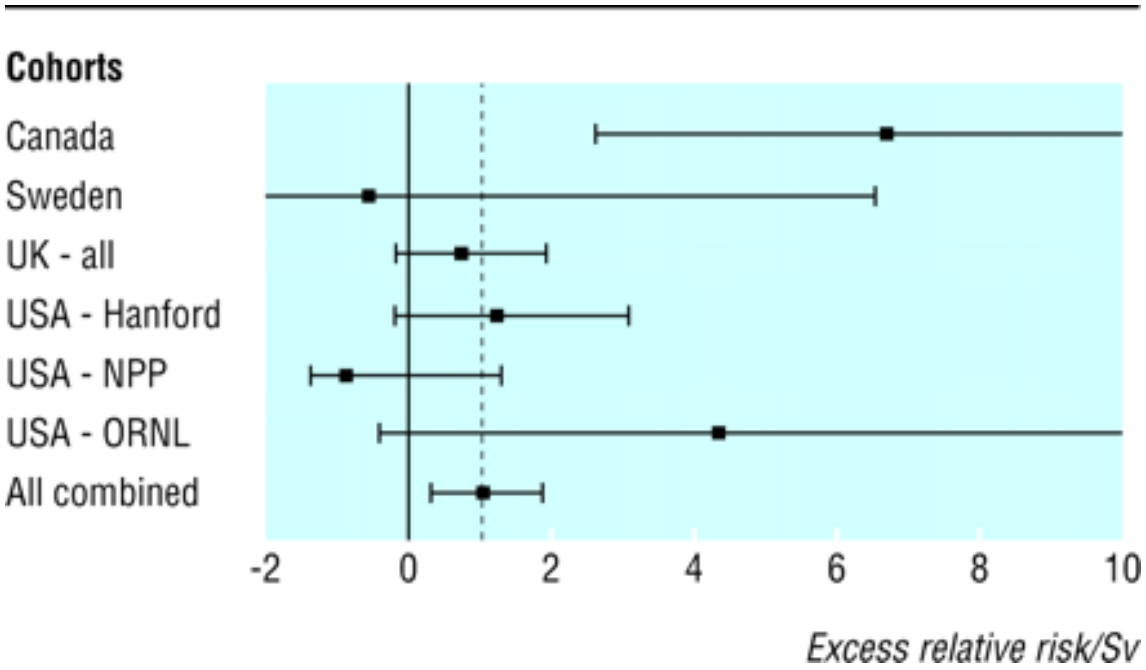


Fig 2 Excess relative risks per Sv for all cancer excluding leukaemia in cohorts with more than 100 deaths (NPP=nuclear power plants, ORNL=Oak Ridge National Laboratory)

BMJ, Vol. 331, 9 July 2005, 77-80

Table 2 Estimates of excess relative risk per Sv (95% confidence interval) for all cancers excluding leukaemia, solid cancers, and leukaemia excluding chronic lymphocytic leukaemia, for nuclear workers and survivors of A bomb in Japan*

	15 country study		Atomic bomb survivors (men exposed at age 20-60)	
	No of cancers	Risk	No of cancers	Risk†
All cancers excluding leukaemia	5024	0.97 (0.14 to 1.97)		
Solid cancers	4770	0.87 (0.03 to 1.88)	3246	0.32‡ (0.01 to 0.50)
Leukaemia excluding CLL:				
Linear model	196	1.93 (<0§ to 8.47)	83	3.15¶ (1.58 to 5.67)
Linear quadratic model				1.54** (–1.14 to 5.33)

CLL=chronic lymphocytic leukaemia.
*Colon dose used for all cancers and solid cancer analyses, bone marrow dose for leukaemia.
†Note that because analyses were restricted to men aged 20-60 at exposure the confidence intervals are much wider than those presented by other investigators,[13 14] based on the full cohort.
‡Analyses carried out at IARC with excess relative risk model that allows for age at exposure modification, adjusted for attained age, calendar period, and city. Estimate for men exposed at age 35.
§Estimate on boundary of parameter space.
¶Analyses carried out at IARC with constant excess relative risk model, adjusted for attained age, calendar period, and city.
**Analyses carried out at IARC—linear term of linear quadratic model—preferred model for describing leukaemia mortality in analyses of data on A bomb survivors.[14]

What is already known on this topic

Current radiation protection standards are based mainly on data from the survivors of the atomic bomb in Japan

The estimation of risks after low dose protracted or fractionated exposures to ionising radiation is controversial

What this study adds

A small excess risk of cancer exists, even at the low doses typically received by nuclear industry workers in this study

Abstract:
1-2% aller Krebstodesfälle in der Kohorte durch berufliche Strahlenbelastung bedingt *(bis zu ca. 1000-2000)*

BMJ, Vol. 331, 9 July 2005, 77-80

BRIEF COMMUNICATION

Breast Cancer Mortality Among Female Radiologic Technologists in the United States

Aparna K. Mohan, Michael Hauptmann, Martha S. Linet, Elaine Ron, Jay H. Lubin, D. Michal Freedman, Bruce H. Alexander, John D. Boice Jr., Michele Morin Doody, Genevieve M. Matanoski

JNCI 94.12(2002), 943-948

We evaluated breast cancer mortality through 1997 among 69 525 female radiologic technologists who were certified in the United States from 1926 through 1982 and who responded to our questionnaire. Risk of breast cancer mortality was examined according to work history and practices and was adjusted for known risk factors. Breast cancer mortality risk was highest among women who were first employed as radiologic technologists prior to 1940 (relative risk [RR] = 2.92, 95% confidence interval [CI] = 1.22 to 7.00) compared with risk of those first employed in 1960 or later and declined with more recent calendar year of first employment (*P* for trend = .002). Breast cancer mortality risk increased with increasing number of years of employment as a technologist prior to 1950 (*P* for trend = .018). However, risk was not associated with the total number of years a woman worked as a technologist. Technologists who first performed fluoroscopy (RR = 1.69, 95% CI = 1.02 to 3.11) and multifilm procedures (RR = 1.87, 95% CI = 1.04 to 3.34) before 1950 had statistically significantly elevated risks compared with technologists who first performed these procedures in 1960 or later. The

Mammakarzinome bei MTA (USA)

Kohorte, N=69.525

RR 2,9 (1,2-7,0) für Tätigkeit < vs. ≥1960

RR 1,7 (1,0-3,1) für Durchleuchtg. <1950

Kein Trend mit Anzahl Dienstjahre insgesamt

pos. Trend mit Anzahl Dienstjahre <1950

neg. Trend mit Jahr des Dienstantritts

ORIGINAL ARTICLE

Breast cancer risk in airline cabin attendants: a nested case-control study in Iceland

V Rafnsson, P Sulem, H Tulinius, J Hrafnkelsson

Occup Environ Med 2003;**60**:807–809

See end of article for authors' affiliations

Correspondence to: Dr V Rafnsson, Department of Preventive Medicine, Soltun 1, 105 Reykjavik

Aims: To investigate whether length of employment as a cabin attendant was related to breast cancer risk, when adjusted for reproductive factors.

Methods: Age matched case-control study nested in a cohort of cabin attendants. The cases were found from a nationwide cancer registry (followed up to end of year 2000) and the reproductive factors (age at first childbirth and number of children) from a registry of childbirth, in both instances by record linkage with the cabin attendants' identification numbers. The employment time of the cabin attendants at the airline companies and the reproductive factors had been systematically recorded prior to the diagnosis of breast cancer in the cohort. A total of 35 breast cancer cases and 140 age matched controls selected from a cohort of 1532 female cabin attendants were included in the study.

Results: The matched odds ratio from conditional logistic regression of breast cancer risk among cases and controls of cabin attendants was 5.24 (95% CI 1.58 to 17.38) for those who had five or more years of employment before 1971 compared with those with less than five years of employment before 1971, adjusted for age at first childbirth and length of employment from 1971 or later.

Conclusions: The association between length of employment and risk of breast cancer, adjusted for reproductive factors, indicates that occupational factors may be an important cause of breast cancer among cabin attendants; the association is compatible with a long induction period.

Breast Cancer Mortality After Diagnostic Radiography

Findings From the U.S. Scoliosis Cohort Study

Michele Morin Doody, MS,* John E. Lonstein, MD,† Marilyn Stovall, PhD,‡
David G. Hacker, BS,§ Nickolas Luckyanov, PhD,* Charles E. Land, PhD,* for
the U.S. Scoliosis Cohort Study Collaborators

SPINE 25.16(2000), 2052-2063

Study Design. A retrospective cohort study was conducted in 5573 female patients with scoliosis who were referred for treatment at 14 orthopedic medical centers in the United States. Patients were less than 20 years of age at diagnosis which occurred between 1912 and 1965.

Objectives. To evaluate patterns in breast cancer mortality among women with scoliosis, with special emphasis on risk associated with diagnostic radiograph exposures.

Summary of Background Data. A pilot study of 1030 women with scoliosis revealed a nearly twofold statistically significant increased risk for incident breast cancer. Although based on only 11 cases, findings were consistent with radiation as a causative factor.

Methods. Medical records were reviewed for information on personal characteristics and scoliosis history. Diagnostic radiograph exposures were tabulated based on review of radiographs, radiology reports in the medical records, radiograph jackets, and radiology log books. Radiation doses were estimated for individual examinations. The mortality rate of the cohort through January 1, 1997, was determined by using state and national vital statistics records and was compared with that of women in the general U. S. population.

Results. Nearly 138,000 radiographic examinations were recorded. The average number of examinations per patient was 24.7 (range, 0–618); mean estimated cumulative radiation dose to the breast was 10.8 cGy (range, 0–170). After excluding patients with missing information, 5466 patients were included in breast cancer mortality analyses. Their mean age at diagnosis was 10.6 years and average length of follow-up was 40.1 years. There were 77 breast cancer deaths observed compared with the 45.6 deaths expected on the basis of U.S. mortality rates (standardized mortality ratio [SMR] = 1.69; 95% confidence interval [CI] = 1.3–2.1). Risk increased significantly with increasing number of radiograph exposures and with cumulative radiation dose. The unadjusted excess relative risk per Gy was 5.4 (95% CI = 1.2–14.1); when analyses were restricted to patients who had undergone at least one radiographic examination, the risk estimate was 2.7 (95% CI = −0.2–9.3).

