ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 12, pp.42790-42796, December, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EXAMINATION OF MULTIPLE COMPARISON TESTS IN THE CASE OF HOMOGENEITY AND HETEROGENEITY OF VARIANCES: AN APPLICATION ON HEALTH DATA

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ARTICLE INFO

Article History:
Received 08th September, 2016
Received in revised form
20th October, 2016
Accepted 22nd November, 2016
Published online 30th December, 2016

Key words:

Heterogeneous Variance,
Post-Hoc Test, Health indicator.

ABSTRACT

After the analysis of variance, selection of multiple comparison statistics is important. Analysis of variance is performed only when the assumption of homogeneity of variance hold. Nevertheless, it is a test suitable for heterogeneous variance that can be used when there is a deviation from equal variance assumption. Having inappropriate multiple comparison statistics will increase type I and II errors of hypothesis and then conclusion of study may be bias. In this study, Tukey HSD and Scheffe tests gave good results when group variances were homogeneous. Tamhane's T2 and Games-Howell tests gave good results when group variances were heterogeneous.

Citation: Senol Celik 2016. "Examination of multiple comparison tests in the case of homogeneity and heterogeneity of variances: an application on health data", *International Journal of Current Research*, 8, (12), 42790-42796.

INTRODUCTION

Analysis of Variance is one of the statistic method which is used to determine differences among more than two groups to be compared in the statistic (ANOVA; Analysis of Variance) Şenoğlu and Acıtaş, 2010. However, to be made analysis of Variance, it is need to provide some of estimation which include parametric items, such as homogeneity, normality and additivity (Ferguson, 1981). ANOVA is performed only when the assumption of homogeneity of variance holds. However, because it is a robust statistic that can be used when there is a deviation from this assumption. When the design involves unequal variances, there are several post hoc procedures, including Games-Howell, Tamhane T2, Dunnett T3 and Dunnett C (De Muth, 2006). In cases where there is a difference between the groups, the statistic that determines the group from which the difference is derived is known as multiple comparison tests (Erbaş and Olmuş, 2005; Köklu et al., 2006). In the general meaning, multiple comparison tests (post-hoc statistics) handle under two different classes: in terms the condition of homogeneity of between-groups variance and the condition of non-homogeneity of between-groups variance (Nelson, 1983). The Least Significant Difference (LSD), Sidak, Bonferroni, Tukey, Duncan and Scheffe multiple comparison tests (pairwise) are used when the variances are equal. The test of Tukey (honestly significant difference) necessitate to equal amount of sample in the group (Tukey, 1949). These multi comparison tests adjust confidence interval in the analysis (Sincich, 2003). The Scheffe method has been developed to compare all possible linear combinations among groups. Scheffe's method is a post – hoc type, that is most flexible one and in case number of group is quite high, it can keep under control α margin of error (conservative) and also ignore assumption of observation amount in the group (Scheffe, 1953; Scheffe, 1959). The post-hoc statistics to be used in case of unequal variance among the groups are Games-Howell, Tamhane's T2, Tamhane's T3, Dunnet's C and Dunnet's T3 (Sparks, 1963). The Games-Howell test statistic runs on both the "student t" and the expanded t module base (Games, 1971). Tamhane's T2 and Tamhane's T3 statistics are only tests conducted at the "student t" base, making conservative and careful comparisons (Hochberg and Tamhane, 1987). In this research, it has compared multiply comparison tests for equal and unequal population variances for application purpose.

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MATERIALS AND METHODS

The data of the subsection "Health Statistics / Distribution of health personnel by provinces, 2014" of Health Statistics in TUIK (Turkish Statistical Institute) database were made use of (TUIK 2014). Tamhane T2 test proposed by Tamhane T2 employs Sidak's (1967) multiplicative inequality in

conjunction with the Welch approximate solution. Tamhane T2 test can be applied to any linear contrast. Tamhane T2 indicates that the Games-Howell procedure can be slightly liberal and therefore TamhaneT2 advocate a procedure known as a Tamhane T2 method (Olejnik and Lee, 1990). This method is based on the student t-distribution. It uses Sidak test to set the alpha level and Welch procedure to determine degrees of freedom. Tamhane T2 test statistics is given equation (1) (Doğan and Doğan, 2014).

$$\text{Tamhane T2} = t_{\alpha;\upsilon_{i-j}} * SH_{i-j} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

$t_{\alpha';\upsilon_{i-j}}$ is the two sided α'point of student t distribution with υ_{i-j} degree of freedom.

$$\alpha' = 1 - (1-\alpha)^{1/c}$$

c: Number of comparison

$$\upsilon_{i-j} = \frac{\left[\frac{S_i^2}{n_i} + \frac{S_j^2}{n_j}\right]^2}{\frac{\left(\frac{S_i^2}{n_i}\right)^2}{n_i - 1} + \frac{\left(\frac{S_j^2}{n_j}\right)^2}{n_j - 1}}$$

$$SH_{i-j} = \sqrt{\frac{S_i^2}{n_i} + \frac{S_j^2}{n_j}}$$

Reject the null hypothesis, $\bar{x}_i - \bar{x}_j \geq \text{Tamhane T2}$ and accept null hypothesis otherwise.

