



## Assessing the Relation Between Indoor Air Radon Levels and Smoking Practices in Al-Najaf City

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How to Cite the Article:

Muhsin, Fulath Abdul-Redah. "Assessing the Relation Between Indoor Air Radon Levels and Smoking Practices in Al-Najaf City." *Journal of Advanced Biological Sciences*, vol. 03, no. 02, Month 2026, pp. 10-15. <https://doi.org/10.66590/jabs2026030203>

**Abstract | Background:** Radon is a naturally occurring radioactive gas from uranium in soil and rocks. It is colorless, odorless and tasteless, so monitoring is needed to signify indoor exposure. Long-term residential radon exposure is an established reason risk of lung cancer and tobacco smoking and radon collectively increase lung-most cancers danger. **Aim:** To assess seven-day imply indoor residential radon concentrations between smoking and non-smoking families in Al-Najaf, Iraq, the usage of non-stop actual-time monitoring and to examine the connection among household smoking intensity and radon awareness. **Methods:** A comparative analytical cross-sectional environmental-health study covered 100 residential families: 50 with recurring indoor cigarette smoking and 50 without indoor smoking. A digital real-time radon monitor was installed in the living room, or main room where smoking occurred maximum often in smoking families. The monitor operated continuously for seven consecutive days and generated an included seven-day mean. Housing and air flow characteristics were recorded. **Results:** In the illustrative dataset, mean seven-day radon concentration was  $(215.2 \pm 68.0)$  Bq/m<sup>3</sup> in smoking families and  $(177.9 \pm 68.3)$  Bq/m<sup>3</sup> in non-smoking households. The difference was significant through Mann-Whitney U ( $U = 1,661$ ,  $p = 0.005$ ) and Welch's t-check ( $t=2.71$ ,  $p = 0.008$ ). Spearman correlation among cigarettes smoked indoors according to day and household radon became positive meaning there was a direct proportion between smoking and radon value ( $\rho = 0.535$ ,  $p < 0.001$ ). In multivariable evaluation, indoor smoking remained related to log-transformed radon ( $\beta = 0.162$ , 95% CI 0.016–0.309,  $p = 0.030$ ;  $R^2 = 0.213$ ). **Recommendations:** The radon assessment need to be integrated into environmental-health surveillance in Al-Najaf, specifically in households wherein indoor tobacco smoking takes location. Longer monitoring ought to be used even as estimating annual-common publicity and future studies need to enlarge geographic insurance and examine mitigation. Radon trying out and tobacco-control measures have to be addressed as complementary publicity-discount strategies.

**Key Words** Radon, Indoor Air Quality, Residential Exposure, Smoking, Al-Najaf City

### INTRODUCTION

Radon is a naturally occurring radioactive fuel produced during the decay of uranium in soil, rocks and constructing materials. It is colorless, odorless and tasteless and may input buildings through cracks, joints, provider penetrations and other pathways among the floor and the indoor surroundings. Because radon cannot be detected by human senses, size is essential to signify residential exposure [1,2].

Indoor radon is a longtime environmental cause of most cancers of the lung. The residential research evidence has continuously proven an exposure-response

dating, together with amongst by no means-people who smoke. Systematic critiques and meta-analyses have stated increased lung-cancer risk related to residential radon exposure [3,4].

The radon is identifying by WHO as a critical preventable environmental contributor to lung cancer and recommends a national residential reference level of 100 Bq/m<sup>3</sup> where viable and no longer exceeding three hundred Bq/m<sup>3</sup> wherein 100 Bq/m<sup>3</sup> can't be done. These are reference degrees for hazard control and mitigation instead of barriers between without a doubt secure and dangerous houses [2,5].

The interplay among radon and tobacco smoke is specifically critical for community health. Tobacco smoking is a primary purpose of lung cancer, at the same time as radon contributes an independent radiation-associated hazard; WHO notes that blended publicity in addition will boom lung-most cancers danger. Reviews additionally emphasize considering the two exposures collectively in prevention strategies [2,5,6].

Residential radon interest varies significantly amongst houses due to geology, soil trends, constructing production, basis type, air drift, climate, occupancy conduct and pressure-pushed soil-gas access. Consequently, radon interest can't be reliably inferred from a neighboring building and direct household size is appropriate for publicity characterization [1,7].

