Study on possible different distributions of indoor radon levels in dwellings and workplaces: preliminary results

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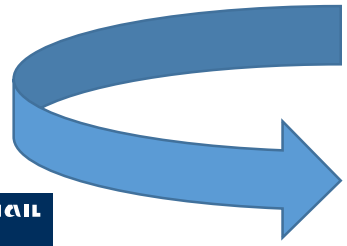
Indoor Rn - Differences between dwellings (DW) and workplaces (WP)

Workplaces (WP) can differ from **dwellings** (DW) in terms of:

- **Building structure**: multi-storey buildings with large entrance hall and large rooms (*open spaces*),
- **Microclimatic conditions**: humidity rate, dust, aerosols, temperature etc.
- High presence of **air-conditioning systems** or **forced ventilation**;
- Widespread use of rooms at **ground floor** or **basement**;
- **Occupancy factors**: not continuous usage pattern (closure during nights, weekends, holidays, etc.)
- **Inhomogeneity**: different working activities



These differences could affect radon levels and trends.
Compared with dwellings, workplaces are often characterized by relatively larger spatial and temporal variations in radon levels.

Indoor Rn - Differences between dwellings (DW) and workplaces (WP) – cont.

✓Few indoor radon surveys investigated indoor radon levels both in dwellings and workplaces within the same area.

*Previous surveys carried out in **Italy** and in **Japan** showed radon levels higher in workplaces respect to dwellings.*

*Conversely, opposite trends were found in other studies carried out in **Finland** and in **Mexico**.*

Compared with workplaces, dwellings seem to have less internal variability, less CV, more uniform living habits, so dwellings are more suitable than workplaces to represent radon distribution in a certain area.

Bucci S. et al. *Radon in workplaces: first results of an extensive survey and comparison with radon in homes.* Radiat. Prot. Dosim. 145:202-205 (2011)

Espinosa G. et al. *Nationwide survey of radon levels in indoor workplaces in Mexico using Nuclear Track Methodology*. Radiat. Meas. 44:1051-1054 (2009)

Oikawa S. et al. *A survey of indoor workplace radon concentration in Japan.* J. Environ. Radioact. 87:239-245 (2006)

Mäkeläinen I. et al. *Indoor occupancy and radon exposure in Finland.* Radioactivity in the Environment. Elsevier 2005; 7:687-693 (2005)

MetroRADON Subtask 4.1.1.2
Radon dwellings vs workplaces (DW/WP)

In the framework of **WP4: Radon priority areas (RPAs) and the development of the concept of a "geogenic radon hazard index" (RHI)**

the subtask **4.1.1.2** focused on *Radon: dwellings vs workplaces*

Main goals:

1. re-analyze radon data collected in WP and DW in some European countries, in order to **compare the results** and **find information about a possible correlation** of the **distribution** of indoor radon levels in **workplaces** and in **dwellings**.
2. elaboration of a **model** predicting the direction in which radon levels in workplaces and dwellings **could diverge**.

Step 1

1.1 **Build-up of reliable radon datasets** (dwellings and workplaces) coming from surveys carried out in some European countries.

The building-up of national **reliable** radon datasets (dwellings and workplaces) from surveys carried out in some European countries requires the **collection** of data **comparable** in terms of:

- Position: data referred only to rooms located at **ground floor.**
- Quantity of interest: **radon annual average concentration.**
- Duration of measurements: **long term measurements** to evaluate the average radon activity concentration.
- About workplaces dataset, the need to collect data about **different type of workplaces.**

Step 1 – results

	Italy	Finland	Germany	Austria
Duration of measurements/ DW	Annual sampling	60-70 days	4 – 12 months	**6 months** (*half winter half summer*)
Duration of measurements/ WP	Annual sampling	60-70 days	Annual sampling	**3 months** for schools **6 months** (*half winter half summer*) for administrative buildings
Workplaces considered	Several types of workplaces – no special workpl. (*as mines, etc.*)	Several types of workplaces – no special workpl. (*as mines, etc.*)	Public buildings (*administrative buildings, schools, kindergartens*)	Public buildings (*administrative buildings, schools, kindergartens*)

***Critical issue**:* It is evident the problem of harmonizing data in order to compare the same quantity of interest at national level, as among countries.