Conclusions. These data suggest that exposure to multiple diagnostic radiographic examinations during childhood and adolescence may increase the risk of breast cancer among women with scoliosis; however, potential confounding between radiation dose and severity of disease and thus with reproductive history may explain some of the increased risk observed. [Key words: breast neoplasms, radiation-induced, cohort study, epidemiology, mortality, radiation, radiography, scoliosis]
Spine 2000;25:2052–2063

Studies of the atomic bomb survivors,[28] patients with tuberculosis who underwent multiple fluoroscopic examinations during treatment,[3,14,23] and patients who underwent therapeutic irradiation for a variety of conditions, including benign breast disease,[22] acute postpartum mastitis,[32] enlarged thymus,[12] Hodgkin's disease,[2] and skin hemangiomas,[21] have established that exposure to ionizing radiation increases the risk of breast cancer. Age at exposure has been found to modify response to radiation, with childhood exposures conferring the highest risk and exposure after age 40 imparting low or minimal risk.[4,18] It has been hypothesized that the period between Tanner stage breast-2[33] and the onset of menarche may be a particularly sensitive biologic stage with respect to the action of radiation and other environmental carcinogens.[15] No such pattern has been apparent among atomic bomb survivors and other populations exposed during childhood and adolescence,[17,34,35] but published analyses have not focused on the narrow range

5466 Patienten, MW 24,7 Rö-US (0-618) (N=138.000)

mittl. Follow-up 40 J.

77 Fälle (erw. 45,6), SMR 1,69 (1,3-2,1)

Organdosis Mamma durch diagn. Rö-US: Mittelw. 108 mSv (0-170 mSv)

sign. Trend mit Anzahl der Rö-US

sign. Trend mit kum. Dosis

Effect of low doses of ionising radiation in infancy on cognitive function in adulthood: Swedish population based cohort study

Per Hall, Hans-Olov Adami, Dimitrios Trichopoulos, Nancy L Pedersen, Pagona Lagiou, Anders Ekbom, Martin Ingvar, Marie Lundell, Fredrik Granath

BMJ 328(2004), 19-24, bmj.com

Abstract

Objective To determine whether exposure to low doses of ionising radiation in infancy affects cognitive function in adulthood.
Design Population based cohort study.
Setting Sweden.
Participants 3094 men who had received radiation for cutaneous haemangioma before age 18 months during 1930-59.
Main outcome measures Radiation dose to frontal and posterior parts of the brain, and association between dose and intellectual capacity at age 18 or 19 years based on cognitive tests (learning ability, logical reasoning, spatial recognition) and high school attendance.
Results The proportion of boys who attended high school decreased with increasing doses of radiation to both the frontal and the posterior parts of the brain from about 32% among those not exposed to around 17% in those who received >250 mGy. For the frontal dose, the multivariate odds ratio was 0.47 (95% confidence interval 0.26 to 0.85, P for trend 0.0003) and for the posterior dose it was 0.59 (0.23 to 1.47, 0.0005). A negative dose-response relation was also evident for the three cognitive tests for learning ability and logical reasoning but not for the test of spatial recognition.
Conclusions Low doses of ionising radiation to the brain in infancy influence cognitive abilities in adulthood.

3094 Männer nach Strahlentherapie wg. Hämangiom vor dem 18. LM

Umfangreiche Dosisermittlung (mittl. Organdosis Gehirn < 100, Max.>250 mGy)

High school attendance, military cognitive tests (learning ability, logical reasoning)

Risiken konsistent erhöht (vergl. Tinea capitis)

kein wesentlicher Einfluss von Confoundern

Stat. sign. Trends

Höhere Risiken bei Dosismaximum im Frontalhirn

Mittl. Organdosis kann für Kleinkinder im diagnostischen CT erreicht werden

What is already known on this topic

High doses of ionising radiation to the developing human brain cause mental retardation

It is unknown whether low level exposure in infancy has more subtle effects on cognitive function

What this study adds

Intellectual development is adversely affected when the infant brain is exposed to ionising radiation at doses equivalent to those from computed tomography of the skull

Diagnostic evaluation of children with minor head injures needs to be re-evaluated

BMJ 328(2004), 19-24, bmj.com

Occupational Exposure to Ionizing Radiation Is Associated with Autoimmune Thyroid Disease

Henry Völzke, André Werner, Henri Wallaschofski, Nele Friedrich, Daniel M. Robinson, Stefan Kindler, Matthias Kraft, Ulrich John, and Wolfgang Hoffmann

Institute of Epidemiology and Social Medicine (H.V., A.W., N.F., S.K., U.J.), Medical Department (H.W., D.M.R., M.K.), and Institute for Community Medicine (W.H.), Ernst Moritz Arndt University, D-17487 Greifswald, Germany

The Journal of Clinical Endocrinology & Metabolism 90(8):4587–4592
Copyright © 2005 by The Endocrine Society
doi: 10.1210/jc.2005-0286

Context: The thyroid gland is a potential target organ for radiation-related damage.

Objective: The aim of the analysis was to investigate the association between occupational exposure to ionizing radiation and autoimmune thyroid disease (AITD).

Design: Our design was the cross-sectional Study of Health in Pomerania.

Setting: The setting was the general community.

Subjects: Analyses were performed in a population-based sample of 4299 subjects. Among them, 160 persons reported a history of occupational exposure to ionizing radiation.

Main Outcome Measure: AITD was defined as the combined presence of hypoechogenicity in thyroid ultrasound and antithyroxiperoxidase antibodies greater than 200 IU/ml.

Results: Females with occupational exposure to ionizing radiation had more often AITD than nonexposed females (10.0 *vs.* 3.4%; $P < 0.05$). This association persisted after adjustment for relevant confounders (odds ratio, 3.46; 95% confidence interval, 1.16–10.31; $P < 0.05$). In males, there were too few subjects who fulfilled the criteria of AITD, but the association between the exposure to radiation and hypoechogenicity of the thyroid gland barely missed statistical significance (odds ratio, 2.20; 95% confidence interval, 0.92–5.26; $P = 0.08$). In both females and males, subjects who reported a length of exposure of more than 5 yr exhibited the highest risk of the endpoints.

Conclusions: We conclude that occupational exposure to ionizing radiation is related to the risk of AITD. The usage of thyroid protection shields by radiation workers is strongly recommended. (***J Clin Endocrinol Metab* 90: 4587–4592, 2005**)

Radiation Dose-Response Relationships for Thyroid Nodules and Autoimmune Thyroid Diseases in Hiroshima and Nagasaki Atomic Bomb Survivors 55-58 Years After Radiation Exposure

Keizo Sugino, MD
Gen Suzuki, MD
Renju Maeda, MD
Shigenobu Nagataki, MD
Katsumi Eguchi, MD

Results Thyroid diseases were identified in 1833 (44.8%) of the total participants (436 men [32.2% of men] and 1397 women [51.0% of women]) ($P<.001$). In 3185 participants, excluding persons exposed in utero, not in the city at the time of the atomic bombings, or with unknown radiation dose, the prevalence of all solid nodules, malignant tumors, benign nodules, and cysts was 14.6%, 2.2%, 4.9%, and 7.7%, respectively. The prevalence of positive thyroid antibodies, antithyroid antibody–positive hypothyroidism, and Graves disease was 28.2%, 3.2%, and 1.2%, respectively. A significant linear dose-response relationship was observed for the prevalence of all solid nodules, malignant tumors, benign nodules, and cysts ($P<.001$). We estimate that about 28% of all solid nodules, 37% of malignant tumors, 31% of benign nodules, and 25% of cysts are associated with radiation exposure at a mean and median thyroid radiation dose of 0.449 Sv and 0.087 Sv, respectively. No significant dose-response relationship was observed for positive antithyroid antibodies ($P=.20$), antithyroid antibody–positive hypothyroidism ($P=.92$), or Graves disease ($P=.10$).

Conclusions A significant linear radiation dose response for thyroid nodules, including malignant tumors and benign nodules, exists in atomic bomb survivors. However, there is no significant dose response for autoimmune thyroid diseases.

JAMA. 2006;295:1011-1022 www.jama.com

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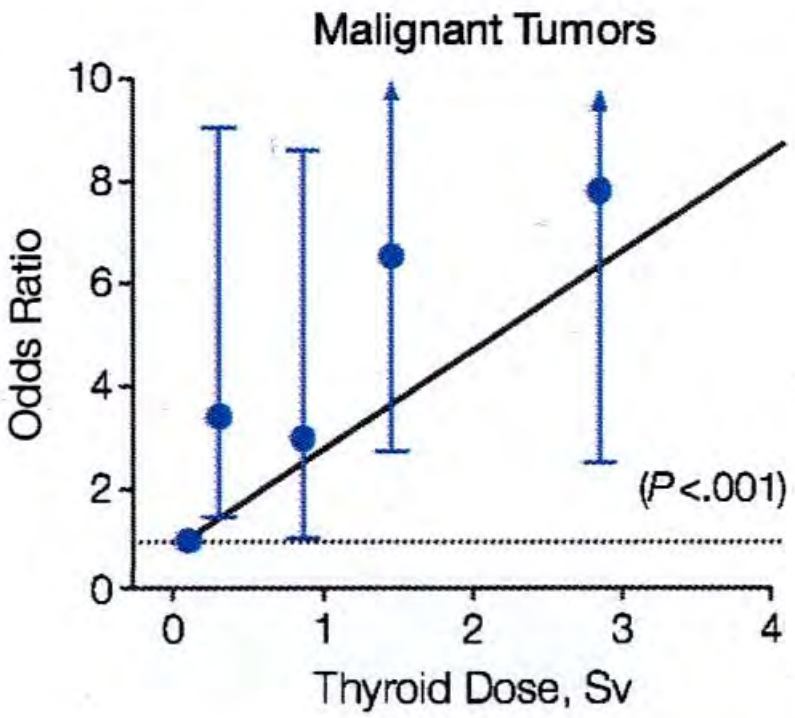
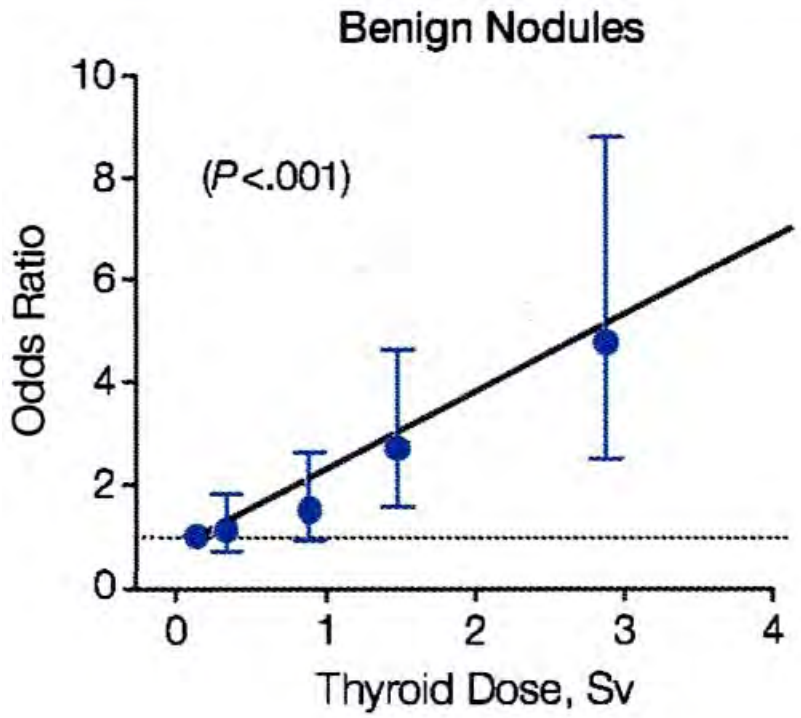
Dose Response for Thyroid Diseases