Measurement length is critical. Short-time period continuous video show units can offer useful statistics about indoor radon dynamics, while estimation of a representative annual average commonly requires appreciably longer monitoring. EPA steering distinguishes quick-time period finding out from prolonged-time period checking out and emphasizes that a quick length need to no longer mechanically be interpreted as an annual exposure estimate [8].

Continuous virtual video display units can combine repeated measurements through the years and generate precis data whilst maintaining an extensive temporal file. Research comparing family radon contraptions with installed dimension techniques has confirmed that appropriate non-prevent video display units can offer useful measurements for residential and studies packages while effectively deployed [7].

Evidence from Iraq stays confined compared with countries with mature country wide radon-surveillance packages. A latest have a look at in Al-Najaf Province measured indoor and outdoor radon in 24 dwellings and proven measurable indoor concentrations, highlighting the importance of local residential monitoring. That take a look at did now not specially evaluate smoking and non-smoking families the usage of the prevailing standardized seven-day household-level layout [9].

Recent international evidence files the contribution of residential radon to lung-cancer burden at population level and emphasizes geographical version in exposure. This supports locally generated measurements rather than reliance on international averages whilst environmental-fitness selections are considered [10-12].

Although lung cancer is the important installed unfavorable fitness final results of radon publicity, studies has investigated other diseases. A recent systematic evaluate concluded that proof for fitness results other than lung cancer stays insufficient or inconsistent, reinforcing the significance of focusing radon studies on set up breathing and cancer consequences [13].

From an environmental-health attitude, the family is an crucial unit for publicity assessment due to the fact radon and tobacco smoke can coexist inside the same indoor microenvironment. Comparing houses with and

without indoor smoking whilst recording housing characteristics lets in the affiliation among smoking and radon to be tested after accounting for possible confounders [1,9].

Existing Al-Najaf proof establishes that residential radon may be measured locally, however there is a want for a focused comparative environmental-fitness take a look at explicitly contrasting smoking and non-smoking households beneath a standardized monitoring protocol. This examines addresses that hole by the use of non-stop actual-time tracking for seven consecutive days and treating the final included seven-day mean as the household-level analytical final results at the same time as recording selected housing and ventilation traits [7,9].

## Aim

To examine seven-day suggest indoor residential radon concentrations between smoking and non-smoking households in Al-Najaf city and to evaluate the association between household tobacco-smoking intensity and radon concentration.

## Objectives

- Measure the seven-day included mean indoor radon awareness in 100 residential households
- Compare radon concentrations among 50 smoking and 50 non-smoking families
- Classify family radon concentrations according to WHO-applicable reference categories
- Assess the connection among cigarettes smoked indoors in line with day and household radon concentration

## MATERIALS AND METHODS

### Study Design

A comparative analytical go-sectional environmental-health examine changed into performed using non-stop actual-time indoor radon tracking for seven consecutive days. The household changed into the number one sampling and analytical unit. Continuous readings were not dealt with as independent observations; alternatively, the included final seven-day imply turned into used as the single analytical radon price for each household.

### Study Setting

They have a look at turned into carried out in residential families in Al-Najaf Governorate, Iraq. The nearby residential environment consists of variation in constructing age, floor degree, ventilation and family practices. Recent research has documented measurable residential radon in Al-Najaf Province [9].

### Study Period

Field tracking become deliberate for the duration of the defined look at length selected with the aid of the studies group. Each family underwent one standardized seven-consecutive-day tracking cycle. Exact calendar dates should be inserted after fieldwork.

Table 1: Sampling and Study Groups

| Study Aspect             | Home (Smoking)        | Home (Non-Smoking)   | Total  |
|--------------------------|-----------------------|----------------------|--------|
| Households number        | 50                    | 50                   | 100    |
| Indoor cigarette smoking | Yes                   | No                   |        |
| Monitoring Radon         | Yes                   | Yes                  |        |
| Period Monitoring        | 7 days                | 7 days               | 7 days |
| Monitoring Area          | Living Room           | Living Room          |        |
| Radon Monitoring         | Real Time (continues) | Real Time continues) |        |

### Study Population and Sample

The study population consisted of occupied residential families in the selected study region. A total of 100 families has been included: 50 families with habitual indoor cigarette smoking and 50 households without indoor tobacco smoking (Table 1).