Step 2

1.2 **Development of an analysis protocol**: to investigate the difference between distributions of Rn in DW and WP in a certain area, the knowledge of the measurement position is necessary. For data protection and privacy reasons, it was preferred to carry out the analysis on spatially aggregated data.

As aggregation unit, it was chosen the same as already used on dwellings data to update the EIRM (European Indoor Radon Map) of JRC, based on 10 km × 10 km grid cells. Participants were asked to aggregate workplaces' data into the same grid cells and provide the relevant statistics for further analysis.

The same statistics were provided, i.e. AM, SD, AML, SDL, Median, Min, Max and number of data n

Step 2 – results

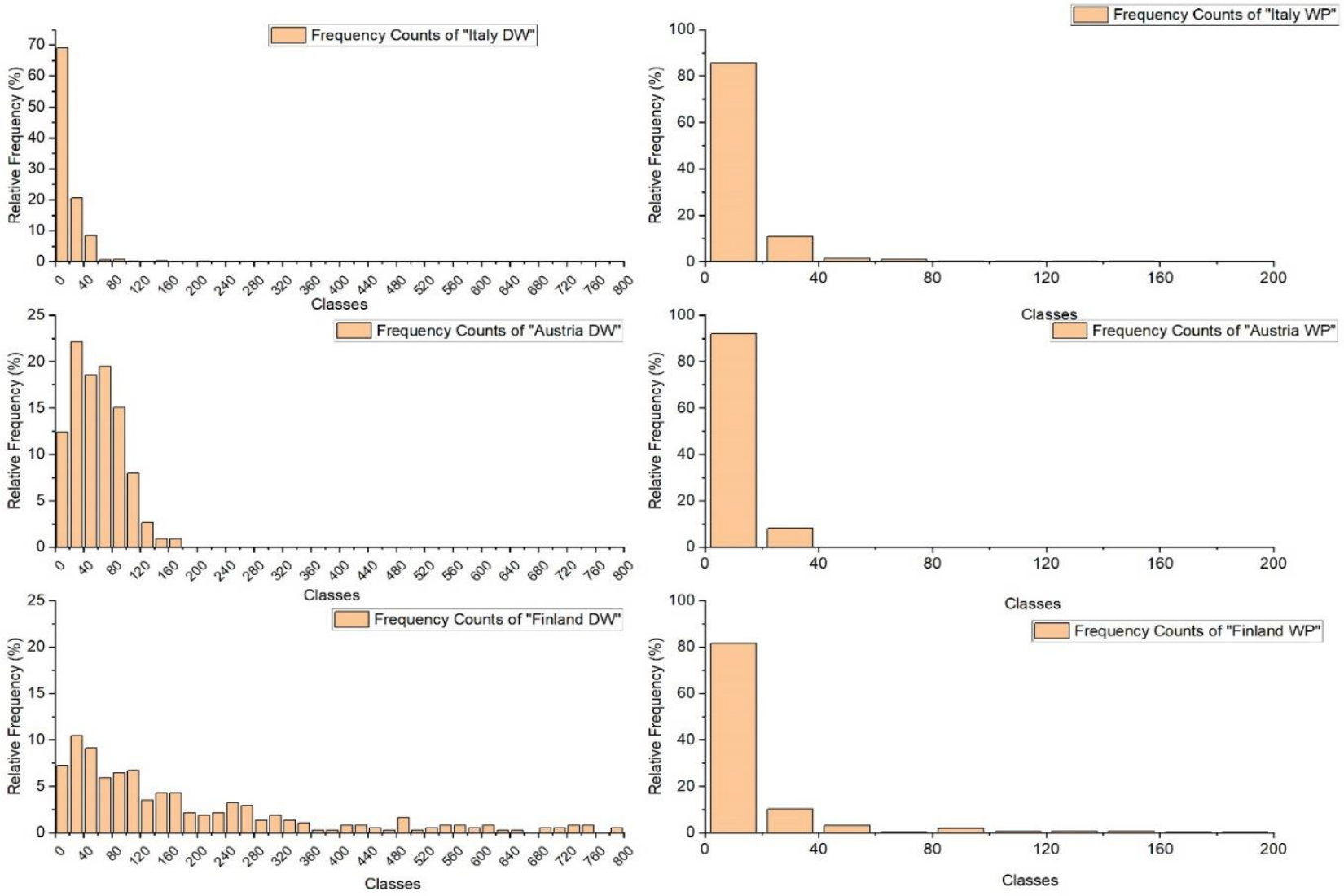
Participants/ Countries	DW (raw dataset)	WP (raw dataset)
Austria	~7000	~1,200 (1000 public buildings + 200 schools – kindergartens)
Germany (Saxony)	Data collection in progress	~3,400 (1,200 workplaces + 708 public buildings + 710 schools/kindergartens + 711 workplaces in the administrative buildings)
Italy	~14,700	9,000 (2,416 workplaces + 6,297 schools – kindergartens)
Finland	~200,000	~6,300