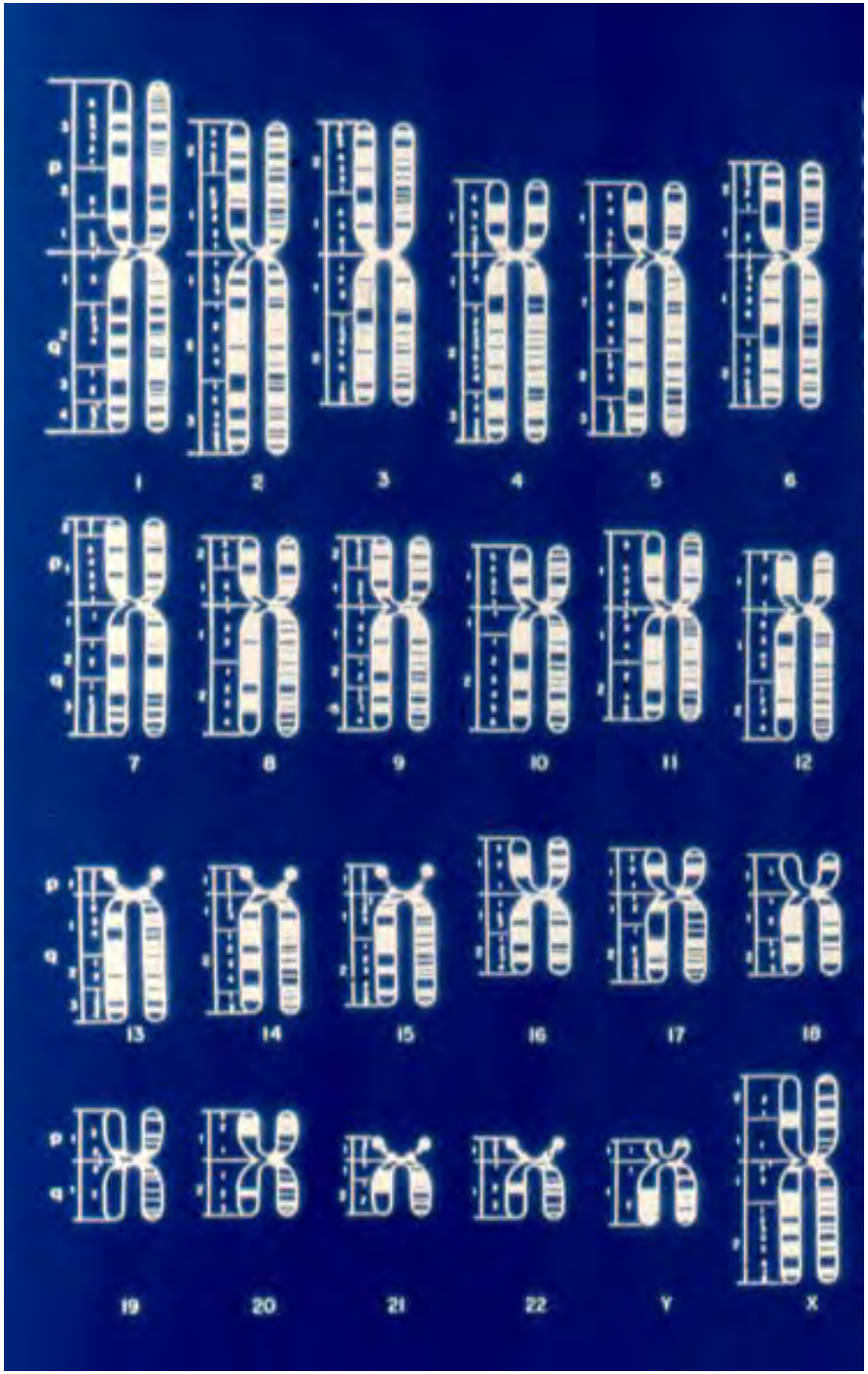


JAMA. 2006;295:1011-1022

Dose Response for Thyroid Diseases



JAMA. 2006;295:1011-1022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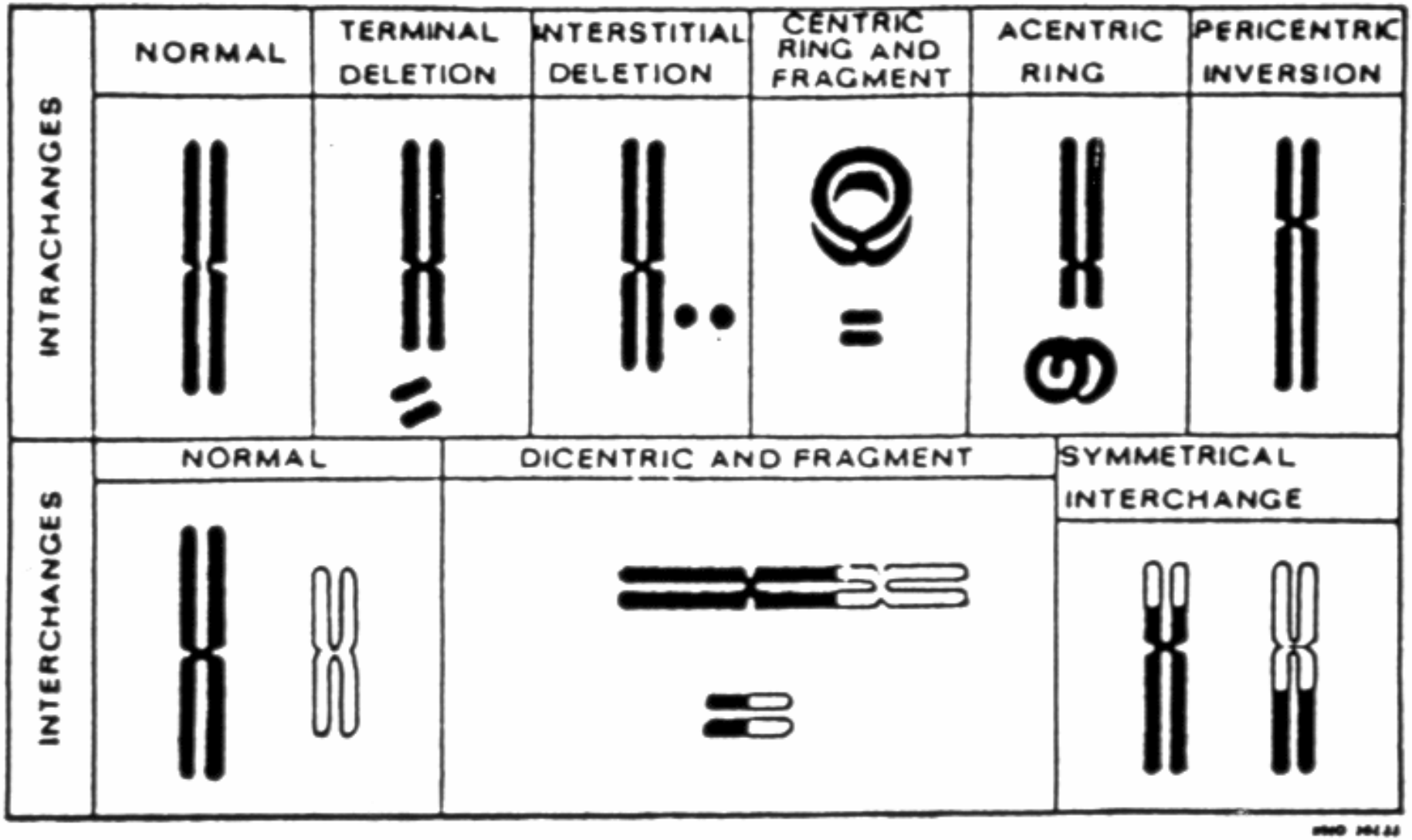
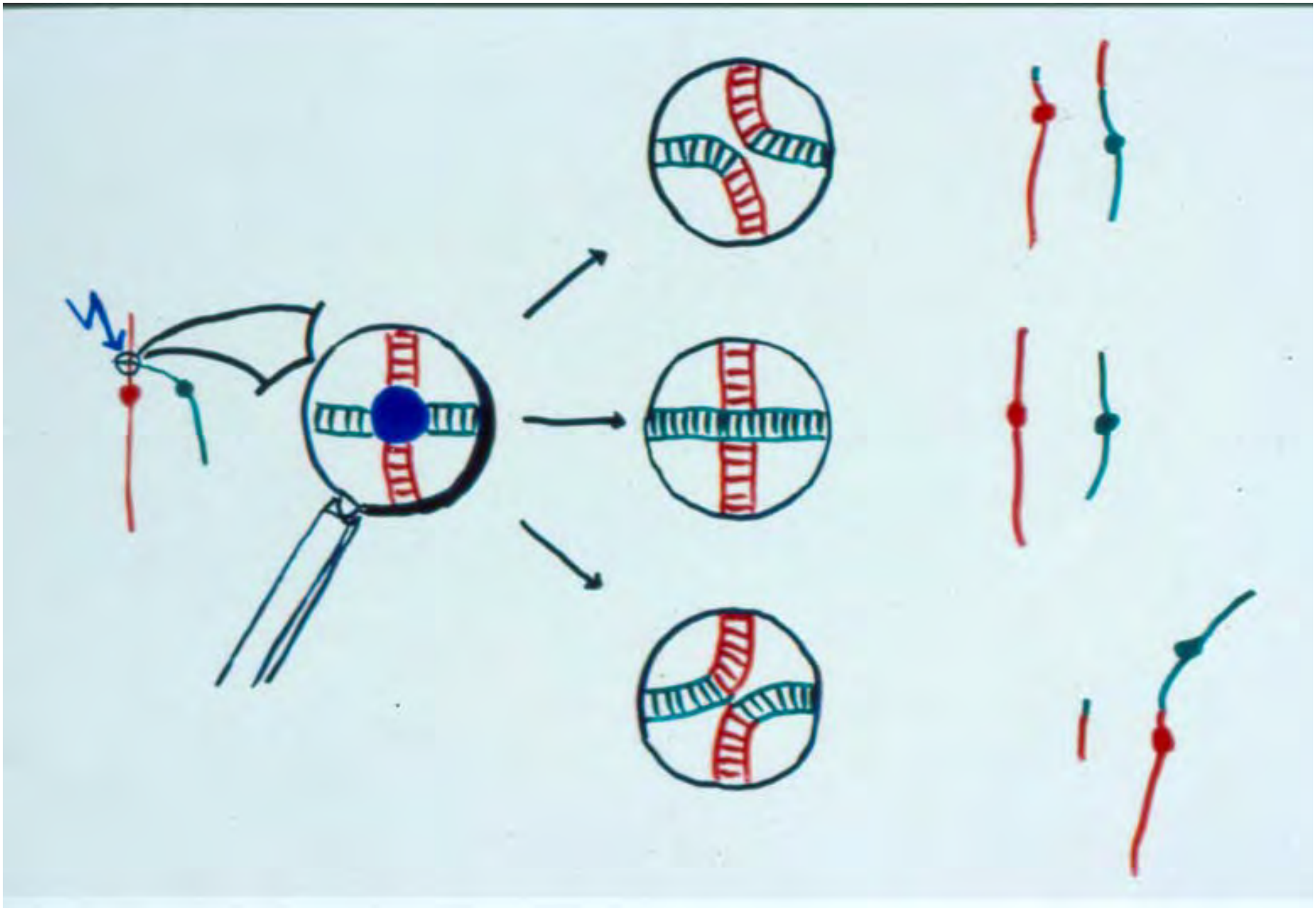
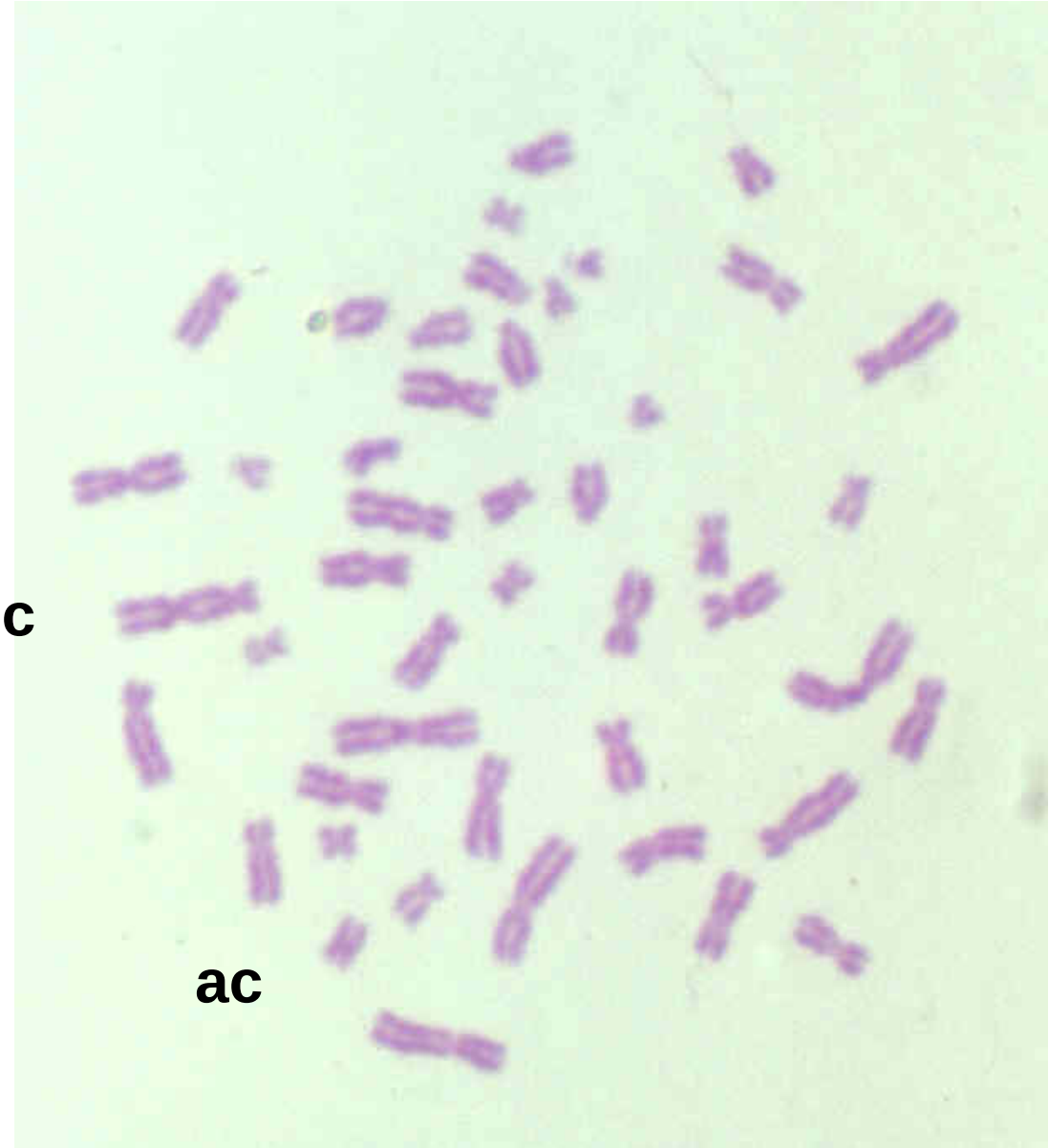


