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NEW JERSEY REAL ESTATE STUDY

Herbert C. Roy
N.J. Dept. of Environmental Protection, Radon Section
Trenton, NJ

ABSTRACT

Since May 13, 1991, every person or business offering radon testing or mitigation services in New Jersey must be certified with the New Jersey Department of Environmental Protection (DEP). To fulfil our obligation to ensure that New Jersey citizens are getting accurate radon test results, it was decided to study real estate and non-real estate radon test results.

This paper describes the results of statistical analysis of radon test results by the DEP. In most cases, there is a higher percentage of non-real estate transaction passive radon test results greater than or equal to 4 picoCuries/Liter (pCi/L) compared with those of real estate transactions. This difference is greater if the testing firm is certified for both radon testing and mitigation. Active test devices do not show this trend.

Possible effects associated with geographic, seasonal and location of testing firm were studied and determined not to be significant.

INTRODUCTION

Effective May 13, 1991, the State of New Jersey adopted a mandatory radon certification program which charges the DEP with monitoring radon testing and mitigation work. Certified radon testing firms must submit monthly test results to the DEP Radon Section and indicate whether a test was done as part of a real estate transaction. From this information it was determined that approximately 80% of radon testing in New Jersey is associated with real estate transactions. The next step was to determine whether there was a difference between real estate and non-real estate radon test results?

In this study radon readings associated with real estate transactions were compared to readings associated with non-real estate transactions. This study looks at the real estate and non-real estate radon test result populations to determine if these populations are comparable. A decision has to be made between two hypotheses, the "so-called" null hypothesis that the sample means are equal $H_o: \mu_1 = \mu_2$ and the "so-called" alternate hypothesis that the sample means are not equal $H_a: \mu_1 \neq \mu_2$.

Each population has an associated mean and standard deviation. If the number of elements in both populations are large (e.g. greater than or equal to 30) they can be compared using the Z-Statistic, which looks at the difference of the sample means plus the effects of random sampling. Additionally, for large populations, Z will have an approximately normal distribution. This test requires no assumption as the shape of the population distribution (Bhattacharyya, 1977).

$$Z = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S^2_1}{n_1} + \frac{S^2_2}{n_2}}}$$

Where

$\bar{X}_1$ is the sample mean of population one

$\bar{X}_2$ is the sample mean of population two

n_1 is the number of elements in population one

n_2 is the number of elements in population two

s_1 is the sample standard deviation of population one[1]

s_2 is the sample standard deviation of population two

How is the Z-Statistic used to determine whether to accept the null hypothesis (H_o) or the alternate hypothesis (H_a)?

Our goal is to be 95% sure which hypothesis is correct--95% certain that the populations are either the same or significantly lower or higher. The Z-Statistic can be compared to a critical value. This critical value is associated with a probability of being than that critical value through a normal distribution curve--Normal distribution curve and table is sown in Figure 1 (Orkin, 1975). The area (critical value) represents the region of certainty. Since our hypothesis is not one-sided (such a test would entail testing whether one population mean is strictly greater than or less than the other) but two-sided (tests whether one population mean is either greater than or less than the other) the desired level of significance would be 0.05/2 or 0.025. We want to be 95% certain of being neither too high or low--thus the 95% area of confidence would be sandwiched between two tails enclosing 5% of the total area.

The area in the "center" of the normal distribution tends to confirm the null hypothesis (the populations are similar), whereas areas to the extreme left or right side of the normal distribution curve tend to confirm the alternate hypothesis (the populations are different). The area on the left side representing 0.025 (or 2.5% of the z values confirming that the populations are different) is represented by z-values less than -1.96 (observe that if z = -1.96, the area to the left is 0.025). Conversely, the area on the right side representing the 0.025 (or 2.5% of the z values also confirming that the populations are different) is represented by z-values greater than 1.96 (observe that if z = 1.96, the area to the left is 0.975; thus the area t the right is 1.0 - 0.975 or 0.025).

If the Z-statistic is between -1.96 and +1.96, the populations can be said to be similar. Otherwise, if the Z-statistic is less than -1.96 or greater than +1.96, the population can be said to be different.

Fortunately, there is a graphical analogue to the Z-Statistic which will be used in this report to compare

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[1]The sample standard deviation is defined as the square root of the sums of the squared differences between the individual radon tests divided by the number of tests minus 1.

real estate and non-real estate radon test results. This involves looking at the mean ± the standard error[2], which represents the range of values that the population mean takes on if the sample population is representative of the real estate and non-real estate radon test results. For example, assume the arithmetic mean of a sample population of real estate radon test results is 1.5 pCi/L with a standard error of 0.2 pCi/L--the true arithmetic means lies somewhere between 1.3 pCi/L and 1.7 pCi/L. Further, assume the arithmetic mean of a sample population of non-real estate radon tests results is 1.2 pCi/L with a standard error of 0.3 pCi/L--the true arithmetic mean lies somewhere between 0.9 pCi/L and 1.5 pCi/L. Since some of the possible mean values are common (between 1.3 pCi/L and 1.5 pCi/L) we can say that the real estate and non-real estate radon tests are comparable.