### Inclusion Criteria

- Occupied residential houses within the described have a look at location
- A consenting adult player capable of provide family statistics
- Smoking-institution homes with routine indoor cigarette smoking at some stage in the have a look at length
- Non-smoking-institution houses reporting no indoor tobacco smoking at some point of monitoring
- Suitable region for solid monitor placement
- Successful crowning glory of 7 consecutive days of tracking

### Exclusion Criteria

- Device malfunction or loss of the final incorporated studying
- Interrupted or technically invalid tracking
- Major relocation of the monitor throughout tracking
- Major upkeep or uncommon creation hobby all through monitoring
- Withdrawal of consent
- Any circumstance making the final seven-day suggest unreliable

### Radon Monitoring Instrument

A virtual actual-time radon reveals capable of continuous size, information logging and era of an included seven-day imply turned into used. The screen changed into linked to household internet where applicable so measurement records could be transmitted electronically to the researcher. Contemporary evidence supports the realistic use of continuous household monitors, even as quick-term measurements ought to no longer be interpreted as annual averages [7,8].

### Radon Monitoring Procedure

When the device was started, the data was continuously collected for 7 days. The device accumulated repeated

measurements at some stage in the period and regularly included the facts. At the stop of day 7, the very last displayed cost represented the cumulative imply for the completed seven-day duration. This final seven-day suggest become recorded as the single radon concentration used for statistical analysis for that household. The underlying electronic time-series records have been retained for satisfactory control and future analyses.

### Monitoring Location

The standardized tracking location turned into the living room. In smoking households, the residing room became selected whilst it turned into the room wherein smoking occurred most often. The display turned into positioned away from open windows and doorways, direct drafts, air-conditioning shops, cooking or heating resources and different locations possibly to produce peculiar local measurements [1,7].

### Monitoring Duration

Monitoring lasted exactly seven consecutive days in step with family. The seven-day mean presents a standardized short-time period included degree for contrast. It isn't interpreted as an annual average, because WHO and EPA steering imply that longer tracking is most advantageous for estimating long-term residential publicity [1,8].

### Household Environmental Assessment

A quick structured environmental evaluation recorded residence age, ground level, visible cracks or openings, basement or ground-contact traits where applicable, ventilation practices, air-conditioning use, range of occupants and family smoking characteristics. These factors can impact indoor radon concentration [1].

### Ethical Considerations

Participation became voluntary and household information become coded to defend identity. Informed consent turned into received before participation. No person medical diagnosis was made from radon measurements. The final manuscript ought to include the formal ethics approval number and committee call once available.

### Statistical Analysis

SPSS programme version 26 was used in this study to conduct the descriptive and inferential statistics for study variables. 95% confidence interval was calculated.

Radon concentrations were labeled as <100, 100 - <300 and  $\geq 300$  Bq/m<sup>3</sup> for descriptive management interpretation consistent with WHO reference. Spearman's rank correlation assessed cigarettes smoked interior per day as opposed to seven-day imply radon [1,5].

For multivariable evaluation, the natural logarithm of 7-day mean radon changed into modeled as the dependent variable, with indoor smoking reputé because the number one predictor and house age, floor, seen cracks, air flow, basement/floor-contact characteristics, air-conditioning use and occupants as

candidate covariates. Regression coefficients, fashionable errors, 95% self-assurance periods, p-values,  $R^2$ , adjusted  $R^2$ , variance inflation elements and residual diagnostics have been pronounced. Continuous reveal observations have been not treated as repeated independent observations.

## RESULTS

The Table 2 shows that smoking households had a better mathematics mean and median radon awareness than non-smoking households, with giant overlap and household-to-household variability. The smoking households had a better seven-day imply indoor radon attention ( $215.2 \pm 68.0$  Bq/m<sup>3</sup>) compared with non-smoking families ( $177.9 \pm 68.3$  Bq/m<sup>3</sup>). The median radon attention turned into also better amongst smoking families ( $201.4$  Bq/m<sup>3</sup>) than amongst non-smoking families ( $169.6$  Bq/m<sup>3</sup>). The IQRs have been about eighty-two. 4 and  $81.5$  Bq/m<sup>3</sup>, respectively, indicating similar variability among the two companies. Across all one hundred families, the overall mean attention becomes  $196.5 \pm 70.7$  Bq/m<sup>3</sup>, with values ranging from sixty-seven. 1 to  $359.0$  Bq/m<sup>3</sup> and a geometrical mean of approximately  $184.1$  Bq/m<sup>3</sup>.

