Risk of Lung Cancer Mortality in Nuclear Workers from Internal Exposure to Alpha Particle-emitting Radionuclides

James Grellier1,2,3,4; Will Atkinson5; Philippe Bérard6; Derek Bingham7; Alan Birchall8; Eric Blanchard9; Richard Bull3; Irina Guseva Canu10; Cécile Challeton-de Vathaire10; Rupert Cockerill7; Minh T. Do11; Hilde Engels12; Jordi Figuerola1,2,3; Adrian Foster13; Luc Holmstock12; Christian Hurtgen12; Dominique Laurier9; Matthew Puncher8; Anthony E. Riddell8; Eric Samson9; Isabelle Thierry-Chef14; Margot Tirmarche9; Martine Vrijheid1,2,3; Elisabeth Cardis1,2,3

1ISGlobal, Centre for Research in Environmental Epidemiology, Barcelona, Spain; 2Universitat Pompeu Fabra, Barcelona, Spain; 3CIBER Epidemiología y Salud Pública, Madrid, Spain; 4Department of Epidemiology and Biostatistics, Imperial College, London, United Kingdom; 5Nuvia Limited, Didcot, United Kingdom; 6Commissariat à l’Energie Atomique, Fontenay-aux-Roses, France; 7Atomic Weapons Establishment, Aldermaston, United Kingdom; 8Public Health England, Didcot & Moor Row, United Kingdom; 9Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, France; 10Institut de Veille Sanitaire, Saint Maurice, France; 11Occupational Cancer Research Centre, Toronto, ON, Canada; 12Studiecentrum voor Kernenergie • Centre d’Étude de l’énergie Nucléaire, Mol, Belgium; 13UK Atomic Energy Authority, Culham, United Kingdom; 14Autorité de Sûreté Nucléaire, Paris, France; 15International Agency for Research on Cancer, Lyon, France.

Background: Carcinogenic risks of internal exposures to alpha-emitters (except radon) are poorly understood. Since exposure to alpha particles—particularly through inhalation—occurs in a range of settings, understanding consequent risks is a public health priority. We aimed to quantify dose–response relationships between lung dose from alpha-emitters and lung cancer in nuclear workers.

Methods: We conducted a case–control study, nested within Belgian, French, and UK cohorts of uranium and plutonium workers. Cases were workers who died from lung cancer; one to three controls were matched to each. Lung doses from alpha-emitters were assessed using bioassay data. We estimated excess odds ratio (OR) of lung cancer per gray (Gy) of lung dose.

Results: The study comprised 553 cases and 1,333 controls. Median positive total alpha lung dose was 2.42 mGy (mean: 8.13 mGy; maximum: 316 mGy); for plutonium the median was 1.27 mGy and for uranium 2.17 mGy. Excess OR/Gy (90% confidence interval)—adjusted for external radiation, socioeconomic status, and smoking—was 11 (2.6, 24) for total alpha dose, 50 (17, 106) for plutonium, and 5.3 (−1.9, 18) for uranium.

Conclusions: We found strong evidence for associations between low doses from alpha-emitters and lung cancer risk. The excess OR/Gy was greater for plutonium than uranium, though confidence intervals overlap. Risk estimates were similar to those estimated previously in plutonium workers, and in uranium miners exposed to radon and its progeny. Expressed as risk/equivalent dose in sieverts (Sv), our estimates are somewhat larger than but consistent with those for atomic bomb survivors.