Suppose there were 758 radon test results, 42% of which were greater than or equal to 4 pCi/L. The following equation (Lancaster, 1974) is used to calculate the standard error.

$$SE = \sqrt{\frac{pq}{N}}$$

where

p is the probability of event occurring as a decimal

q is one (1) minus p

N is the total number of sample points

In the example shown above, p = 0.42, q = 1 - 0.42 = 0.58 and N is 758. The standard error is 0.018 or 1.8%. Therefore, for this sample, 42% ± 1.8% (40.2% to 43.8%) of these radon tests are greater than or equal to 4 pCi/L.

MATERIALS AND METHODS

N.J.A.C. 7:28-27 (Certification of Radon Testers and Mitigators) requires the monthly submission of radon test results to the DEP. These reports contain the following information: name of the testing firm, name of incorporated municipality and county in which a particular test was performed, the type of building (residential, non-residential or school), type of test (real estate, screening, follow-up, diagnostic, duplicate, blank and pre or post-mitigation), stop and start date, who performed test (certified individual or homeowner), level tested, device used (charcoal canister, alpha track, continuous working level monitor, continuous radon monitor, grab radon sample, grab working level sample, short term or long term electric) and the test result.

Using these monthly test reports, real estate and non-real estate radon tests from the mandatory certification database were separated according to device type (passive or active device[3]), measurement firm type (those certified as both a measurement and mitigation business versus those certified only for measurement work and all businesses

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[2]The standard error is the square root of the quotient of the population variance divided by the number of sample points.

[3]Active device (those requiring external power to operate) test results analyzed in this study were the continuous radon monitor and the grab radon devices. Passive device (those which do not require external power to operate) test results analyzed in this study were the alpha track, charcoal canister and electret detectors.

certified to perform radon tests), municipality type (all New Jersey municipalities or only high radon potential municipalities) and according to time frame (1992-93 heating season, the summers of 1992 and 1993 and since the start of mandatory certification) and analyzed to determine if these groups were statistically comparable.

Suppose radon tests were deployed throughout New Jersey regardless of whether or not these tests were conducted as part of a real estate transaction. If a large sample homogeneously distributed throughout the three radon potential regions and throughout the year is analyzed, one would expect the percent of tests greater than or equal to 4 pCi/L to be equal for both real estate and non-real estate transactions. Analysis of radon test results submitted to the DEP since mandatory radon certification went into effect does not substantiate such a trend. In fact, a trend showing a higher percentage of non-real estate test results greater than or equal to 4 pCi/L compared to real estate tests were observed when using passive devices. An inconclusive trend was observed when analyzing active devices, attributable to the lower number of active tests deployed.

RESULTS

Radon tests from the start of mandatory certification until April 1994 were considered in this analysis. Table 1 compares passive real estate radon test results obtained throughout New Jersey to non-real estate results and are shown as percent ± the two sigma standard error--the number of test results greater than or equal 4 pCi/L divided by the total number of radon tests is shown in parenthesis.

Table 1 - Passive Radon Test Results

Time Frame	Real Estate	Non-Real Estate
12/01/92 to 03/31/93	14.3% ± 0.9 (846/5919)	23.4% ± 1.9 (468/1996)
06/01/92 to 09/30/92	16.4% ± 0.8 (1355/8285)	23.0% ± 2.0 (709/1779)
06/01/93 to 09/30/93	13.9% ± 0.7 (1213/8723)	21.0% ± 1.6 (532/2539)
From Start of Mandatory Certification until April 1994	15.2% ± 0.3 (10696/70233)	23.4% ± 0.7 (3969/16967)

Observe, that regardless of which time frame is selected, non-real estate radon test results have a higher percentage greater than or equal 4 pCi/L when compared with real estate test results. Within each time frame, there is no overlapping of the percent of radon tests results greater than or equal to 4 pCi/L when real estate results are compared with those from non-real estate transactions.

If this investigation is confined to just high radon potential regions a similar trend is observed. Within the same time frames and considering only passive tests the results shown in Table 2 were obtained. Note that the percentages in Table 2 are higher than those given in Table 1, which is expected since these tests results were from high radon potential areas. Again, results from real estate transactions are lower than those from non-real estate transactions.

