
MGP
INSTRUMENTS
RATE
CONTAMINATION
CPS
CAP OFF
DOSE RATE
µSv/h
CAP ON
ON/OFF
LIGHT
RAM GENE-1
MARK II

Foreground: © IARC/Joachim Schüz;
background: Tokyo Electric Power Company

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The Section of Environment and Radiation (ENV) is charged with investigating environmental, lifestyle, occupational, and radiation-related causes of cancer in human populations. These exogenous factors are explored with the goal of contributing to cancer prevention and increasing the understanding of biological mechanisms of carcinogenesis. ENV achieves these objectives through collaborative international epidemiological studies using a multidisciplinary approach, when possible, or through the initiation of individual analytical epidemiological studies. Another approach used is the coordination of international consortia of epidemiological studies.

Central to ENV is the investigation of external environmental exposures, such as pollutants and occupational exposures, and lifestyle factors. Major areas of interest are pesticides, asbestos, other occupational risk factors for lung cancer, and uranium. Potential interactions between environmental and other factors for the risk of and survival from cancer are investigated in studies in sub-Saharan African countries, with a focus on breast and oesophageal cancers. ENV is also involved in many projects related to ionizing radiation from medical diagnostic examinations, occupational activities, and environmental exposures from fallout from nuclear accidents, nuclear weapons testing, and nuclear waste disposal. With regard to non-

ionizing radiation, research activities include investigations of mobile phone use and studies on extremely low-frequency magnetic fields and childhood cancer.

Translating research into prevention policy is particularly important for environmental risk factors, many of which are modifiable. ENV has played a large role in IARC's update of the European Code Against Cancer, which makes recommendations about what actions to take to improve general health and reduce the risk of cancer.

Environmental and occupational exposures

Pesticides

Parental exposure to pesticides has been suggested to increase the risk of cancer in their offspring. Data from case–control studies participating in the Childhood Leukemia International Consortium were pooled, totalling more than 8000 cases of acute lymphoblastic leukaemia (ALL), more than 1300 cases of acute myeloid leukaemia (AML), and more than 14 000 controls. A 20% increased risk of ALL was observed for paternal occupational exposure before conception and a 90% increased risk of AML for maternal occupational exposure during pregnancy (Bailey et al., 2014a). Home pesticide use before conception, during pregnancy, and after birth also showed positive associations with the risk of ALL (a 30–50% increased risk) as well as AML (a similarly increased risk, except for after birth, where there was no association) (Bailey et al., 2015a). In contrast, a register-based nested case–control approach in the Nordic populations, totalling almost 10 000 cases and more than 30 000 controls, showed no association between paternal or maternal exposure to pesticides and the risk of testicular cancer in their sons (Le Cornet et al., 2015). Risks of haematological malignancies in agricultural workers are currently being investigated by pooling large cohort studies from France, Norway, and the USA; a systematic review suggested a positive association between exposures to some pesticides and the risk of non-Hodgkin lymphoma (Schinasi and Leon, 2014).

Occupational risk factors for lung cancer

A study pooling data from 16 case–control studies on lung cancer from Europe and Canada with information on occupational history and lifetime smoking history (the SYNERGY project), comprising almost 20 000 cases and more than 23 000 controls, showed some positive associations between occupations and lung cancer after adjustment for smoking. Risk increases were about 30–50% for bricklayers (Consonni et al., 2015), painters, miners (Taeger et al., 2015), and welders. Increased risks of lung cancer seen in cooks (Bigert et al., 2015) and hairdressers are most likely attributable to their smoking behaviour. No increased risk was seen in bakers. The results are summarized in Figure 1. Further findings indicate that after accounting for co-occurring respiratory diseases, chronic bronchitis and emphysema have a positive association with lung cancer risk (Denholm et al., 2014). Using a modelling approach, analyses are under way to investigate the effect of known lung carcinogens such as respirable crystalline silica, nickel, chromium, polycyclic aromatic hydrocarbons, and asbestos, including the effects accounting for smoking and simultaneous exposures to several of these carcinogens. Cancer risks in workers exposed to asbestos in a large open-pit mine in the Southern Urals, Russian Federation, are also being explored, including the quantification of known associations such as with mesothelioma or lung cancer, but asbestos may also be related to other cancers for which the scientific evidence has not been established so far, for instance stomach or colorectal cancer. Although the use of asbestos has been banned in many countries, the peak burden of mesothelioma is still to occur, as illustrated using mortality data for Germany (Schonfeld et al., 2014a).