Critical issue: Typically data about workplaces are fewer than radon data about dwellings.

Step 2 – results (cont.)

Frequency distribution of sample size (DW and WP) in cells within each national dataset.

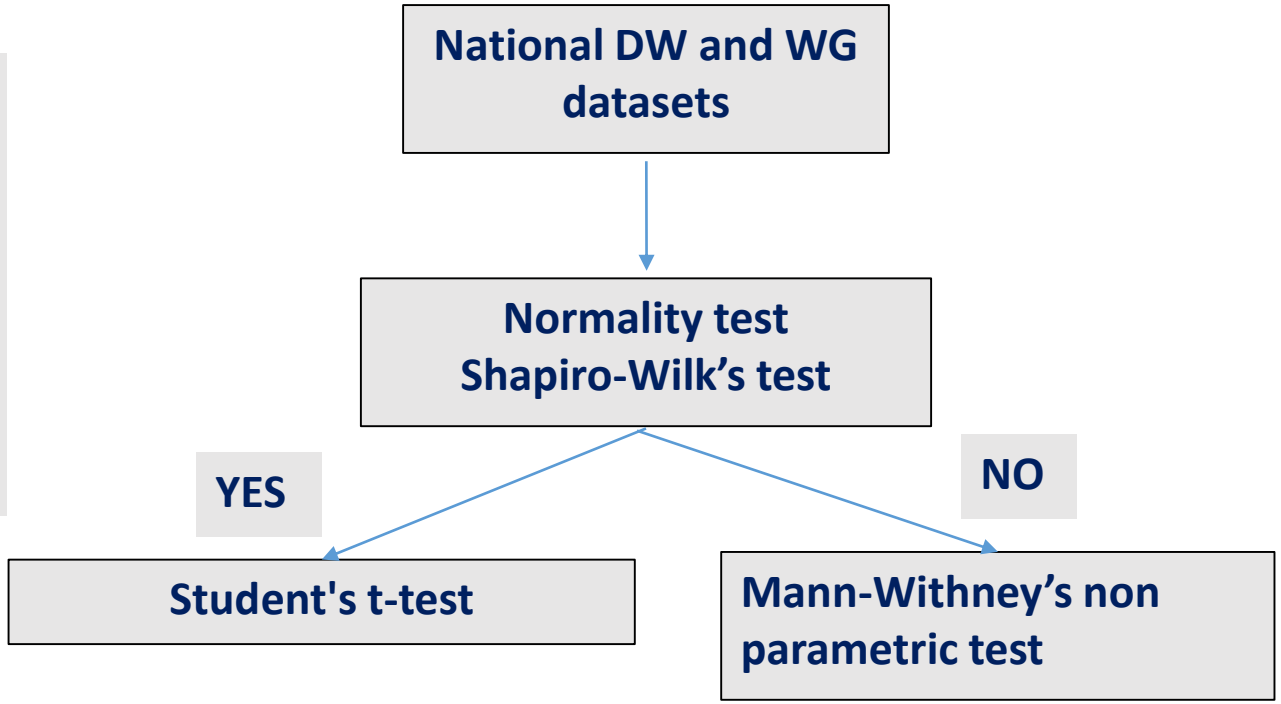
Critical issue: In national DW datasets the sample size is spread in many classes, while in WP datasets, the most of data is in classes of 20 samples per unit (cell)



Step 3

1.3 **Comparison of DW and WP datasets' means to investigate if they have the same distribution**: among available statistical parameters, the AM(ln) and SD(ln) seem to be the best parameters for statistical analysis, because there are no information about the distribution of data (radon annual average concentration) within cells.