Table 2 - Passive Radon Test Results in High Potential Areas

Time Frame	Real Estate	Non-Real Estate
12/01/92 to 03/31/93	28.2% ± 2.0 (594/2106)	36.0% ± 3.0 (367/1020)
06/01/92 to 09/30/92	30.3% ± 1.6 (945/3117)	36.4% ± 3.2 (323/888)
06/01/93 to 09/30/93	28.3% ± 1.7 (831/2940)	34.7% ± 2.8 (416/1198)
From Start of Mandatory Certification until April 1994	30.2% ± 0.6 (7496/24821)	37.3% ± 1.1 (3120/8356)

This trend towards a higher percentage of non-real estate test results greater than or equal to 4 pCi/L does not carry over to active devices--an analysis of these results are shown in Table 3.

Table 3 - Active Radon Test Results

Time Frame	Real Estate	Non-Real Estate
From Start of Mandatory Certification until April 1994 Throughout New Jersey	24.4% ± 2.0 (445/1826)	22.6% ± 2.9 (190/842)
From Start of Mandatory Certification until April 1994 in High Radon Potential Areas	32.9% ± 3.0 (322/980)	34.4% ± 4.5 (153/445)

Notice that regardless of what locations in New Jersey are being considered, the percentages overlap which means these values are comparable. No further analysis of active radon test results was attempted (such as the season of the year these tests were performed) because of the small number of tests performed.

Next, the passive radon test results were separated as to what other activities the radon measurement business was involved (either the business only does radon testing or the business provides mitigation services besides radon testing). Table 4 analyzes radon results from testing firms certified for both testing and mitigation.

Table 4 - Passive Radon Test Results-Throughout New Jersey
by Firms Certified for Both Testing and Mitigation

Time Frame	Real Estate	Non-Real Estate
12/01/92 to 03/31/93	14.4% ± 1.1 (631/4388)	29.7% ± 2.7 (329/1106)
06/01/92 to 09/30/92	18.2% ± 1.1 (972/5353)	29.9% ± 3.0 (273/914)
06/01/93 to 09/30/93	13.9% ± 0.4 (895/6435)	24.0% ± 1.2 (308/1283)
From Start of Mandatory Certification until April 1994	15.5% ± 0.3 (7478/48155)	28.3% ± 0.9 (2624/9283)

When passive radon tests deployed throughout New Jersey through firms certified for both testing and mitigation were analyzed the respective percentages of results greater than or equal to 4 pCi/L are greater for Non-real estate associated radon tests in comparison with those obtained from real estate transactions. However, the difference is stronger than the previous case in which test results were analyzed irrespective of the type of measurement firm (Table 1). In Table 5, radon test results from firms certified only for radon testing were analyzed, observe that for the different time frames, the percentages overlap meaning that real estate results were comparable with non-real estate results.

Table 5 - Passive Radon Test Results-Throughout New Jersey
by Firms Certified Only for Testing

Time Frame	Real Estate	Non-Real Estate
12/01/92 to 03/31/93	14.0% ± 1.8 (215/1531)	15.6% ± 2.4 (139/890)
06/01/92 to 09/30/92	13.1% ± 1.2 (383/2932)	15.7% ± 2.8 (136/865)
06/01/93 to 09/30/93	13.9% ± 0.7 (318/2288)	17.8% ± 1.1 (224/1256)
From Start of Mandatory Certification until April 1994	14.6% ± 0.5 (3218/22078)	17.5% ± 0.9 (1345/7684)

Thus, looking at real estate and non-real estate passive radon devices deployed throughout New Jersey there is a statistical difference if the measurement firm also performed mitigations. However, no clear cut difference is observed if these tests were performed by a firm certified only for radon testing.

Real estate and non-real estate radon tests performed in eight New Jersey counties in which there are high radon potential municipalities (Hunterdon, Mercer, Middlesex, Monmouth, Morris, Somerset, Sussex and Warren) were statistically compared and show:

- For radon testing firms also certified for radon mitigation, six counties show a statistical difference.
- For firms certified only for radon testing, one county shows a statistical difference.
- If all firms regardless of certification status were analyzed, four counties show a statistical difference.

No statistical significance was found if radon tests were compared based on whether the radon test was deployed by a certified professional or the homeowner.

DISCUSSION

A statistical difference has been shown between the results of radon tests associated with real estate transactions when compared with tests associated with non-real estate activities. The percentage of non-real estate test results greater than or equal to 4 pCi/L is higher than the corresponding percentage of real estate test results. This difference is magnified when testing firms are also certified for mitigation. This difference is observed whether or not a certified employee or the homeowner deploys the radon test. No statistically significant difference is observed if firms certified only for testing were analyzed.

For further evaluation of this problem, the radon program is planning to perform a real estate confirmatory study. This study involves sending a letter to 1000 new homeowners who meet the following criteria: 1) Their house had a real estate screening test performed, 2) The house is located within the four counties identified as having a significant difference between real estate and non-real estate test results, 3) radon test was less than 4 pCi/L and the test was performed during the same season as our study. The results presented in this paper were shared with the working group comprised of representatives from lawyers, mortgage lenders, realtors, EPA and AARST. Pursue tampering warnings in DEP brochures, e.g. Real Estate Fact Sheet and Revised Testing Guidance. Investigate tamper resistant protocols.

