

ORIGINAL ARTICLE

The European Cancer Information System: exploring linkages between indoor radon concentrations and data on cancer burden

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Abstract

Cancer is well recognised as a major public health concern in European countries, and the effectiveness of actions to tackle cancer should only be measured via accurate and comparable cancer indicators. The European Cancer Information System (ECIS) compiles and disseminates cancer indicators of Europe based on harmonised and validated cancer data provided by European cancer registries. Indoor radon is a risk factor for lung cancer and is considered to be one of the main causes of lung cancer among people who have never smoked. Large geographical variations are observed in the incidence and mortality rates of lung cancer in Europe. To compare indoor radon levels and lung cancer levels across European countries, ECIS data will be linked with radon concentrations from the European Indoor Radon Map (EIRM) included in the European Atlas of Natural Radiation, also hosted by the Joint Research Centre (JRC). The identification of a common and sufficiently fine geographical unit is a pre-requisite to enable data linkage between these two different JRC data sources, and it requires the agreement between the community of cancer registries and the providers of indoor radon data. The aim of this study is to identify the commonly defined high-risk geographical areas to support the implementation of locally targeted public health policies.

Keywords: *cancer registries; cancer; incidence; mortality; radon; cancer risk*

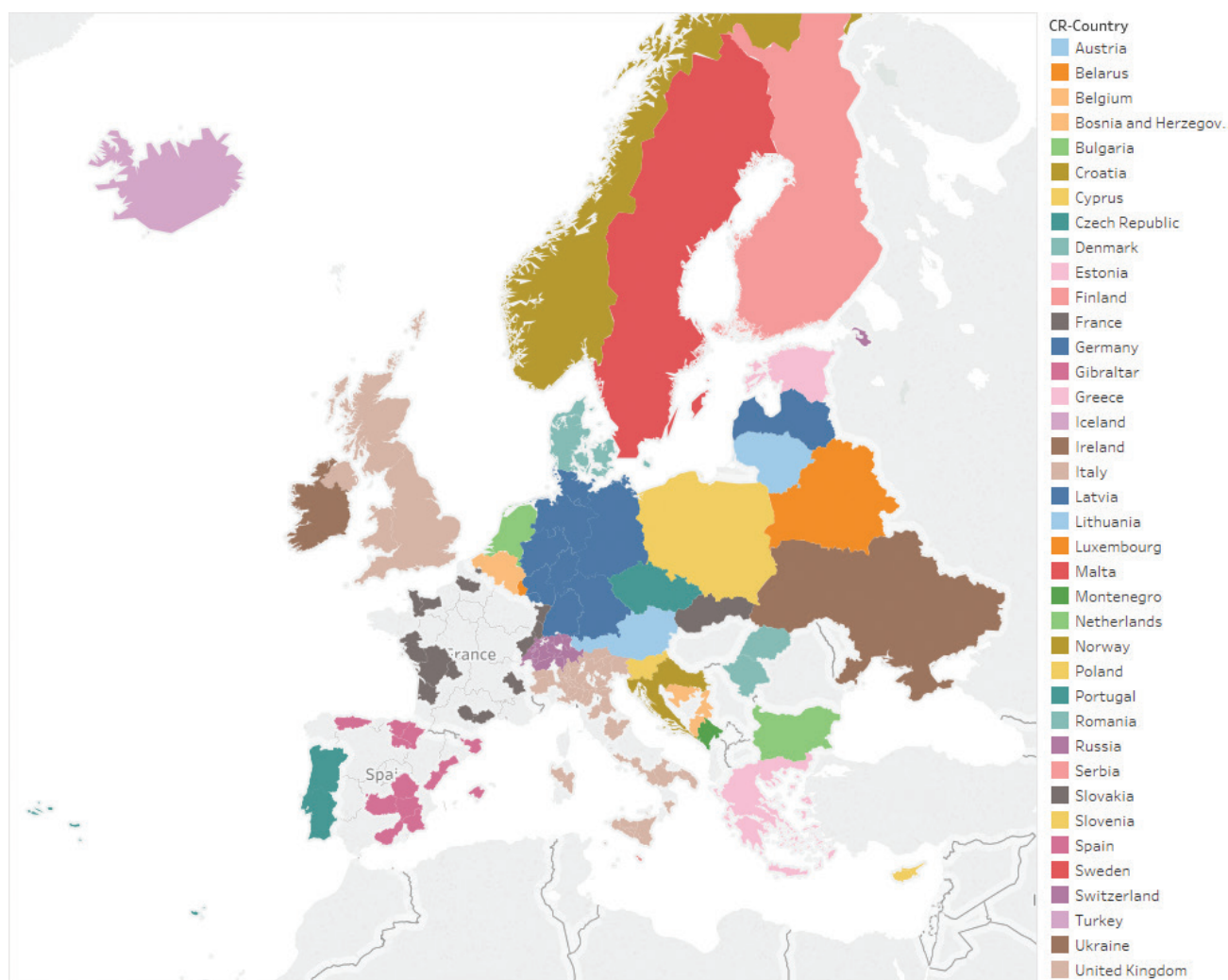
Cancer is well recognised as a major public health concern in European countries. It was the second most common cause of mortality in 2017 (1) and was estimated to be the cause of 1.9 million deaths in 2020 (2). The number of new estimated cancer cases in Europe rose to over 4 million in 2020, corresponding to a lifetime (0–84 years) risk of being diagnosed with cancer of one in two (48%) for men and one in three (34%) for women (2). Large geographical variability in the incidence and mortality rates of cancer is observed between European countries (2), which could be due to many factors, including socioeconomic and lifestyle factors, resource disparities allocated to cancer prevention, different control plans for occupational and environmental exposures and, in some cases, also data issues.