Chromosome-type aberrations distinguishable cytologically at mitosis

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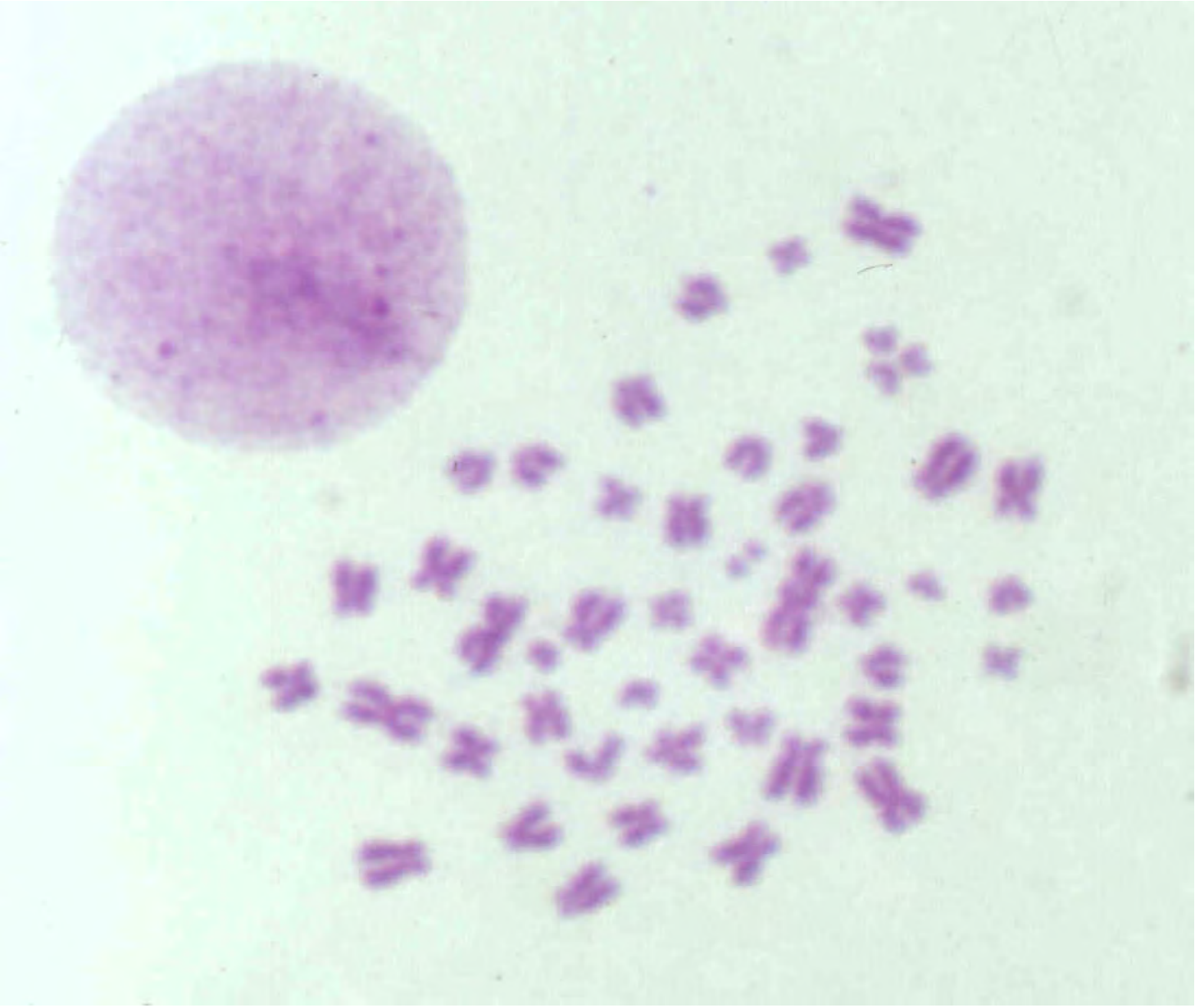
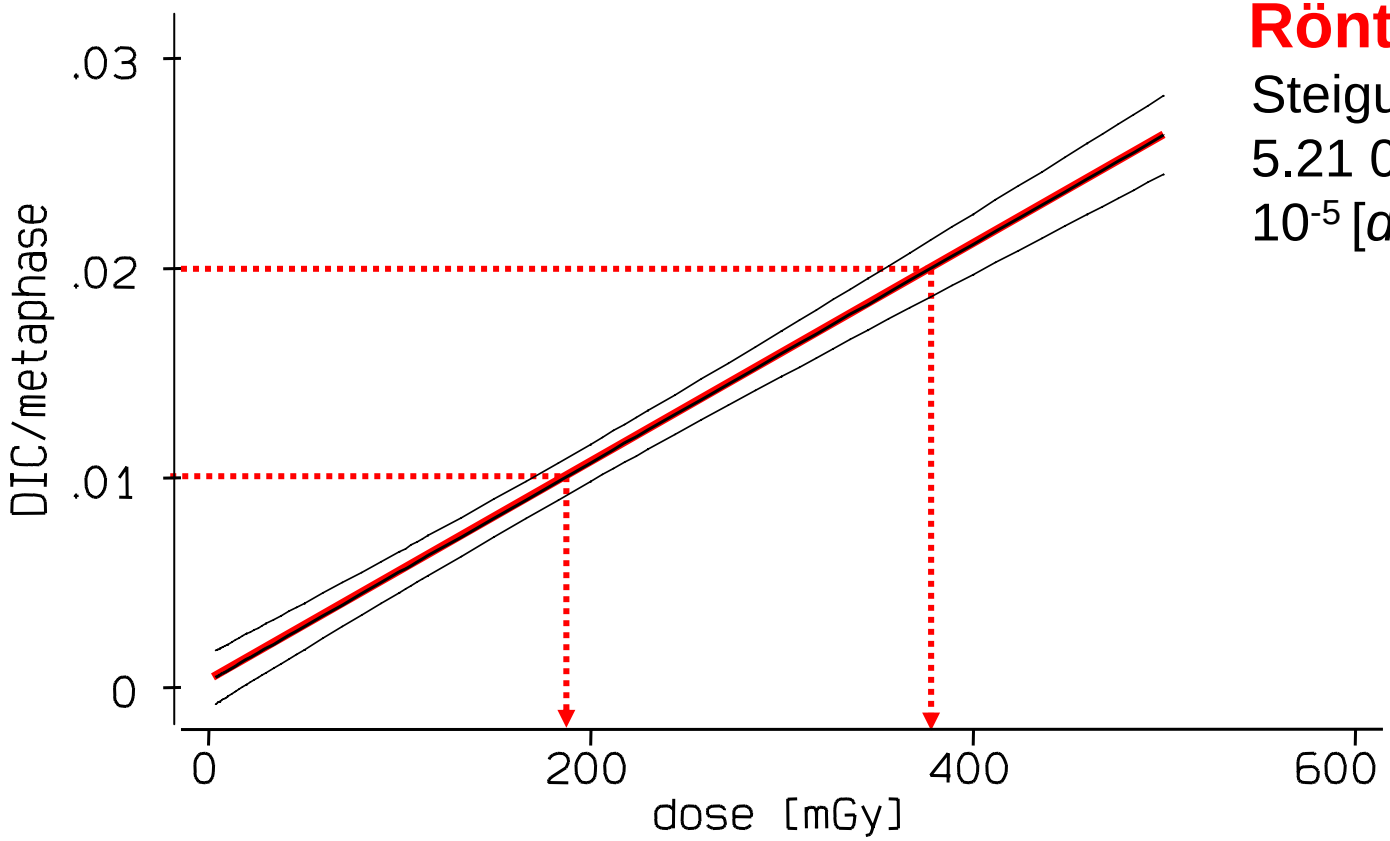