Radiation

Ionizing radiation and risk of death from cancer in nuclear workers

Quantification of the risks associated with very low doses of ionizing radiation is a challenging task because the expected effects are small and difficult to detect. Nevertheless, even small effects become non-negligible when considering millions of people exposed occupationally or millions of patients undergoing diagnostic procedures involving ionizing radiation. A landmark international study coordinated by IARC, the International Nuclear Workers Study (INWORKS) of more than 300 000 nuclear workers in France, the United Kingdom, and the USA, examined causes of death in the workers and has provided the strongest evidence yet that long-term exposure to low-dose radiation increases the risk of subsequent death

Figure 1. Occupations showing (left) increased lung cancer risk after adjustment for smoking, (centre) no increased risk after adjustment for smoking, and (right) no increased risk; data from the SYNERGY project (pool of 16 case–control studies from Europe and Canada). © IARC/ Joachim Schüz.

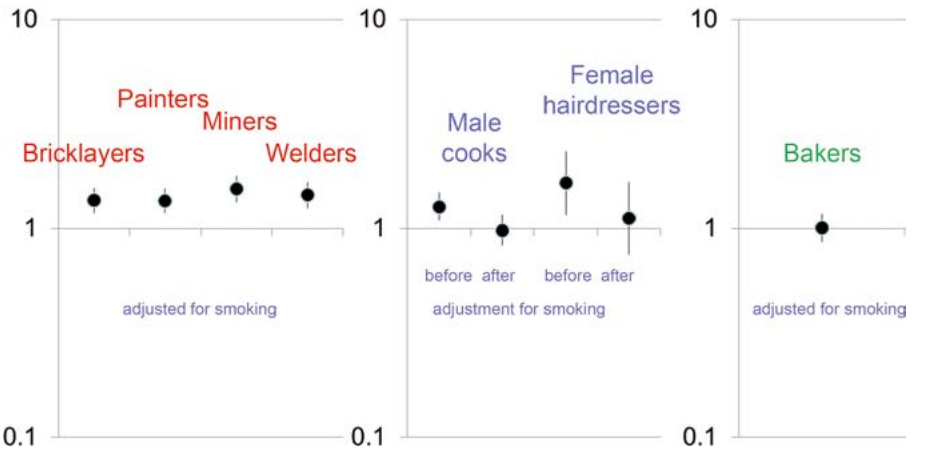


Table 1. Comparison between risks derived from analyses of the Life Span Study population exposed to higher radiation doses and dose rates, and risks observed in the INWORKS study

Cause of death	INWORKS		Life Span Study	
	Number of deaths	Excess relative risk	Number of deaths	Excess relative risk
Leukaemia, excluding chronic lymphocytic leukaemia	531	2.96 (90% CI, 1.17–5.21)[a]	94	2.63 (90% CI, 1.50–4.27)[b]
Solid cancer	17 957	0.47 (90% CI, 0.18–0.79)[c]	3475	0.32 (95% CI, 0.01–0.50)[d]

CI, confidence interval.

[a] Leuraud et al. (2015).

[b] Metz-Flamant C, Laurent O, Samson E, Caër-Lorho S, Acker A, Hubert D, et al. (2013). Mortality associated with chronic external radiation exposure in the French combined cohort of nuclear workers. Occup Environ Med. 70(9):630–8. http://dx.doi.org/10.1136/oemed-2012-101149 PMID:23716722

[c] Richardson et al. (2015).