The effectiveness of actions to tackle cancer should, indeed, only be measured via accurate and comparable cancer indicators, such as incidence, mortality, prevalence and survival. The European Commission services [in particular the directorate generals of Health and Food Safety, and Joint Research Centre (JRC)] in close collaboration

with the major European stakeholders in the cancer information field have established the European Cancer Information System (ECIS) for compiling such indicators based on accurate and harmonised cancer data at European level.

The baseline information necessary to compute the cancer-burden statistics is provided by European population-based cancer registries, which are the official information sources providing data on all cancer cases reported in a well-defined population of a certain geographical area. The European Network of Cancer Registry (ENCR) (3) is active since 1990 and currently includes 187 cancer registries (general ones – registering all ages and all cancer types, childhood registries and cancer-specific registries) from 38 European countries (Fig. 1), considering the UN geographical definition of Europe (4) plus Cyprus. If only general cancer registries are considered, a population coverage of almost 90% is reached in EU-27 countries.

Cancer registration in Europe faces several challenges, ranging from incomplete population coverage to the heterogeneity of organisational and funding structures that



Source: <https://www.enrc.eu>, accessed on 15 June 2021

Fig. 1. Cancer registries that are members of the European Network of Cancer Registries (ENCR)

are themselves dependent on a wide variation in national health-service set-ups. Long-term sustainability of registries can be a burning issue, especially in cases where registries lack a formal data-collection mandate. Further challenges include the multilingual dimension in the harmonisation of information across different countries and timeliness in the provision of quality-checked data as cancer registries can generally only provide incidence data with a 3–4 year time lag. Finally, and not least important, cancer registration involves recording sensitive data and, therefore, falls under precise data-privacy requirements to guarantee non-disclosure of sensitive information. Adherence to the EU's General Data Protection Regulation requirements imposes an additional burden of ensuring that the legal safeguards are met in the management, processing and sharing of cancer data for research purposes (5).

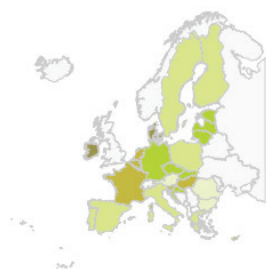
The JRC, after assuming the role of the ENCR secretariat in 2012, directly supports the activities of the

ENCR, and together, they proactively promote the harmonisation of cancer registries' data and registration processes. They also facilitate the cancer-registry data process with a central collection of the minimum data sets needed to compute the European cancer-burden indicators, and harmonised and synchronised validation and analysis.