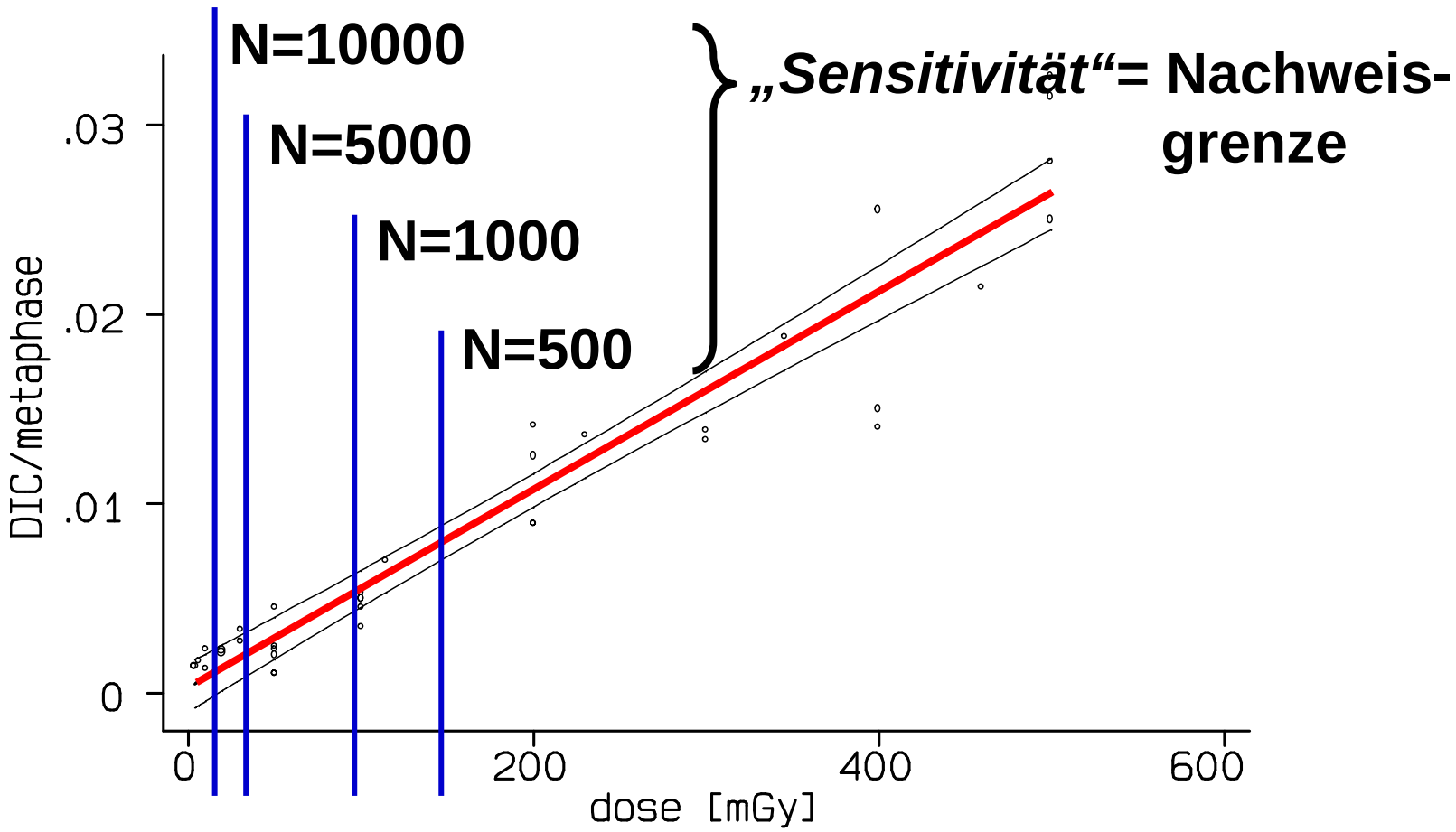
Dosis-Wirkungsbeziehung für *dic* in humanen periph. Lymphozyten (0-500 mGy)
200 kV- Röntgenstrahlung



Röntgen

Steigung = 5.21 0.255 x 10^{-5} [*dic*/mGy^{-1}]

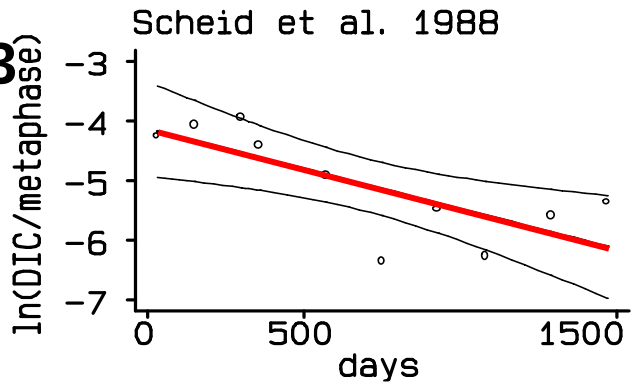
Dosis-Wirkungsbeziehung für *dic* in humanen periph. Lymphozyten (0-500 mGy)
200 kV- Röntgenstrahlung

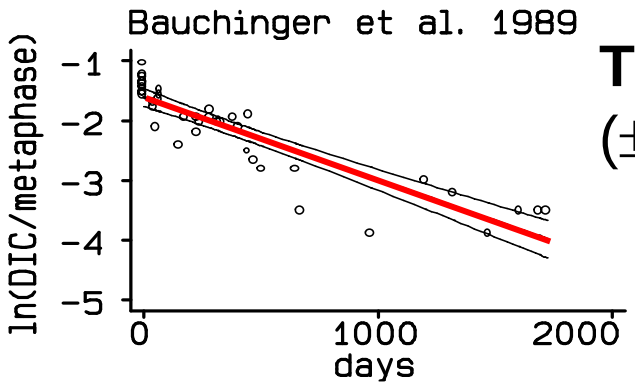


(Steigung α =5.21±0.255 x 10^{-5} [*dic*/mGy^{-1}]; R^2= 0.92, 95 % Konfidenzbereiche für die bedingten MW)

Zeitlicher Abfall von *dic* in menschlichen Lymphozyten

$T_{1/2}$= 573 (±179) **d**





$T_{1/2}$ = 507 (±41) **d**

Int. J. Radiat. Biol., Vol. 83, No. 5, May 2007, pp. 281–287

Enhanced yield of chromosome aberrations after CT examinations in paediatric patients

G. STEPHAN[1], K. SCHNEIDER[2], W. PANZER[3], L. WALSH[3], & U. OESTREICHER[1]

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(Received 5 September 2006; revised 30 January 2007; accepted 8 February 2007)

Abstract

Purpose: To determine whether computed tomography (CT) could enhance the chromosome aberration yields in paediatric patients.

Material and methods: Blood samples were taken before and after CT scans from 10 children for whom the medical justifications for CT examinations were accidental injuries and not diseases as investigated in earlier studies. Chromosome analysis was carried out in lymphocytes by fluorescence plus Giemsa (FPG) staining exclusively in metaphases of the first cell cycle *in vitro*.

Results: The mean blood dose of the 10 children was about 12.9 mGy which was determined by a newly developed dose estimation. Based on more than 20,000 analyzed cells it was found that after CT examination the frequencies of dicentrics (dic) and excess acentric fragments (ace) in lymphocytes were significantly increased. By subdividing the children into two age groups, those with an age from 0.4 years to 9 years and from 10–15 years, it became obvious that the observed increase in chromosome aberrations was mainly contributed by the younger age group. In this group the frequency of dicentrics was significantly increased whereas in the older group the observed increase was not significant.

Conclusion: Our results demonstrate that CT examinations enhance the dicentrics yields in peripheral lymphocytes of children aged up to 15 years. Since in particular significantly increased dicentric yields could be observed in children with an age from 0.4–9 years, it can be assumed that children younger than 10 years may be more radiation sensitive than older subjects.

Table IV. Frequencies of chromosomal aberrations in children who underwent computed tomography (CT).

Patient	D(blood,c) (mGy)		Before CT			After CT		
			Cells	Dic	Ace	Cells	Dic	Ace
1	2.8		49	0	0	398	1	2
2	28.3		1520	0	4	1527	1	4
3	1.2		1634	1	2	1330	1	4
4	31.3		934	0	1	899	2	1
5	16.7		1079	0	2	1543	4	7
6	5.1		1011	0	1	1052	1	3
7	13.3		1010	0	0	1024	0	1
8	6.6		1059	1	0	1034	0	0
9	12.3		1012	2	3	1010	3	6
10	11.4		1004	0	4	741	1	1
	mean 12.9	Σ	10313	4	17	10558	14	29

Dic, dicentrics; Ace, excess acentrics.