- Tests were conducted on a **"matched-pairs sample"** to eliminate the effects of confounding factors (the contribution of soil) on radon levels.
- **P-values <0.05 are considered significant.**



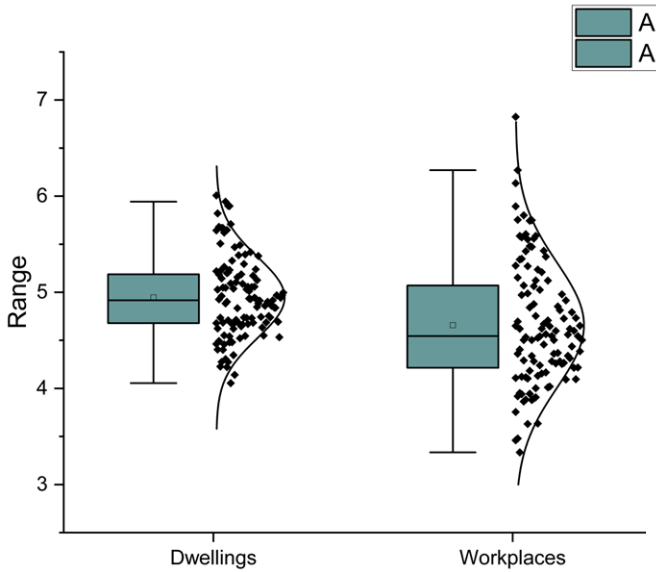
Step 3 – results

	Austria		Finland		Italy	
	DW	**WP**	**DW**	**WP**	**DW**	**WP**
N.samples	6615	1167	161976	5983	11359	7566
N.Cells	113		373		623	
AM(ln)±SD (Bq/m³)	5.0±0.4	4.7±0.7	4.9±0.5	4.1±0.7	4.4±0.5	4.4±0.6
p-Value	Mann-Withney <0.001		Mann-Withney <0.001		T-Student = 0.0126	

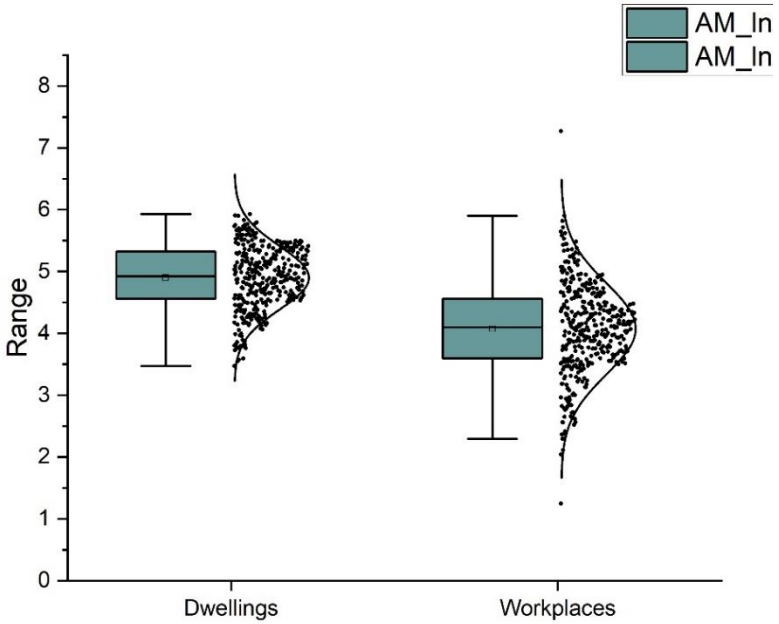
Comments:

1. In Austria, Finland and Italy, within the same area, average radon levels in DW and in "general" WP seem to be **statistically different**. The analysis on German (Saxony) data is ongoing.
2. Respect to DW, in "general" **WP** radon levels are **significantly lower** and **more variable**, in terms of a wider distribution and greater standard deviation (see Box plots).
3. **Critical issue:** The paired sample tests do not account for different sample size of populations (sets of data). The matching is carried out by identifying pairs of values consisting of one observation from each of the two samples.

