

**Title:** Understanding how urban housing design affects residents' exposure to indoor radioactive radon gas compared to the rural equivalents, irrespective of regions in Canada: A geospatial analysis

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**Abstract:** Inhalation of radioactive radon gas within the built environment is a leading cause of lung cancer in Canada, with Canadian exposures being amongst the highest globally. No geographical area of Canada has been found to be risk free of lung cancer from the long-term exposure to radioactive soil gas radon with doses of 100 Bq.m<sup>3</sup> or higher. Differences within the built environment are a primary driver of radon level differences between properties, with newer and larger residential homes with fewer storeys containing even higher levels compared to older, smaller, and multi-storey equivalents. Here, we examined differences in residential radon gas exposure between different community types (city versus large town versus small town versus village-hamlet-isolated properties) across the urban to rural paradigm as classified by Statistics Canada based on population density. We find substantial differences between community types, with people in rural communities in any Canadian province or territory experiencing even greater levels of residential radon exposure relative to urban populations; this was established by unsupervised machine learning multivariate clustering in ArcGIS, as well as a comparative analysis of geometric mean radon. Pairwise and multivariate analysis established that differences in construction years, design type, number of storeys, and ceiling height do not explain urban versus rural differences in radon. However, floorplan size (property square footage) and the usage of groundwater well as a water supply within a community correlated significantly with greater radon in rural community residences. We propose a model in which the proximity of a domestic groundwater well to a residential property operates as a “radon-syphon” enabling greater penetration of surficial soils with radon (from subsurface radon reservoirs in soil gas), generating higher radon levels in rural community homes, especially those that have larger surface areas on the ground. This work highlights a community-based disparity in Canadian residential radon exposure,.

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