Quelle: Stephan,G. et al.,Enhanced yield of chromosome aberrations after CT examinations in paediatric patients, Int. J. Radiat. Biol., Vol. 83, No. 5, May 2007, p. 285

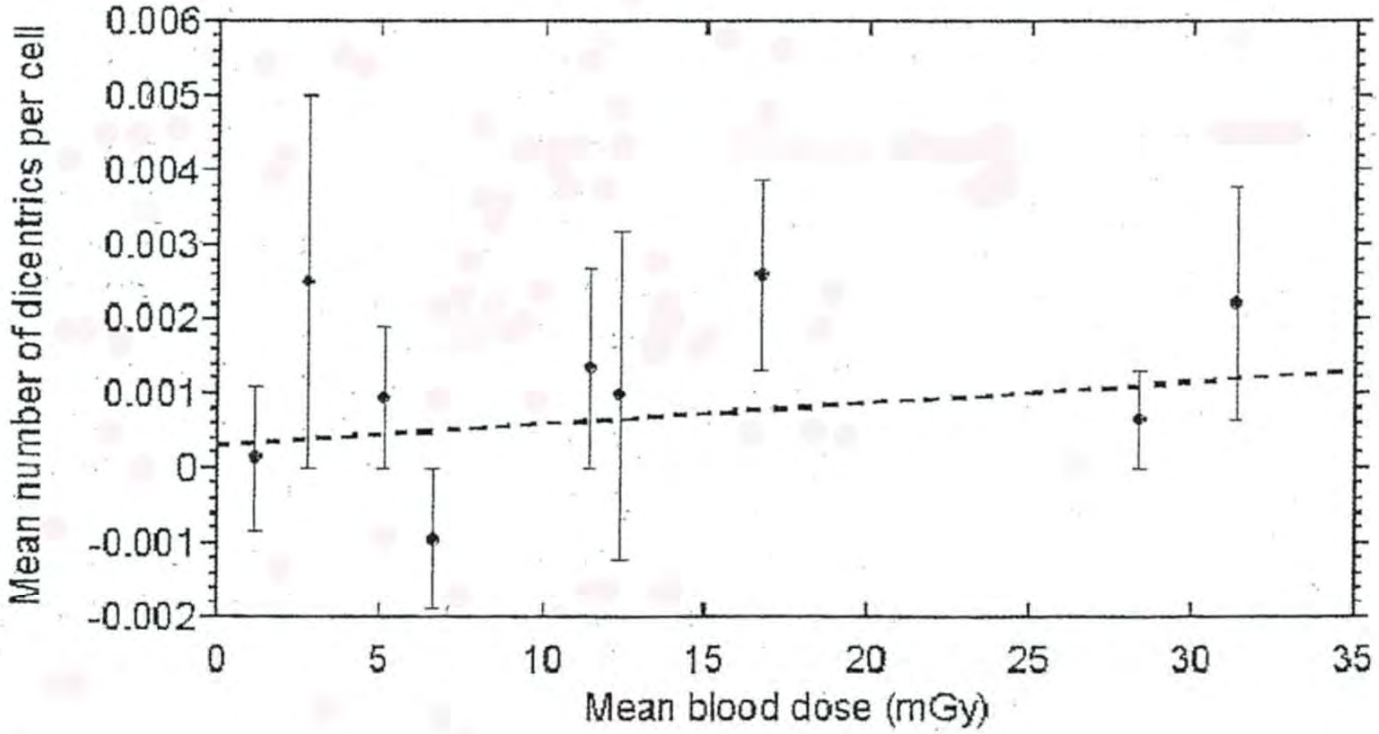


Figure 1. The difference in the mean number of dicentrics per cell as a function of mean blood dose with one standard error bars. For each child, the mean number of dicentrics per cell before CT scan has been subtracted from the mean number after CT scan.

Quelle: Stephan,G. et al.,Enhanced yield of chromosome aberrations after CT examinations in paediatric patients, Int. J. Radiat. Biol., Vol. 83, No. 5, May 2007, p. 285

Leukocyte DNA Damage after Multi–Detector Row CT:

A Quantitative Biomarker of Low-Level Radiation Exposure[1]

Kai Rothkamm, Dipl Phys, Dr rer nat
Sheena Balroop, MSc
Jane Shekhdar, MSc
Patricia Fernie, DCR(R)
Vicky Goh, MRCP, FRCR

Radiology

Purpose: To prospectively determine if γ*H2AX* (phosphorylated form of H2AX histone variant)-based visualization and quantification of DNA damage induced in peripheral blood mononuclear cells (PBMCs) can be used to estimate the radiation dose received by adult patients who undergo multidetector computed tomography (CT).

Results: Compared with the γ*H2AX* focus yields in blood samples taken before CT (0.06 focus per cell ± 0.01 [mean ± standard error of mean]), the yields in blood samples taken 5 minutes after chest-abdominal-pelvic CT (0.52 focus per cell ± 0.02) were 8–10-fold higher and corresponded to a mean radiation dose of 16.4 mGy (95% confidence interval: 15.1, 17.7). The mean yield of 0.24 focus per cell ± 0.04 in one patient after chest CT corresponded to a mean radiation dose of 6.3 mGy ± 1.4. In comparison, phantom dosimetry–calculated total blood doses were 13.85 mGy with whole-body CT and 5.16 mGy with chest CT.

Radiology: Volume 242: Number 1—January 2007

Quantitative Nutzen– und Risikoabschätzung

Bp. Screening-Mammographie

Heilung durch Früherkennung

Brustkrebs-Früherkennung durch Mammographie

Was ist Mammographie?

Mammographie ist eine Röntgenuntersuchung der Brust. Dabei wird das gesamte Drüsengewebe mit Hilfe einer geringen Strahlendosis auf einem Röntgenbild dargestellt.
Folglich ist die regelmäßige Mammographie als Vorsorgeuntersuchung ungefährlich.

Weshalb Mammographie?

Brustkrebs ist nach wie vor die häufigste bösartige Erkrankung der Frau.
Das Erkrankungsrisiko steigt mit zunehmendem Alter. Ein erhöhtes Risiko besteht bei Frauen, deren Mutter oder Schwester an Brustkrebs erkrankt sind.

Nur durch die Mammographie können nicht tastbare Veränderungen der Brust in einem Frühstadium erkannt werden.
Damit wird nicht nur eine Heilung, sondern auch die Erhaltung der Brust möglich.

Daher: Früherkennung durch Vorsorge!

Erste Mammographie im Alter von 35 Jahren.
Bei erhöhtem Risiko (siehe oben) mit 30 Jahren.

Häufigkeit der Folgeuntersuchungen in Abhängigkeit vom Ausgangsbefund.

Jährliche Untersuchung ab dem 50. Lebensjahr.

Ihrer Gesundheit gelten unsere Bemühungen!

Wenden Sie sich an den Arzt Ihres Vertrauens oder an spezialisierte Einrichtungen.

FUJI FILM

Eine Initiative von
Dr. med. H. F. Rauschecker,
Chirurgische Universitätsklinik Göttingen

IPPNW

Freitag, 9. Juni 2000, 19.00 Uhr
Die Glocke, Bremen
Domsheide 4/5

Mammographie-Screening in der Kontroverse

Professor Dr.
Cornelia J. Baines
Toronto

berichtet über die Ergebnisse des Früherkennungsprogramms für Brustkrebs in Kanada

Die enttäuschenden Ergebnisse des derzeit größten laufenden Screening-programms (NBSS) lösten vor einigen Jahren heftige Auseinandersetzungen über den Nutzen von Mammographie-Reihenuntersuchungen aus, die bis heute anhalten. Nach 7 Jahren Beobachtungszeit war noch keine Senkung der Brustkrebssterblichkeit in der Gruppe mit einem Eintrittsalter von 40 bis 49 Jahren eingetreten. Es zeigten sich sogar mehr Karzinome in fortgeschrittenem Stadium als in der Kontrollgruppe. Bei den Frauen mit einem Eintrittsalter ab 50 Jahren war ebenfalls keine Senkung der Sterblichkeit zu verzeichnen, wenn man sie mit Frauen vergleicht, die sich einer jährlichen professionellen Untersuchung - jedoch ohne Röntgen - unterzogen.

Cornelia Baines, Professorin für Öffentliches Gesundheitswesen an der Universität Toronto und Leiterin des kanadischen Programms, bewertet die Ergebnisse nach weiteren 13 Jahren Laufzeit.

Eintritt frei **Simultanübersetzung aus dem Englischen**

Gesellschaft für Strahlenschutz e.V.
und
Internationale Ärzte für die Verhütung des Atomkrieges, Ärzte in sozialer Verantwortung e.V.