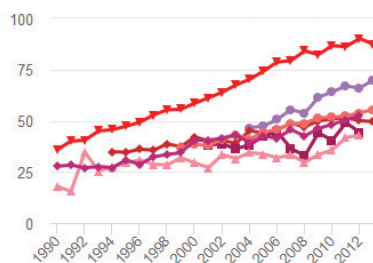
ECIS comprises the central data repository from which the indicators are computed and afterwards uploaded to the ECIS web application (<https://ecis.jrc.ec.europa.eu/>), which serves as the system's front-end for visualising the cancer indicators (through graphs, maps and tables) and for making them available for download. The ECIS web application thereby supports research and public health decision-making with the most up-to-date statistics on cancer; it also serves as an information reference point for European citizens.

The ECIS web application displays geographical patterns and temporal trends of cancer incidence, mortality

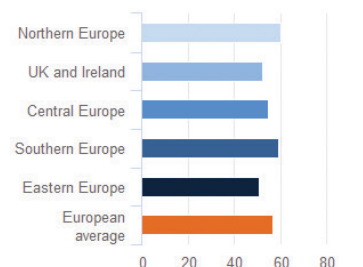
ECIS - European Cancer Information System



Incidence and mortality estimates 2020



Incidence and mortality historical data



Survival estimates

Source: Adapted from <https://ecis.jrc.ec.europa.eu/>, accessed on 15 June 2021

Fig. 2. The three data modules of the ECIS web application.

and survival statistics for 58 cancer entities. The application includes three main types of information on cancer (Fig. 2): (1) estimated national incidence and mortality for 2020, (2) historical incidence and mortality indicators at a registry level, and (3) national survival estimates. The database feeding the web application is updated with new data as soon as they are made available. As of 2020, more than 34 million cancer cases submitted by approximately 150 European population-based cancer registries from 34 European countries are represented.

Radon as a risk factor for lung cancer

With the aim of reducing the personal risk of getting cancer, the European Code Against Cancer (6) describes 12 preventive actions that citizens must undertake. The Code is a European Commission funded initiative developed by the World Health Organization's International Agency for Research on Cancer (IARC) and is compiled by leading cancer scientists from across Europe based on the latest scientific evidence on cancer prevention. It has been estimated that if everyone follow these 12 recommendations, almost half of all deaths from cancer in Europe could be avoided. In the ninth recommendation, citizens are advised to verify their exposure to radiation from naturally high radon levels in their home and to take action to reduce any such radon level.

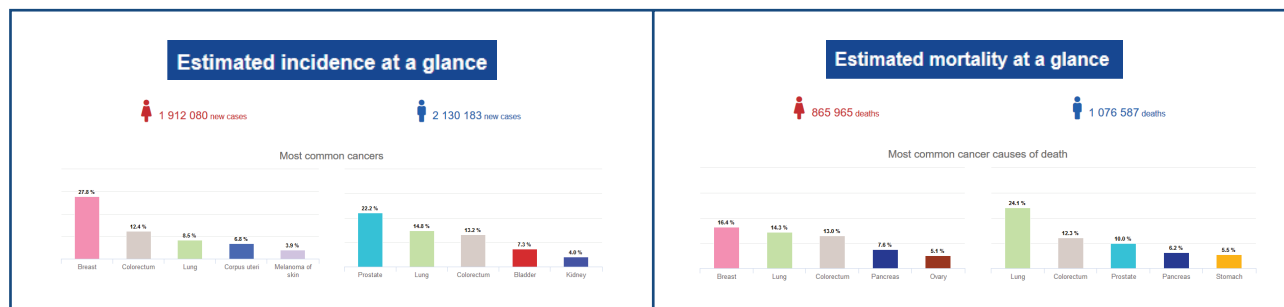
Radon is a naturally occurring radioactive gas and is generally one of the most important contributors to the radiation exposure (7). It was classified as a class 1 human carcinogen in 1988 by IARC (8), and no known threshold concentration can guarantee that radon exposure presents no risk (9). Several studies have shown that exposure to radon in dwellings increases the risk of lung cancer

(9, 10, 11), while its causative effect on other cancers has yet to be consistently demonstrated. Nevertheless, radon is one of the leading causes of deaths from lung cancer worldwide after tobacco smoking (9). In fact, the majority of radon-related lung-cancer deaths are reported among people exposed to low and moderate levels of indoor radon that are below the commonly used indoor radon reference levels (9).