CONCLUSIONS

Non-real estate transaction passive radon tests generally show a higher percentage of results greater than or equal to 4 pCi/L than results of real estate transactions. This difference is greater if the testing firm is certified for both radon testing and mitigation.

Active test devices do not show this trend; however, the total number of devices deployed since the start of mandatory radon certification is not as much as the number of passive tests deployed.

Possible effects associated with geographic, seasonal and location of test firm were studied and determined not to be significant.

REFERENCES

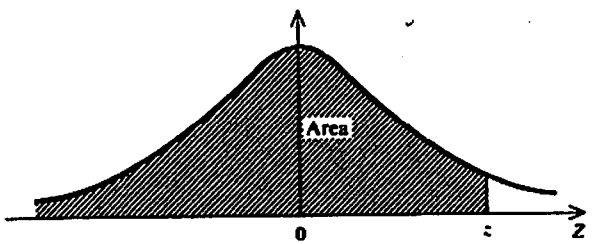
Bhattacharyya, Gouri, et. al., Statistical Concepts and Methods, John Wiley & Sons, New York, 1972, page 262.

Orkin, M. and Drogin, R., Vital Statistics, McGraw-Hill Book Company, c. 1975, pages 350-351.

Lancaster, H. O., An Introduction to Medical Statistics, John Wiley & Sons, New York, c. 1974, p.181.

Normal distribution

The table gives the area to the left of z under a standard normal curve, for various values of z.



To obtain probabilities use the fact that

Area to the left of $z = P(Z \leq z)$

where Z is a variable with a standard normal distribution.

z	Area	z	Area	z	Area
−4	.00003	−2.74	.0031	−2.29	.0110
−3.9	.00005	−2.73	.0032	−2.28	.0113
−3.8	.0001	−2.72	.0033	−2.27	.0116
−3.7	.0001	−2.71	.0034	−2.26	.0119
−3.6	.0002	−2.70	.0035	−2.25	.0122
−3.5	.0002	−2.69	.0036	−2.24	.0125
−3.4	.0003	−2.68	.0037	−2.23	.0129
−3.3	.0005	−2.67	.0038	−2.22	.0132
−3.2	.0007	−2.66	.0039	−2.21	.0136
−3.1	.0010	−2.65	.0040	−2.20	.0139
−3.09	.0010	−2.64	.0041	−2.19	.0143
−3.08	.0010	−2.63	.0043	−2.18	.0146
−3.07	.0011	−2.62	.0044	−2.17	.0150
−3.06	.0011	−2.61	.0045	−2.16	.0154
−3.05	.0011	−2.60	.0047	−2.15	.0158
−3.04	.0012	−2.59	.0048	−2.14	.0162
−3.03	.0012	−2.58	.0049	−2.13	.0166
−3.02	.0013	−2.57	.0051	−2.12	.0170
−3.01	.0013	−2.56	.0052	−2.11	.0174
−3.00	.0013	−2.55	.0054	−2.10	.0179
−2.99	.0014	−2.54	.0055	−2.09	.0183
−2.98	.0014	−2.53	.0057	−2.08	.0188
−2.97	.0015	−2.52	.0059	−2.07	.0182
−2.96	.0015	−2.51	.0060	−2.06	.0197
−2.95	.0016	−2.50	.0062	−2.05	.0202
−2.94	.0016	−2.49	.0064	−2.04	.0207
−2.93	.0017	−2.48	.0066	−2.03	.0212
−2.92	.0017	−2.47	.0068	−2.02	.0217
−2.91	.0018	−2.46	.0069	−2.01	.0222
−2.90	.0019	−2.45	.0071	−2.00	.0228
−2.89	.0019	−2.44	.0073	−1.99	.0233
−2.88	.0020	−2.43	.0075	−1.98	.0239
−2.87	.0021	−2.42	.0078	−1.97	.0244
−2.86	.0021	−2.41	.0080	−1.96	.0250
−2.85	.0022	−2.40	.0082	−1.95	.0256
−2.84	.0023	−2.39	.0084	−1.94	0262
−2.83	.0023	−2.38	.0087	−1.93	.0268
−2.82	.0024	−2.37	.0089	1.92	.0274
−2.81	.0025	−2.36	.0091	−1.91	.0281
−2.80	.0026	−2.35	.0094	−1.90	.0287
−2.79	.0026	−2.34	.0096	−1.89	.0294
−2.78	.0027	−2.33	.0099	−1.88	.030
−2.77	.0028	−2.32	.0102	−1.87	.0307
−2.76	.0029	−2.31	.0104	−1.86	.0314
−2.75	.0030	−2.30	.0107	−1.85	.0322