GSS-Geschäftsstelle, Universität Bremen, FB1, Postf. 330440, 28334 Bremen

Mammographiescreening: Abschätzung des Nutzens

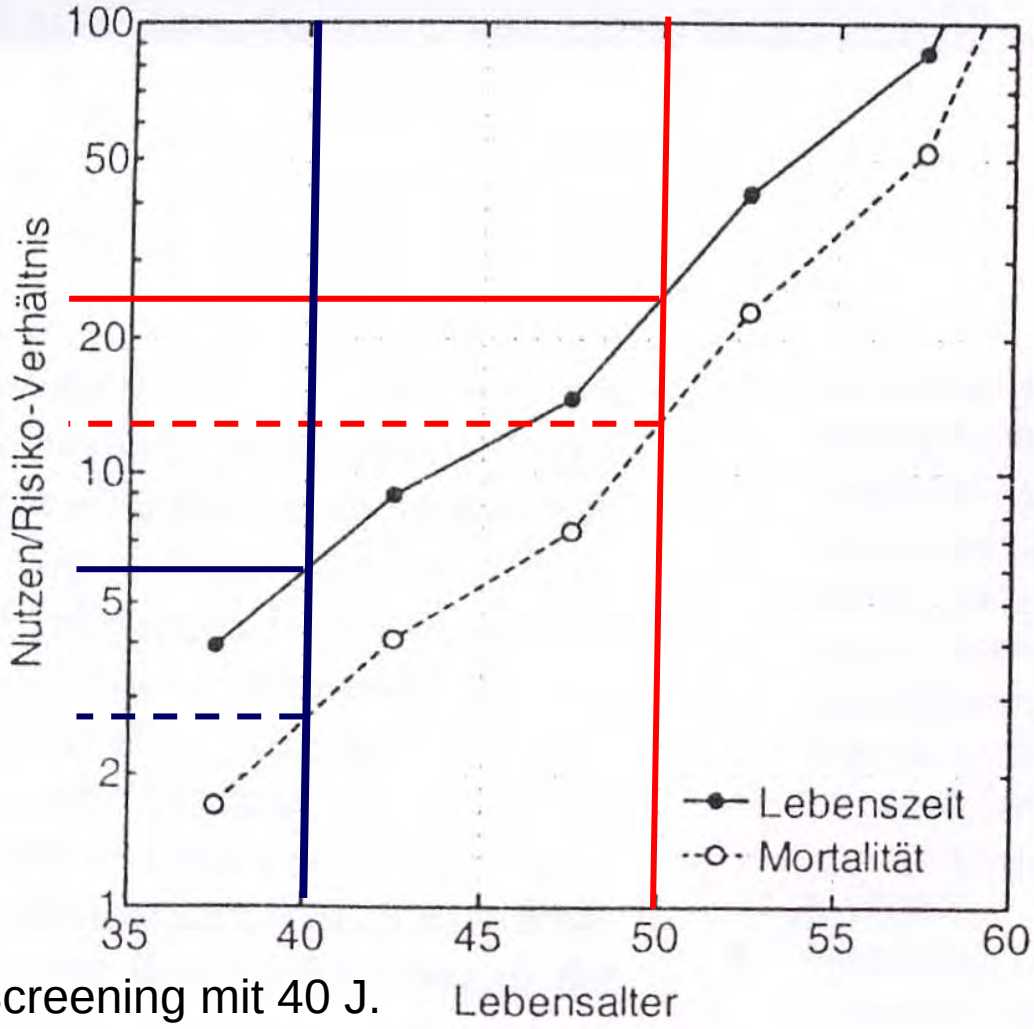


Abb. 8 ◀ **Nutzen-Risiko-Verhältnis für ein hypothetisches Mammographiescreening (nach Abb. 7) in Abhängigkeit vom Lebensalter bei Eintritt in das Screening. ● Nutzen-Risiko-Verhältnis als Quotient der durch Screening gewonnenen Lebensjahre und der Anzahl der durch strahleninduzierte Mammakarzinome verlorenen Lebensjahre. ○ Nutzen-Risiko-Verhältnis aus dem Quotienten von vermiedenen und strahleninduzierten Todesfällen (ohne Berücksichtigung des unterschiedlichen Zeitpunkts)**

Screening mit 40 J.
Screening mit 50 J.

nach: H. Jung, Radiologe 41 (2001) 385-395

Table 3. Estimated ratio of cancer detection to induction (DIR) for women in the normal (N) and high dose (H) groups screened 3 yearly in the NHSBSP

Age (years)	Ratio detected/induced (DIR)							
	Normal group (N)				High dose subgroup (H)			
	RBE=1	RBE=2	RBE=4	RBE=6	RBE=1	RBE=2	RBE=4	RBE=6
50–54	89	45	22	15	18.3	9.1	4.6	3.0
55–59	120	60	30	20	24.5	12.3	6.1	4.1
60–64	182	91	46	30	37.2	18.6	9.3	6.2
65–70	300	150	75	50	61.4	30.7	15.4	10.2

RBE, relative biological effectiveness; DIR, detection to induction ratio; N, normal population; H, high dose subgroup; NHSBSP, National Health Service Breast Screening Programme.

Risikogruppe Frauen mit Brustkrebs in der Familie

Table 1. Total number of breast cancers induced per million women screened per mGy absorbed for women of different ages (after Law et al [4])

Age (years)	Total breast cancers induced per million women exposed per mGy
25–29	18.4
30–34	18.2
35–39	17.8
40–44	16.6
45–49	15.0
50–54	13.2
55–59	11.5
60–64	9.4
65–70	7.4

[1]G J HEYES, PhD, [2]A J MILL, PhD and [2]M W CHARLES, PhD, DSc

The British Journal of Radiology, 79 (2006), 195–200

Risikogruppe Frauen mit Brustkrebs in der Familie

Table 1. Total number of breast cancers induced per million women screened per mGy absorbed for women of different ages (after Law et al [4])

Age (years)	Total breast cancers induced per million women exposed per mGy		
25–29	18.4	82.8	family history of breast cancer
30–34	18.2	81.9	
35–39	17.8	80.1	
40–44	16.6	74.7	
45–49	15.0	67.5	
50–54	13.2		
55–59	11.5		
60–64	9.4		
65–70	7.4		

[1]G J HEYES, PhD, [2]A J MILL, PhD and [2]M W CHARLES, PhD, DSc

The British Journal of Radiology, 79 (2006), 195–200

Quantitatives Strahlenisko

Umgang mit dem Risiko
Risikokommunikation

"STANDARD"

RADIUM PREPARATIONS

"Standard" Radium Solution for Drinking

—

Each bottle contains two micrograms radium element in 60 cc. aqua dist.

—

Maximum-equilibrium constant of radium emanation, 5400 mache units.

PERMANENT

"Standard" Radium Solution for Intravenous Use.

—

In Ampulles of 2 cc. N. P. S. S. containing 5, 10, 25, 50, or 100 micrograms radium element.

PERMANENT

"Standard" Radium Compress

—

A means of applying radium locally for the relief of pain.

—

A flexible pad of standardized, guaranteed radium element content.

PERMANENT RADIO-ACTIVITY

INDICATIONS

Subacute and Chronic Joint and Muscular Conditions.
High Blood Pressure. Nephritis.
The Simple and Pernicious Anemias.

"The value of radium is unquestionably established in chronic and subacute arthritis of all kinds (luetic and tuberculous excepted) acute, subacute and chronic joint and muscular rheumatism (so called) in gout, sciatica, neuralgia, polyneuritis, lumbago and the lancinating pain of tabes."—Rowntree and Baetjer, Journal A. M. A. Oct. 18, 1913.

For Descriptive and Clinical Literature Address

RADIUM CHEMICAL COMPANY

PITTSBURGH

New York
C. Everett Field, M. D.,
50 E. 41st St.

Boston
Samuel Delano, M. D.,
32 Newbury St.

Chicago
C. W. Hanford, M. D.,
749 1st Nat'l Bank Bldg.