[d] Cardis E, Vrijheid M, Blettner M, Gilbert E, Hakama M, Hill C, et al. (2005). Risk of cancer after low doses of ionising radiation: retrospective cohort study in 15 countries. BMJ. 331(7508):77. http://dx.doi.org/10.1136/bmj.38499.599861.E0 PMID:15987704

caused by leukaemia (excluding chronic lymphocytic leukaemia) (Leuraud et al., 2015) and solid cancer (Richardson et al., 2015). The workers received average doses of just 1.1 mSv per year above background radiation, which is about 2–3 mSv per year from sources such as cosmic rays and radon (Thierry-Chef et al., 2015). Although based on a substantially lower dose distribution, the estimated excess relative risk of leukaemia mortality excluding chronic lymphocytic leukaemia (2.96 per Gy; 90% CI, 1.17–5.21) was consistent with risks derived from analyses of other populations exposed to higher radiation doses and dose rates (Table 1). The rate of mortality from all cancers was estimated to increase with cumulative dose by 51% per Gy (90% CI, 23–82%), lagged 10 years (Richardson et al., 2015). A similar association was estimated for all solid cancers (an increase of 47% per Gy; 90% CI, 18–79%), and further excluding lung cancer deaths from the analysis led to a minimal change in the magnitude of the estimated association, suggesting that positive bias due to confounding by smoking was unlikely. These findings show the importance of adherence to the basic principles of radiation protection: to optimize protection to reduce exposures as much as is reasonably achievable and – in the case of patient exposure – to justify that the exposure does more good than harm.

Cancer risk related to computed tomography examinations during childhood

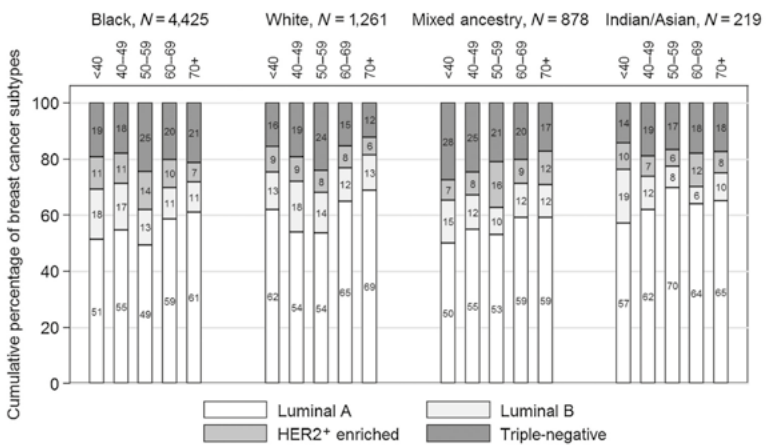
The growing use of computed tomography (CT) technology raises concerns about radiological protection, especially for children and adolescents. The EPI-CT multinational collaborative study, which aims to estimate individual radiation organ doses (and associated uncertainties) from CTs in young people and assess subsequent cancer risk, was specifically designed to address factors that can affect the interpretation of results from CT studies, including reverse causation, confounding by predisposing factors and other causes, and possible effect modification (Bosch de Basea et al., 2015). To date, the study includes 1 163 571 patients from nine European countries (Belgium, Denmark, France, Germany, the Netherlands, Norway, Spain, Sweden, and the United Kingdom). Data on 2 166 479 CT examinations (53.33% of them head CT scans) have been retrieved from participating radiology departments. An in vitro assessment of the γ-H2AX-foci assay as a cellular biomarker of age-dependent radiosensitivity demonstrated that it is feasible to apply the assay in a multicentre prospective study in paediatric CT imaging (Vandevoorde et al., 2015). EPI-CT, the first large-scale international collaborative study, will contribute to estimating effects of low-level radiation in children and providing a basis for the optimization of paediatric CT protocols and patient protection, and also has the potential to consolidate a European paediatric cohort for long-term follow-up.