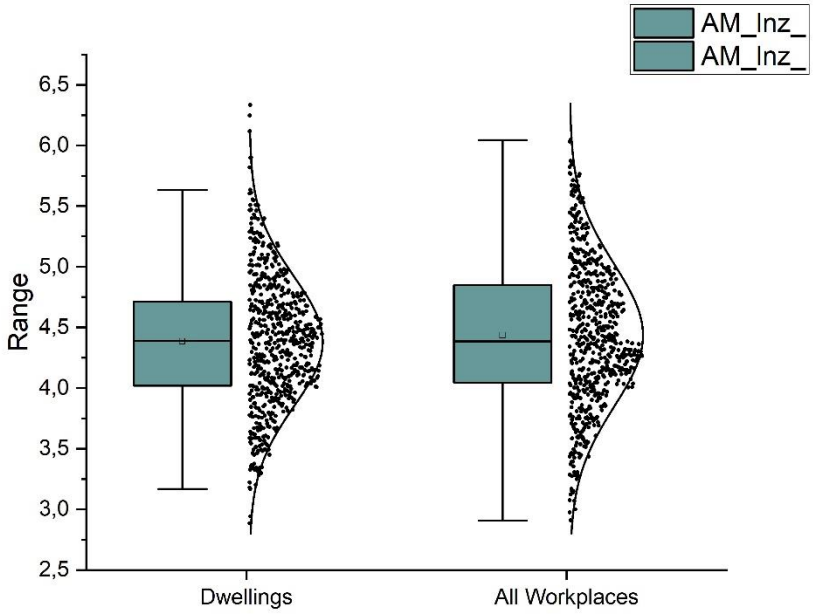
Step 3 – results – Blox plots



Austria



Finland

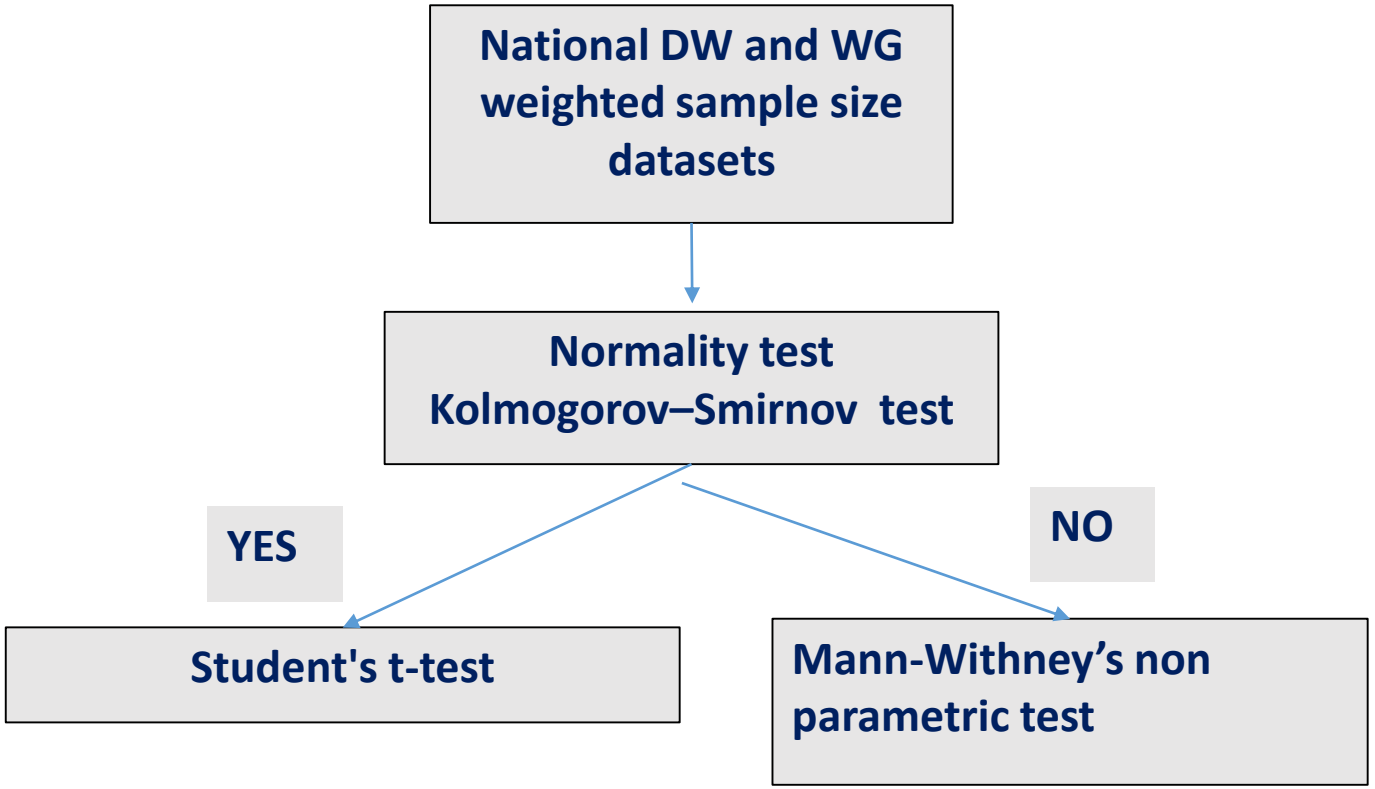


Italy

Step 4

1.4 **Comparison of sample means AM(ln) by using weighted sample size data:** to take into account the different number of samples of DW and WP in each cell, weighted sample size data were considered in a new analysis.

- Normality Test (Kolmogorov–Smirnov test): to test the hypothesis that data come from a normally distributed population
- In case of data not normally distributed, the Mann-Withney's non parametric test was applied.
- **P-values <0.05 are considered significant.**



Step 4 – results

	Austria		Finland		Italy	
	DW	**WP**	**DW**	**WP**	**DW**	**WP**
N.samples	6615	1167	161976	5983	11359	7566
N.Cells	113		373		623	
AM(ln)±SD	4.9±0.4	4.6±0.6	5.1±0.4	4.2±0.5	4.5±0.5	4.4±0.5
p-Value	Mann-Withney <0.001		Mann-Withney <0.001		Mann-Withney <0.001	

Comments:

1. In Austria, Finland and Italy, average radon levels in dwellings and in "general" workplaces seem to be **statistically different**. The analysis on Saxony data is ongoing.
2. It is confirmed that, in "general" **WP** radon levels are **significantly lower** and **more variable** than in DW, as in terms of a wider distribution as of greater standard deviation.
3. **Critical issue**: the comparison of weighted data does not account a confounding factor (soil).

Step 5

1.5 Comparison of sample means (GM) by multivariate logistic regression analysis - in progress

A tentative to take into consideration simultaneously the influence of soil (as confounding factor) and of the sample size is ongoing by running a **multivariate logistic regression analysis on national datasets, in particular on GMs.**

Conclusions and perspectives

- Typically, international/national regulations introduce specific requirements to control radon exposure in workplaces located within such areas (RPA) defined on the basis of surveys carried out in DWs.
- The **correlation** between indoor radon levels in WPs and in DWs should be known before taking such decisions.
- A study on Austrian, Finnish, Italian and German data is ongoing.
- First results show a distribution of radon in DWs and WPs within the same area **statistically different** and respect to DWs, in "general" WPs radon levels are significantly lower and more variable.
- A critical issue is the different number of data between DWs and WPs (**sample size**): workplace radon data are few respect to DWs ones.
- "**WPs**" are a **broad category** which includes schools, public buildings, hospitals, factories, shops, etc. The comparison between DWs and particular categories of WPs (such as school, public building etc.) is in progress as well as the comparison between different categories of WPs.

Thank you!

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