San Francisco
Fred I. Lackenbach
Biologic Depot
508 Butler Bldg

RADIOLOGISCHE PRAKTIKA • BAND X

Röntgentherapie des Schwachsinnes bei Kindern

von

Dr. Wolfgang Freiherr von Wieser

Doramad-Mundpflege

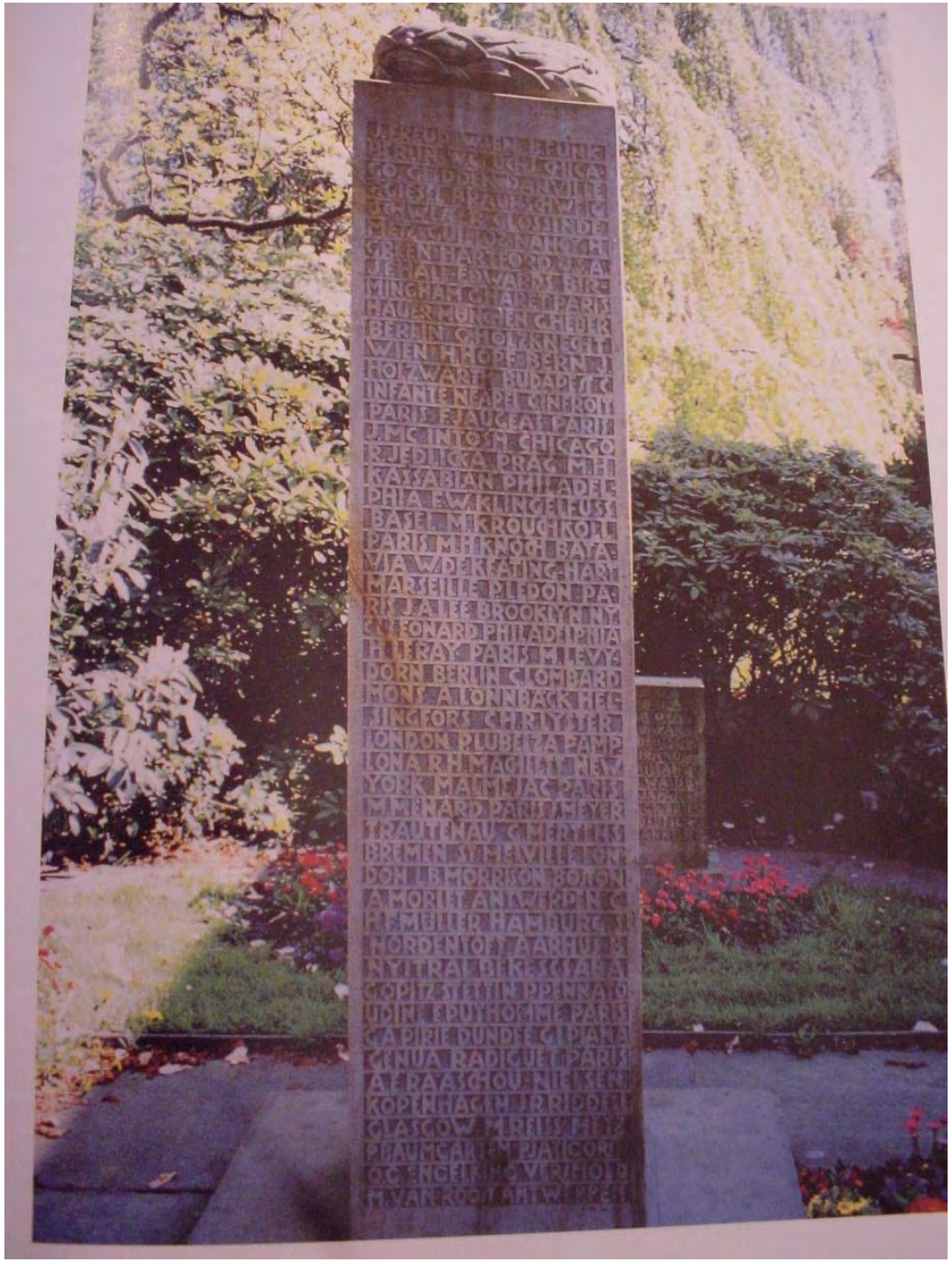
Radioaktive Zahncreme - Zahnbürsten

ZWEI ECHTE ERZEUGNISSE

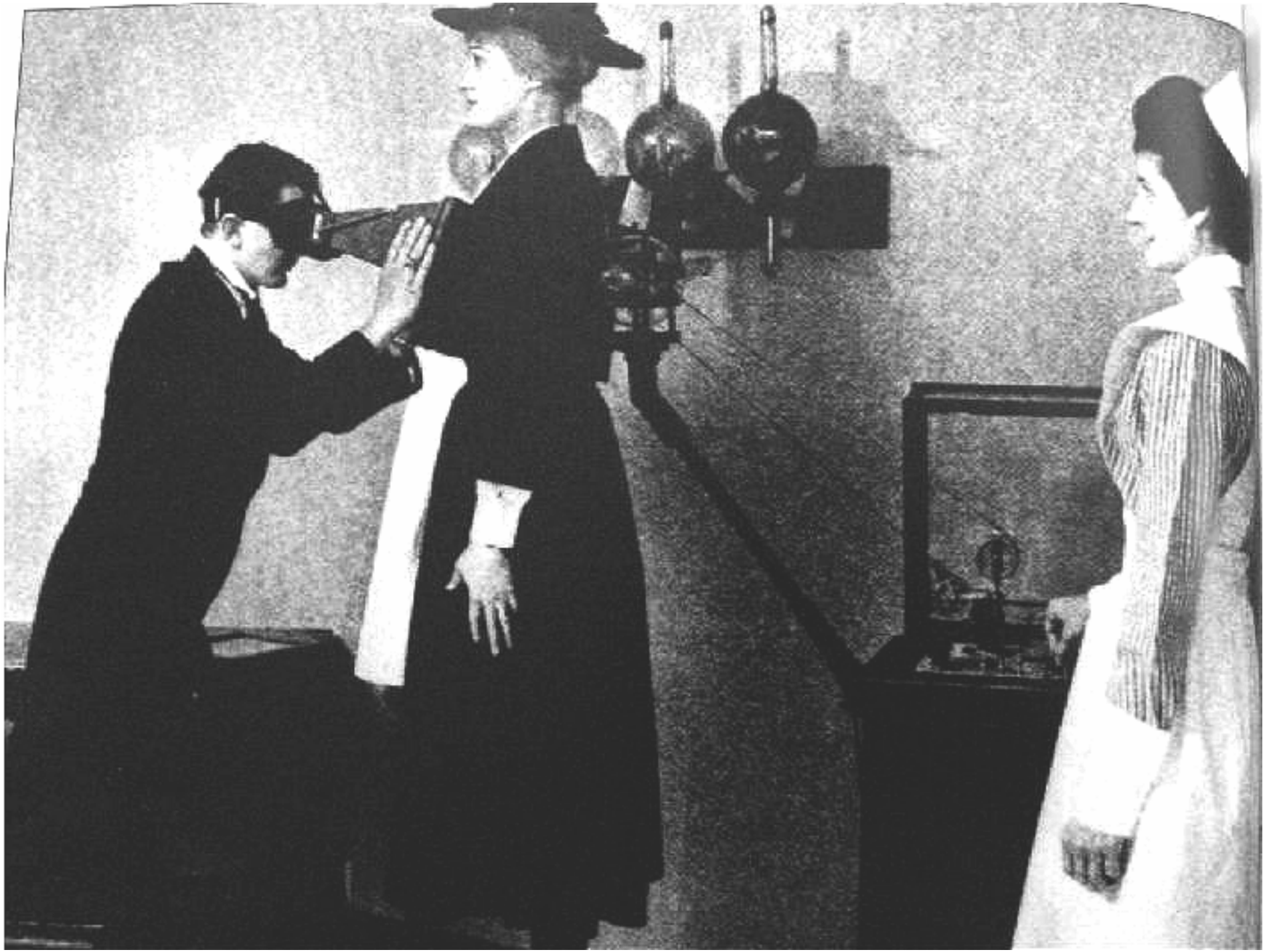
Abb. 1: Werbung für das Radiumbad Oberschlema um 1938 – allerdings nicht das weltstärkste, denn die Wettinquelle in Bad Brambach liegt mit 160.000 Bq/l noch deutlich höher

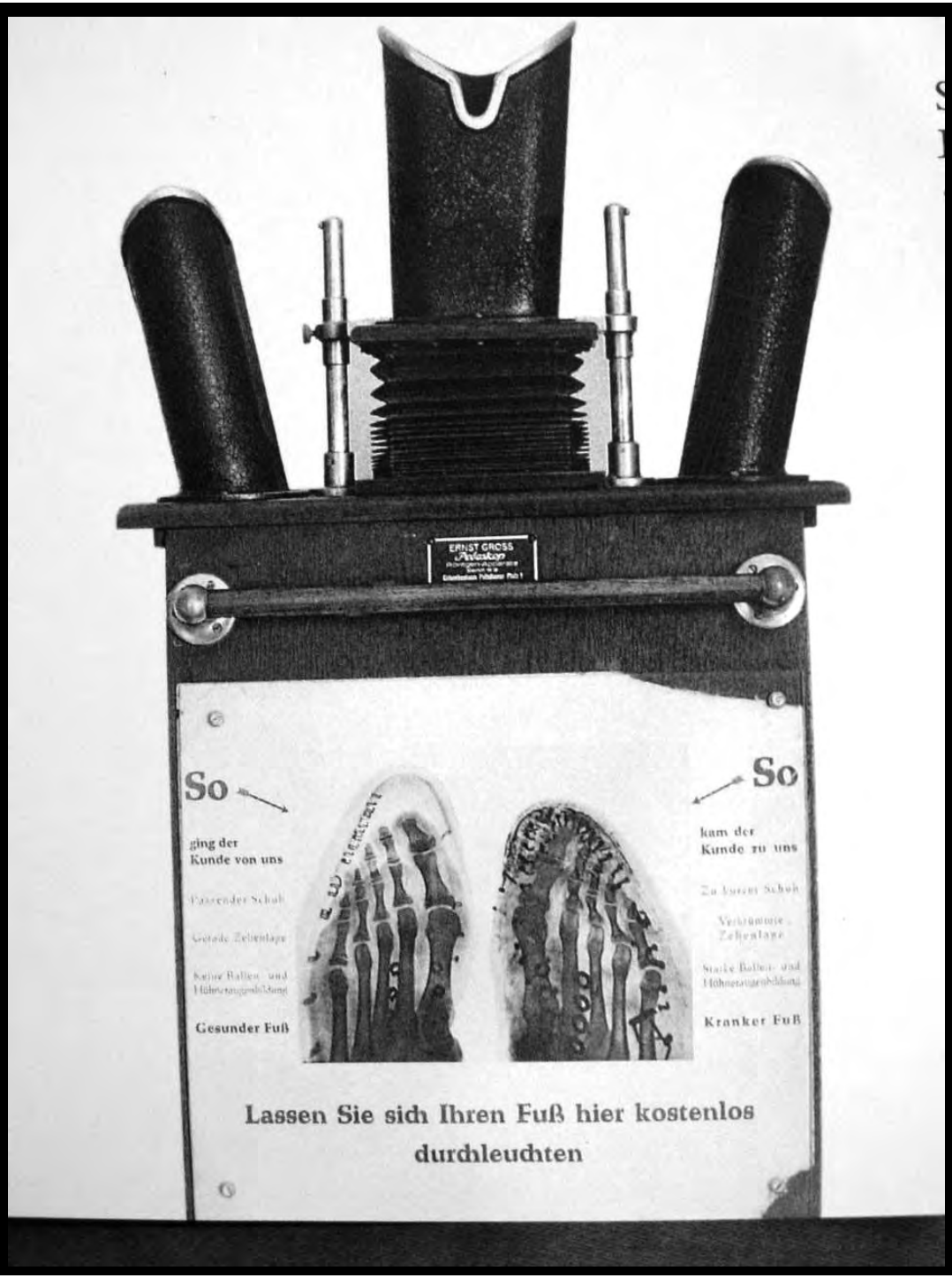
Quelle: Bericht über die 4. Biophysikalische Arbeitstagung vom 22.-24. September 2006 in Bad Schlema in: Strahlenschutz Praxis Heft 1/2007 S. 76-79

Wilhelm Conrad Röntgen
* 27.3.1845
+ 10.2.1923



Gedenkstein für Röntgenärzte, die an Strahlenfolgen verstarben
(im Park des AK St.Georg, Hamburg)




ERNST GROSS
So
ging der
Kunde von uns
Gesunder Fuß
So
kam der
Kunde zu uns
Kranker Fuß
Lassen Sie sich Ihren Fuß hier kostenlos
durchleuchten

Seit den 20er Jahren haben in vielen

Bodyscan-Lastwagen: *Wanderheiler vor der Dorfkirche*

Der Spiegel 30/2002

HAMBURGER
MORGEN POST
Montag, 16. März 1992 · 70 Pf · C 1906 A
r. 64 12 · Redaktion: (040) 36 30-0 · Anzeigen: (040) 36 30-336

HSV: Bitteres 0:2 in München

Vom Schiri um Punkt betrogen

Kommt Uli Stein als Manager zurück?

Nach dem 28. Bundesliga-Spieltag müssen 13 Vereine um den Klassenerhalt zittern. Nach dem 0:2 in München auch der HSV, der vom Schiedsrichter-Gespann um einem Punkt betrogen wurde. Interessant: Frankfurts Torhüter Stein ist als neuer HSV-Manager im Gespräch. Sport ab S. 19

STREIKS!

Diese Woche wird heiß

Bericht Seite 11

Die Leukämie-Kinder von Sittensen

Er wurde zu Tode geröntgt

Andreas starb mit 9 Jahren an Leukämie Foto: Brinkm

Professorin: Zu hohe Bestrahlung löste den Blutkrebs aus

Zwei Jahre lang kämpfte Andreas Petersen (9) aus Sittensen mit dem Blutkrebs. Dann starb er. Wie vier andere der sechs Leukämie-Kinder der kleinen Gemeinde. Jetzt scheint das Rätsel des unheimlichen Kinderkrebses gelöst. Die Bremer Professorin Inge Schmitz-Feuerhake: „Mindestens drei Kinder wurden falsch geröntgt." Andreas war einer von ihnen. Wie es dazu kam und wie gefährlich das Röntgen ist: Seite 16

abenteuer & exotik
Reiseabenteuer !
Oster-Abenteuer !!!
Ägypten – classic ab DM 2 490,–
Ägypten ab DM 2 590,–
Indien/Rajasthan ab DM 3 590,–
Tibet/Nepal ab DM 5 290,–
ab DM 3 545,–

Strahlenschutz in der Röntgendiagnostik

„… Es erscheint unstrittig, dass eine substanzielle Verringerung der Patientendosis in der medizinischen Diagnostik ohne Beeinträchtigung der Patientenversorgung möglich ist.“

Regulla D et al., Z.Med. Phys. 13(2003), 127-135

Das Gütesiegel „Der Blaue Engel“

Niedrigdosiseffekte in der Röntgendiagnostik - Fazit

Nachweis nur mit Epidemiologie möglich !
(große Kohortenstudien, lange Nachbeobachtung)

Neue Daten liegen vor
(realistische Dosisbereiche, Endpunkte, Expositionsbedingungen, Strahlen-qualitäten, repräsentative Gruppen, Expositionserfassung, follow-up…)

Zunehmende Differenzierung der Datenlage
(individuelle Sensitivität, Suszeptibilität)
- wichtig für Screening !

→ **Kein Hinweis auf Schwellendosis**
→ **Kein Hinweis auf DDREF**
→ **Rö-Risiko > Hiroshima/Nagasaki** (bis ca. 1 Größenordnung)
→ **neue Endpunkte** (benigne Schilddrüsenerkrankungen, ZNS)