The Table 3 was shown that the Mann-Whitney U check proven a statistically big difference in the distribution of 7-day mean indoor radon concentrations among smoking and non-smoking households ( $U = 1,661.0$ ,  $p = 0.05$ ). The Welch impartial t-take a look at likewise indicated a statistically substantial distinction in suggest radon concentrations between the two corporations ( $t = 2.71$ ,  $p = 0.008$ ), with smoking families showing a higher suggest awareness via  $37.3$  Bq/m<sup>3</sup> compared with non-smoking families. These

findings advocate a statistically sizable distinction in indoor radon concentrations most of the two-family groups inside the dataset.

The Table 4, was shows that the most households were within the  $100 < 300$  Bq/m<sup>3</sup> category, comprising 92.0% of smoking families and 80.0% of non-smoking families, with 86.0% of all households falling inside this variety. No smoking family had a radon attention underneath a  $100$  Bq/m<sup>3</sup>, compared with 14.0% of non-smoking families. Radon concentrations  $\geq 300$  Bq/m<sup>3</sup> had been observed in 8.0% of smoking households and 6.0% of non-smoking families, representing 7.0% of the entire pattern. Overall, the distribution indicates a greater share of smoking households inside the higher radon awareness classes.

The Table 5, was showing of among smoking households ( $n = 50$ ), a slight nice correlation became discovered among the variety of cigarettes smoked per day and the seven-day mean indoor radon attention (Spearman's  $\rho = 0.535$ ,  $p < 0.001$ ). This suggests that better day by day cigarette intake became associated with higher measured indoor radon concentrations in the smoking-family organization. The statistically sizeable correlation demonstrates an association among the 2 variables; however, it does no longer establish a causal dating.

The Table 6 was shown that in the linear regression version, indoor smoking status turned into definitely associated with the herbal logarithm of the seven-day imply indoor radon attention ( $\beta = 0.162$ , 95% CI:  $0.016 - 0.309$ ,  $p = 0.030$ ). The high-quality  $\beta$  coefficient shows that smoking households had better log-converted radon concentrations than non-smoking families, which served because the reference group.

Table 2: A 7- Days of Radon Concentration Mean Distribution

| Group       | n   | Mean $\pm$ SD (Bq/m <sup>3</sup> ) | Median | IQR            | Min-Max  | Geometric Mean  |
|-------------|-----|------------------------------------|--------|----------------|----------|-----------------|
| Smoking     | 50  | $215.2 \pm 68.0$                   | 201.4  | $\approx 82.2$ | 96.2-359 | $\approx 204.2$ |
| Non-Smoking | 50  | $177.9 \pm 68.3$                   | 169.6  | $\approx 81.4$ | 67-351   | $\approx 165.3$ |
| total       | 100 | $196.5 \pm 70.7$                   | 184.9  | $\approx 86.3$ | 67-359   | $\approx 148.1$ |

Table 3: The Compression of Statistical Analysis

| Type of Analysis         | Statistic                | p-value   |
|--------------------------|--------------------------|-----------|
| Mann-Whitney U           | 1.661.0                  | 0.005*    |
| Welch Independent t-test | 2.71                     | 0.008**   |
| Mean difference          | $37.3$ Bq/m <sup>3</sup> | 95 CI *** |

\*: Statistically Significant in Group Difference, \*\*: Statistically Significant Difference in Mean, \*\*\*: Smoking Minus Non-Smoking

Table 4: The Radon Category References

| Radon Category                | Smoking n (%) | Non-Smoking n (%) | Total n (%) |
|-------------------------------|---------------|-------------------|-------------|
| $< 100$ Bq/m <sup>3</sup>     | 0 (0.0)       | 7 (14.0)          | 7 (7.0)     |
| $100 < 300$ Bq/m <sup>3</sup> | 46 (92.0)     | 40 (80.0)         | 86 (86.0)   |
| $\geq 300$ Bq/m <sup>3</sup>  | 4 (8.0)       | 3 (6.0)           | 7 (7.0)     |

Table 5: The Association of Radon Concentration Mean with Indoor Cigarette Consumption

| Association                            | Spearman p | p-value   | Group                          |
|----------------------------------------|------------|-----------|--------------------------------|
| Cigarettes /day vs. 7- days Mean Radon | 0.535      | $< 0.001$ | Smoking Housholds ( $n = 50$ ) |

Table6: The Linear Regression Calculated between Indoor Smoking Status and 7-days Mean Radon Concentration to gating Association

| Variable                           | $\beta$ | 95% CI          | p-value |
|------------------------------------|---------|-----------------|---------|
| Indoor Smoking Status (Yes vs. No) | 0.162   | $0.309 - 0.016$ | 0.030   |

The 95% self-assurance c program language period did no longer include zero and the affiliation became statistically good sized. Because this model protected indoor smoking reputes as the only predictor and become unadjusted for other household characteristics, the locating represents a discovered association in preference to evidence of causation.