Whereas habitual smoking remains the most important risk factor for developing lung cancer (90% of incident cases of lung cancer are attributable to smoking) (12), radon exposure is considered one of the most important causes (9). The attributable proportion of lung cancer cases due to radon in the general population is estimated to vary from 3 to 14% depending on the indoor radon levels (9). Given the strong interaction between radon exposure and tobacco smoking (10), radon is much more likely to cause lung cancer for (current or former) smokers than for those who have never smoked, although for the latter, radon is considered to be one of the primary causes of lung cancer (9).

A recent meta-analysis on 28 case-control studies suggests that although small-cell lung carcinoma and adenocarcinoma showed stronger associations with radon compared with squamous cell carcinoma and other histological types, radon in residential buildings is a risk factor for all histological types of lung cancer (13).

The lung cancer burden estimated for the year 2020 in ECIS reports approximately 477,500 new lung cancer cases (of which 64% in men) and 257,293 deaths (of which 66% in men) in European countries (2). Lung cancer is the second most diagnosed cancer among men and the third among women, while it is the first cause of cancer deaths among men and the second in women (Fig. 3).



Source: ECIS – European Cancer Information System From <https://ecis.jrc.ec.europa.eu>, accessed on 15/06/2021 © European Union, 2021

Fig. 3. Estimated number of new cases and deaths from all cancers (excluding non-melanoma skin cancer) by sex, plus five cancer entities most frequently diagnosed and five most common causes of cancer death by sex in Europe for 2020.

Large geographical variations are observed in the estimated incidence rates of lung cancer among European countries (Fig. 4) consisting of threefold variation in men and ninefold variation in women. In men, incidence rates were highest in Central and Eastern Europe – Hungary (138 per 100,000), Serbia (136), Bosnia and Herzegovina (131) and Latvia (128), and in Southern and Western Europe – Greece (127), Montenegro (124), and Belgium (124), while lowest rates were estimated for 2020 in Finland (67), Switzerland (64) and Sweden (45). In women, highest incidence rates were estimated in Denmark (85), Ireland (85) Hungary (77), and lowest rates were estimated in Eastern Europe – Ukraine (12) and Belarus (10) (2).

Owing to the relatively poor prognosis of lung cancer, the geographical patterns of mortality are quite similar to those of incidence for both sexes (2). Lung cancer is the leading cause of cancer deaths among men in all European countries (except Sweden) and among women in 33% of European countries (2).

It has to be noted that a number of factors influence the variations of estimated incidence and mortality rates for 2020 across European countries. The proportion of population covered by cancer registration is quite different among European countries, with seven countries having no cancer registration, 11 countries having only partial registration coverage (from 18 to 99%), while three countries with full population coverage did not provide their data to ECIS. Therefore, specific estimation methods had to be applied for these countries. Besides registration coverage and estimation methods, other factors can also explain the geographical variations of incidence levels including different levels of primary prevention and care, and population-based screening.