Lifestyle and behaviour

Breast cancer

In a study of more than 12 000 women with histologically confirmed breast cancer in South Africa and Namibia, it was found that estrogen receptor-positive cancer dominated in all races but that Black women had a modest excess of aggressive subtypes (Figure 2; Dickens et al., 2014a). In more than 1000 breast cancer patients from the largest hospital in Southern Africa,

Figure 2. Cumulative age-specific percentages of breast cancer subtypes in patients from South Africa and Namibia, by race. Numbers within bars indicate subtype percentages. Reprinted from Dickens et al. (2014a) by permission from the American Association for Cancer Research.



the risk of late-stage breast cancer increased with increasing distance from a patient's residence to the hospital, highlighting the prevention potential in this population (Dickens et al., 2014b). To study factors influencing breast cancer survival in sub-Saharan Africa, ENV has recently launched a large-scale survival study including South Africa, Namibia, Uganda, and Nigeria, the African Breast Cancer - Disparities in Outcomes (ABC-DO) study.

Oesophageal cancer

Oesophageal cancer has a peculiar spatial distribution worldwide, including a high-incidence easterly corridor in Africa, which stretches north–south from Ethiopia and Kenya to South Africa (Figure 3). ENV has established a consortium (the ESCCAPE project) with ongoing case–control studies in Kenya and the United Republic of Tanzania and pilot work in Ethiopia, Malawi, and South Africa. Consumption of hot beverages and food is a candidate risk factor, and a tea temperature survey in the United Republic of Tanzania showed that participants started drinking tea at a mean temperature of 70.6 °C (Munishi et al., 2015). In Ethiopia, another candidate risk factor is khat chewing, which is also a suspected risk factor for malignant oral disorders (El-Zaemey et al., 2015).

Childhood cancers

Childhood cancer, especially ALL, shows great international variation, although the disease may be underdiagnosed in low- and middle-income countries (Erdmann et al., 2015a). ENV therefore aims to involve more such countries in the research and has established the Global Acute Leukaemia network (GALnet). Recent research from high-income countries suggests roles, although modest, of parental pesticide exposure (see above) and parental home paint exposure (Bailey et al., 2015b), and a protective effect of maternal supplementation with folic acid (Metayer et al., 2014).

Cancer prevention

The European Code Against Cancer is a preventive tool aimed at reducing the cancer burden by informing people about how to avoid or reduce carcinogenic exposures, adopt behaviours to reduce their cancer risk, or participate in organized intervention programmes. The fourth edition of the Code was launched in October 2014. This update, led by ENV together with the Quality Assurance Group, also includes recommendations on occupational and environmental exposures as well as ionizing radiation and ultraviolet radiation; the Code is shown in Figure 4. It is estimated that the cancer burden could be reduced by up to one half if scientific knowledge on the causes of cancer could be translated into successful prevention.

Figure 3. Incidence of oesophageal cancer (EC) in men and women in African countries, showing high rates in countries along the Great Rift Valley. Reprinted from Schaafsma et al. (2015). © 2015 Schaafsma et al.