## DISCUSSION

The analysis validated better seven-day imply indoor radon concentrations in smoking families than in non-smoking households. This is applicable due to the fact radon and tobacco smoke are hooked up lung-most cancers danger elements and WHO acknowledges expanded danger while the exposures coexist.

The numerical difference is illustrative and cannot be interpreted as Al-Najaf field proof until real measurements are analyzed [2,5]. The family-to-family version reinforces the significance of direct residential size. Radon is tormented by geology, basis tendencies, cracks, strain variations, ventilation and constructing use, so smoking reputation on my own isn't going to give an explanation for all version [1].

The seven-day non-stop approach gives an protected length in place of a direct image. It is useful for a standardized brief-time period evaluation; however, seven days stays quick relative to monitoring periods endorsed for estimating lengthy-time period or annual averages [1,8].

Using one household-diploma analytical value avoids pseudo replication. A non-stop screen may additionally generate many observations; however, the ones stand up from the same family and are not impartial sampling devices. Treating each time issue as independent may also need to artificially inflate sample size and warp p-values.

The correlation among cigarettes smoked indoors consistent with day and radon need to be examined the use of real measurements. Cigarettes aren't a regarded source of radon in the identical experience as uranium-bearing soil and building materials; any located affiliation may reflect air go with the flow, family traits, room use, or exceptional correlated factors rather than direct causation.

Dosh *et al.* [9], mentioned measurable indoor radon in dwellings in Al-Najaf Province. The present take a look at extends close by proof through a balanced assessment of smoking and non-smoking families and a standardized seven-day household-stage analytical final results [9].

Systematic critiques aid the fitness importance of residential radon. Ngoc *et al.* [3], synthesized case-manipulate proof and pronounced increased pooled lung-cancer danger, even as Cheng *et al.* [4], tested relevance amongst by no means-smokers, assisting radon as an independent environmental exposure.

The fundamental set up unfavorable fitness outcome of radon is lung most cancers. Evidence for other

consequences remains uncertain, so environmental-fitness communication need to consciousness at the properly-supported lung-cancer pathway and practical publicity reduction [13].

WHO's reference stage of one hundred Bq/m<sup>3</sup> and a stage not exceeding 300 Bq/m<sup>3</sup> where a hundred Bq/m<sup>3</sup> can't be carried out, provides a framework for deciphering family measurements. These are danger-control reference degrees in preference to binary secure/unsafe thresholds [2,5].

The environmental-health implications expand beyond radon on my own. Tobacco-manage interventions reduce energetic and secondhand smoke exposure, even as radon checking out identifies a separate modifiable environmental risk. An incorporated prevention message can deal with both exposures without assuming that one reasons the alternative [2,6].

Future Al-Najaf research need to amplify geographic coverage, use longer tracking, characterize foundation and geological pathways and compare mitigation. If multiple seven-day cycles are acquired from the same family, combined-results modeling could be suitable to account for within-family dependence [1,8].

## CONCLUSIONS

This observe provides a based framework for evaluating indoor residential radon among smoking and non-smoking families in Al-Najaf the use of non-stop seven-day actual-time tracking. The evaluation suggests higher radon concentrations in smoking families and a tremendous association with indoor cigarette intake, at the same time as multivariable modeling illustrates how housing traits may be considered. These numerical findings are illustrative fine. The final scientific end must be based totally solely on actual seven-day own family measurements and recalculated statistical analyses.

## Recommendations

- Conduct systematic household radon monitoring in consultant areas of Al-Najaf and exclusive Iraqi governorates
- Use longer monitoring intervals even as long-term or annual-average publicity
- Three. Use direct family size in desire to nearby averages to represent publicity
- Promote smoke-loose homes as part of included environmental-health interventions
- Establish mitigation/referral pathways for continuously extended residential radon
- Record constructing developments, air go with the flow and ground-touch talents in future surveys
- Develop a close-by residential radon database for environmental-fitness insurance and hazard mapping
- Repeat monitoring after mitigation to document intervention effectiveness

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