Over the last few decades, incidence and mortality rates of lung cancer in men have shown a generally decreasing trend in many European countries, especially in Northern and Western Europe; however, it is less so in Central and Eastern European countries where incidence and

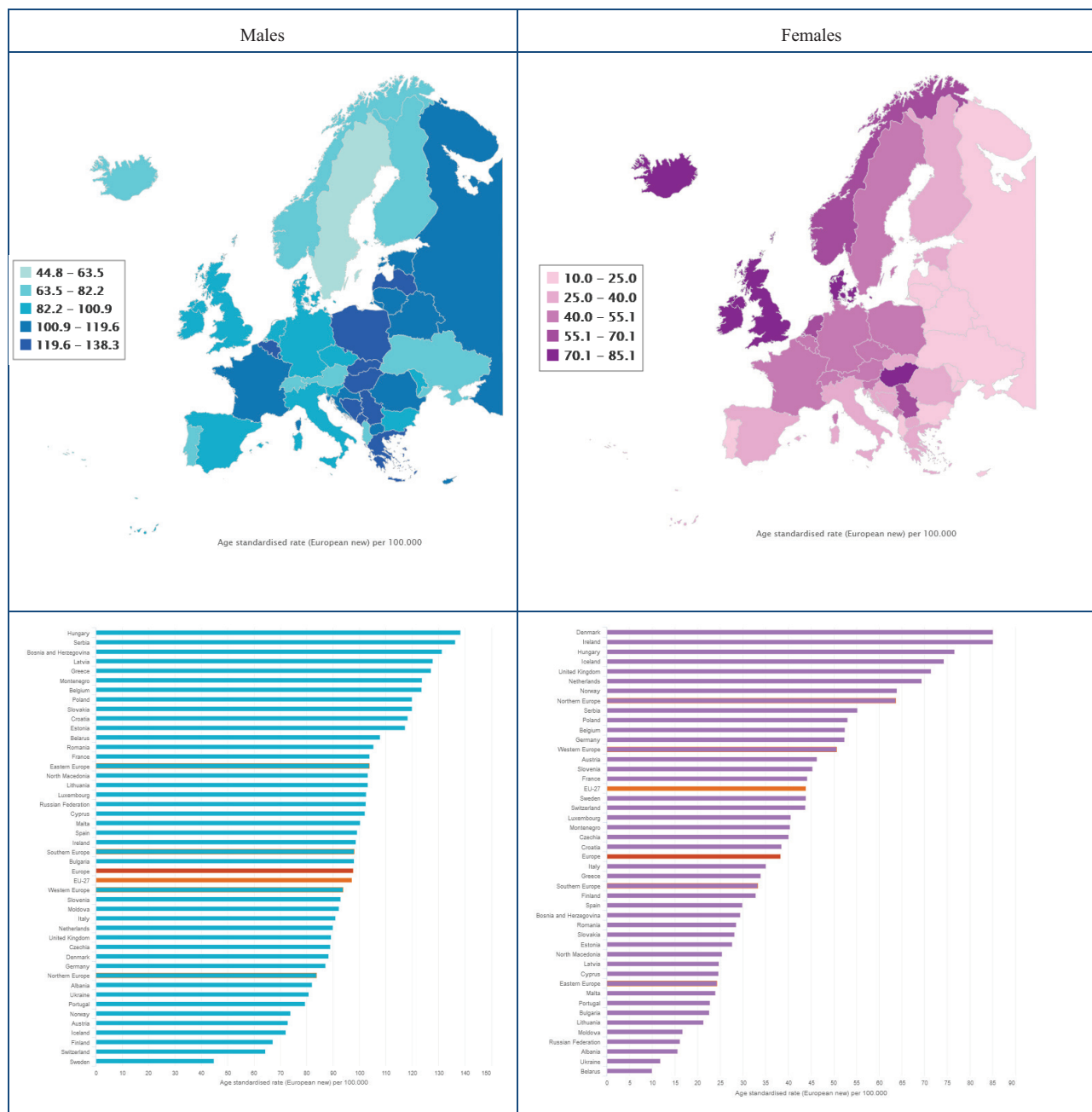
mortality rates still remain high. Lung cancer incidence rates in women are still rising in Europe, although rates are more stable for Northern European countries (2). Women have a more recent history of tobacco exposure, and this may explain the different geographical patterns and time trends when compared with men.

Exploring linkages between indoor radon concentrations and cancer data

A number of ecological studies in Europe have analysed the levels of lung cancer incidence or mortality, together with the prevalence of tobacco smoking, with corresponding indoor radon concentrations measured in the same geographical areas (14, 15).