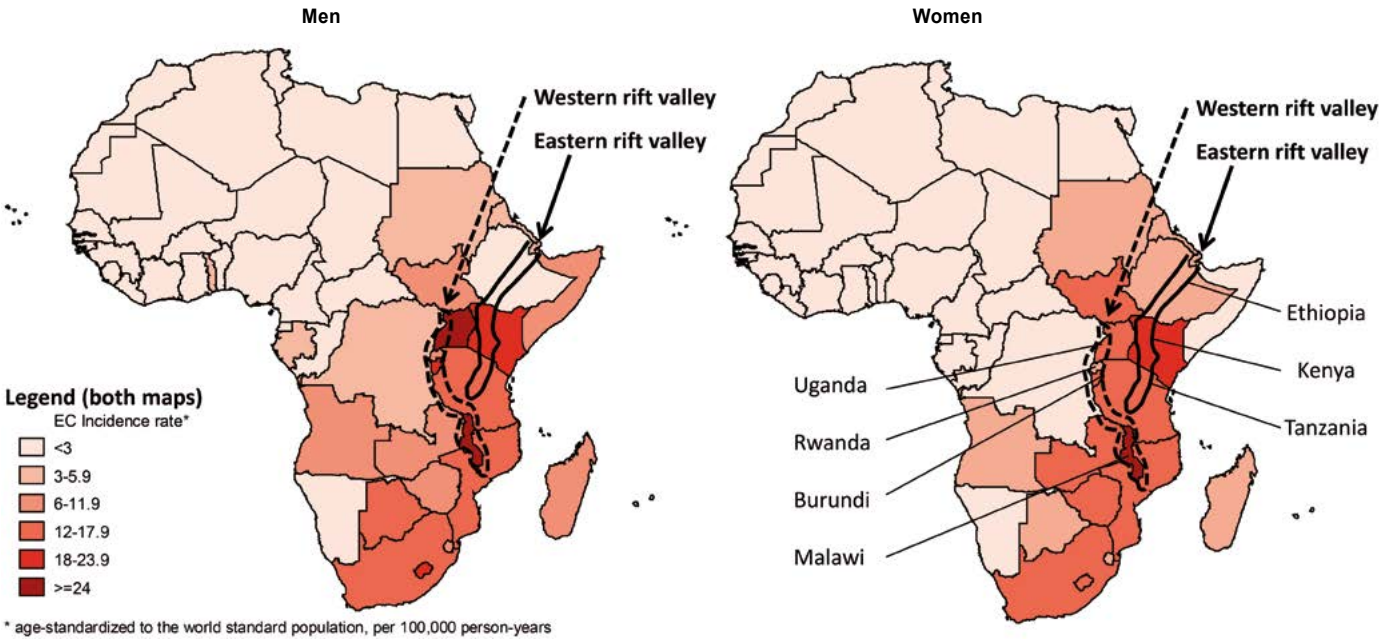


Figure 4. The fourth edition of the European Code Against Cancer, launched in October 2014: 12 recommendations to reduce your cancer risk (http://cancer-code-europe.iarc.fr). © IARC.

European Code Against Cancer

12 ways to reduce your cancer risk

1. Do not smoke. Do not use any form of tobacco.
2. Make your home smoke free. Support smoke-free policies in your workplace.
3. Take action to be a healthy body weight.
4. Be physically active in everyday life. Limit the time you spend sitting.
5. Have a healthy diet:
   - Eat plenty of whole grains, pulses, vegetables and fruits.
   - Limit high-calorie foods (foods high in sugar or fat) and avoid sugary drinks.
   - Avoid processed meat; limit red meat and foods high in salt.
6. If you drink alcohol of any type, limit your intake. Not drinking alcohol is better for cancer prevention.
7. Avoid too much sun, especially for children. Use sun protection. Do not use sunbeds.
8. In the workplace, protect yourself against cancer-causing substances by following health and safety instructions.
9. Find out if you are exposed to radiation from naturally high radon levels in your home. Take action to reduce high radon levels.
10. For women:
    - Breastfeeding reduces the mother's cancer risk. If you can, breastfeed your baby.
    - Hormone replacement therapy (HRT) increases the risk of certain cancers. Limit use of HRT.
11. Ensure your children take part in vaccination programmes for:
    - Hepatitis B (for newborns)
    - Human papillomavirus (HPV) (for girls).
12. Take part in organized cancer screening programmes for:
    - Bowel cancer (men and women)
    - Breast cancer (women)
    - Cervical cancer (women).

The European Code Against Cancer focuses on actions that individual citizens can take to help prevent cancer. Successful cancer prevention requires these individual actions to be supported by governmental policies and actions.

Find out more about the European Code Against Cancer at: http://cancer-code-europe.iarc.fr

International Agency for Research on Cancer

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