The comparison between indoor radon concentrations (Bq/m³) and lung cancer rates (incidence and mortality) could, indeed, highlight possible areas of high risk in Europe. In order to perform such a mapping exercise, historical cancer incidence data at registry level (as the official sources of cancer incidence) and cancer mortality data at national or local level (on the whole Europe) will be linked with radon concentrations from the European Indoor Radon Map (EIRM), which is included in the European Atlas of Natural Radiation (7) also hosted by the JRC. The EIRM map reports the number of measurements and arithmetic means of long-term (ideally, annual or representative of annual average) indoor radon concentrations in ground-floor rooms of dwellings, over 10 km × 10 km grid cells covering Europe (Figs. 5 and 6). The reported means are in effect an overestimation of the real exposure owing to the fact that, in urban areas, the majority of people do not live on the ground floor or in the basement, where the highest radon concentrations are generally measured (16).

The JRC annually updates the EIRM map thanks to the support of the National Authorities. The National Authorities collect data on radon via surveys registering long-term indoor radon concentrations in ground-floor rooms of dwellings; these raw data are then aggregated



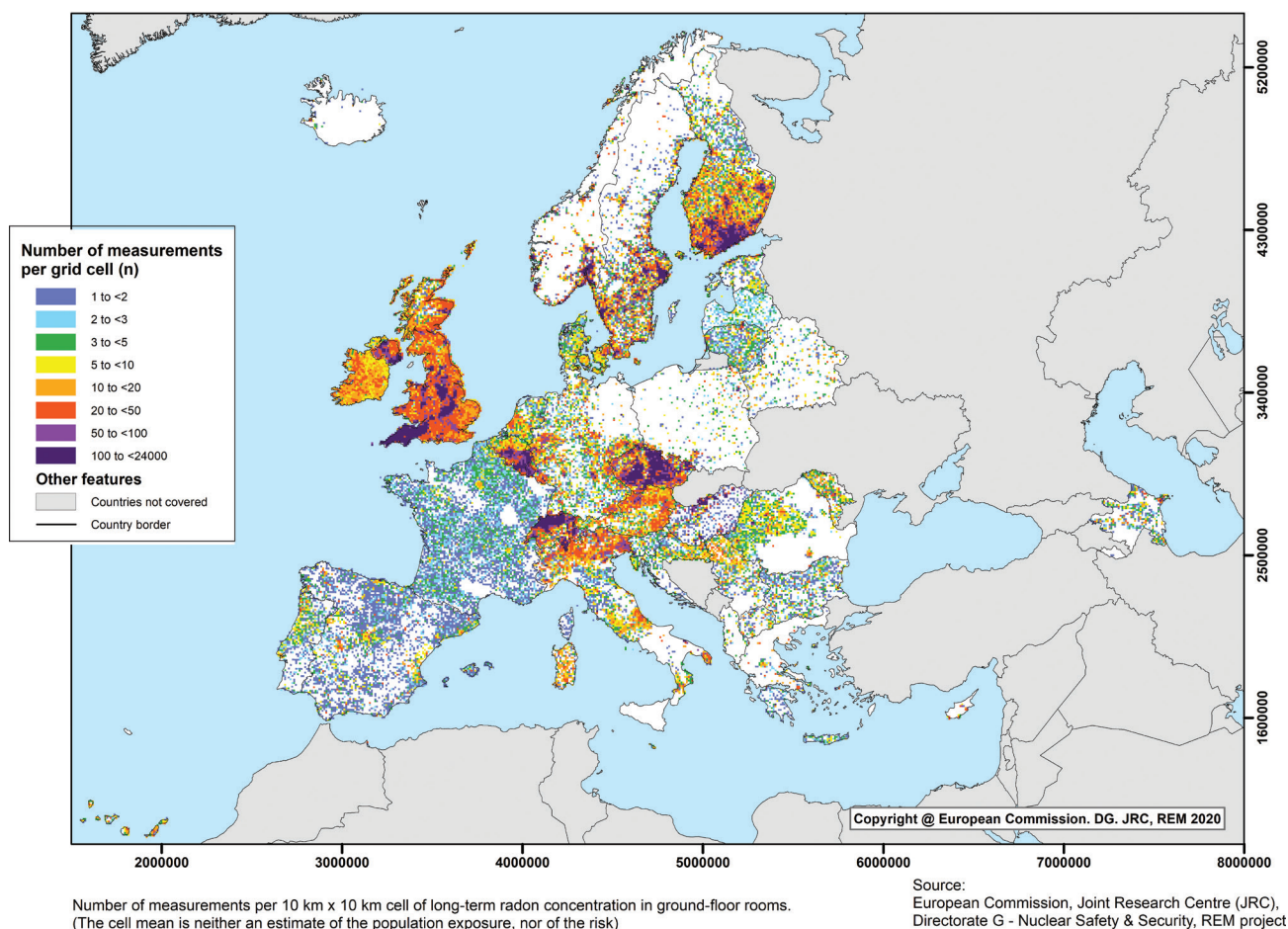
Source: ECIS – European Cancer Information System From <https://ecis.jrc.ec.europa.eu>, accessed on 15/06/2021 © European Union, 2021
 Note: *The age-standardised rate (expressed per 100,000) is a weighted mean of the age-specific rates (based on estimated number of new cases) where the weights are taken from the population distribution of the European standard population 2013.

Fig. 4. Estimated age-standardised incidence rates and corresponding relative changes* of lung cancer by country and sex in Europe for 2020.

over 10 km × 10 km grid cells and transmitted to the JRC (16). The new data received by the National Authorities can help to increase both the sampling density per cell (number of measurements as reported in Fig. 5) and the quality of data, as well as possibly the coverage, which is still poor or missing in some geographical areas (white areas in Figs. 5 and 6).

The identification of a common and sufficiently fine geographical unit is a pre-requisite to enable data linkage between these two different JRC data sources. The definition of a common baseline nomenclature is a challenge still to be overcome, requiring agreement between the community of cancer registries and the providers of indoor radon data. Future improvements include a finer

European Indoor Radon Map, December 2020



Sources: <https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Digital-Atlas> (accessed on 15 June 2021)

Fig. 5. European Indoor Radon Map: the number of measurements (N) of annual indoor radon concentration in ground-floor rooms of dwellings over 10 km × 10 km grid cells.

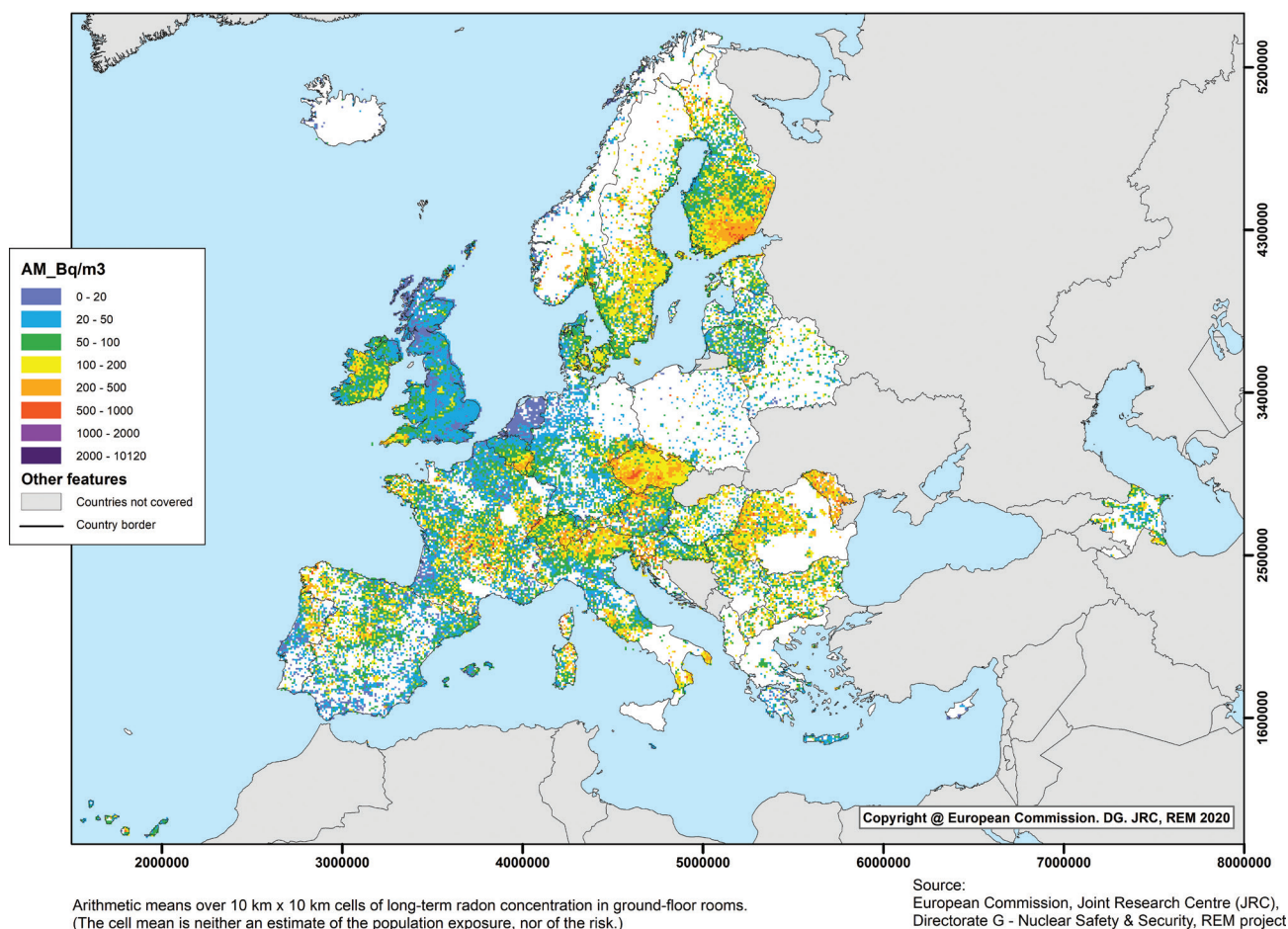
geographical detail in the collected incidence data submitted by the European cancer registries, up to EUROSTAT nomenclature of territorial units for statistics – NUT2. Lung cancer plays a dramatic role in the incidence and mortality cancer burden of European countries. It is therefore important to identify commonly defined high-risk geographical areas, which can then be addressed by locally targeted public health policies.

While considering the linkage between radon and cancer data, another challenge will be retrieving information on important confounding factors not routinely collected by the cancer registries (with the exception of age and sex). The prevalence of smoking habits, for example, can be found at country level in the corresponding Eurostat database (17), and finer geographical information will have to be retrieved from the National Institute of Statistics. Other possible confounders to be considered

could be deprivation index as a proxy of socioeconomic conditions and population density as an urban–rural proxy (15). The lack of ability to control for the effects of potential confounding factors is one of the big limitations when analysing aggregated data (18), such as cancer indicators and radon concentration means. Even if data on confounding factors were available, it could be difficult to adjust for them at a population level (18). All these aspects will have to be considered when designing the analyses and discussing the results.

Future plans for ECIS include speeding up the process for computing the cancer indicators, extending the data coverage and cancer entity definition, improving the geographical detail, inclusion of paediatric cancers, and the additional reporting of cancer stage and treatment information. ECIS is well positioned to monitor the evolving situation of cancer in Europe, to inform policy and to

European Indoor Radon Map, December 2020



Sources: <https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Digital-Atlas> (accessed on 15 June 2021)

Fig. 6. European Indoor Radon Map: the arithmetic mean of the annual indoor radon concentration in ground-floor rooms of dwellings over 10 km × 10 km grid cells.

promote additional research through the integration of its database with other pertinent data sources. This will allow the possibility of exploring potential linkages between human exposure to concentrations of carcinogens, including environmental risk factors, and cancer burden data.

Conflict of interest and funding

The authors declare no potential conflicts of interest.

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