The Games-Howell (GH) test gives the best performance for pair wise comparisons. It may suggested when the sample sizes are greater than 5 (Toothaker, 1991). Along with the assumptions given earlier, in each group we must have at least 6 observations (Games and Howell, 1976). Games-Howell (GH) test statistics is given equation (2) (Doğan and Doğan, 2014).

$$\text{Games} - \text{Howell} = q_{\alpha;\upsilon_{i-j,k}} * SH_{i-j} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,

$q_{\alpha;\upsilon_{i-j,k}}$ is the two sided α point of student t distribution with υ_{i-j} degree of freedom ($\alpha = 0.05$). c: Number of comparison

$$\upsilon_{i-j} = \frac{\left[\frac{S_i^2}{n_i} + \frac{S_j^2}{n_j}\right]^2}{\frac{\left(\frac{S_i^2}{n_i}\right)^2}{n_i - 1} + \frac{\left(\frac{S_j^2}{n_j}\right)^2}{n_j - 1}}$$

$$SH_{i-j} = \sqrt{\frac{1}{2} * \left(\frac{S_i^2}{n_i} + \frac{S_j^2}{n_j}\right)}$$

Reject the null hypothesis, $\bar{x}_i - \bar{x}_j \geq \text{Games} - \text{Howell}$ and accept null hypothesis otherwise.

Tukey (1953) proposed a testing hypotheses for which the overall significance level is exactly α when the sample sizes are equal and at most α when the sample sizes are unequal. Tukey test declares two means significantly different if the absolute value of their sample differences exceeds, for equal sample sizes.

$$T_\alpha = q_\alpha(\alpha, f)\sqrt{\frac{MSE}{n}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where, MSE: Mean Square Error, $q_\alpha(\alpha, f)$: the upper α percentage points of q where f is the number of degrees freedom associated with the MSE (Montgomary, 2001).

Scheffe (1953) has proposed a method for comparing any and all possible contrast between treatment means. Scheffe's procedure corrects alpha for all pair-wise or simple comparisons of means, but also for all complex comparisons of means as well. Scheffe's is also the least statistically powerful procedure. Scheffe's is presented and calculated below for our pairwise situation for purposes of comparison and because Scheffe's is commonly applied in this situation, but it should be recognized that Scheffe's is a poor choice of procedures unless complex comparisons are being made. For pair-wise comparisons, Scheffe's can be computed as equation (4) (Stevens, 1999).

$$S = \sqrt{(k-1)F_{critical}}\sqrt{MSE\left(\frac{1}{n_i} + \frac{1}{n_j}\right)} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

RESULTS

Descriptive statistical findings of the data obtained from the groups in the study are given in Table 1. When Table 1 is examined, it is seen that, the highest arithmetic average meanly, the number of dentists per 100.000 people belongs to Marmara Region and lower arithmetic average, mean, the number of dentists per 100.000 people belongs to Southeastern Anatolia region with 13.669. It is seen that the number of nurse per 100.000 people is highest in the Black Sea (217.678) and lowest in the Southeastern Anatolia (146.926) regions. Whether there is significance difference between number of nurses and dentist per 100.000 people, according to regions is tested with one way variance analysis (One-Way ANOVA). To implement one-way variance analysis, variance of group should be homogeny. That is why "Leneve's Test" was implemented. The results of the test are given in Table 2. According to Table 2, the significance levels were calculated as "p = 0.651" for the number of dentists and "p = 0.036" for the number of nurses. In that situation, it is seen that according to 0.05 significance level, variance are homogeny for dentist number and variance are not homogeny for nurse number. While Tukey, HSD and Scheffe's tests are used for the number of dentists in which the group variances are homogeneous, Tamhane T2 and Games-Howell's test are used for the number of nurses in which group variances are not homogeneous. However, all the tests examined in both cases were applied and the results were compared. The results of variance analysis for the number of dentists and nurses per 100.000 people in Turkey by 7 geographical regions are given in Table 3. As shown in Table 3, it was determined that the number of dentists per 100.000 people significantly differed among regions [F(6-74)=8.716; p<0.01] Similarly, the number of nurses per 100.000 people varied considerably among the regions. [F (6-74)=3.761; p<0.01].

Table 1. Descriptive statistics

		N	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Dentist	Mediterranean	8	26.726	7.825	2.767	15.060	41.750
	Southeastern Anatolia	9	13.669	4.620	1.540	8.790	24.070
	Eastern Anatolia	14	17.041	5.310	1.419	10.230	27.740
	Central Anatolia	13	25.051	9.587	2.659	16.180	53.900
	Aegean	8	27.700	7.633	2.699	18.550	39.000
	Marmara	11	30.453	5.116	1.543	23.340	42.050
	Black Sea	18	24.157	5.099	1.202	17.210	37.560
	General	81	23.364	8.237	0.915	8.790	53.900
Nurse	Mediterranean	8	190.269	55.675	19.684	143.700	317.110
	Southeastern Anatolia	9	146.926	36.082	12.027	98.170	199.380
	Eastern Anatolia	14	178.889	51.269	13.702	107.930	249.110
	Central Anatolia	13	202.918	37.350	10.359	155.890	272.310
	Aegean	8	193.278	11.737	4.150	174.510	209.070
	Marmara	11	176.391	36.835	11.106	139.380	264.310
	Black Sea	18	217.678	36.120	8.514	166.780	316.000
	General	81	190.020	44.193	4.910	98.170	317.110

Table 2. Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Dentist	0.699	6	74	0.651
Nurse	2.400	6	74	0.036

Table 3. ANOVA results

		Sum of Squares	df	Mean Square	F	Sig.
Dentist	Between Groups	2247.640	6	374.607	8.716	0.001
	Within Groups	3180.460	74	42.979		
	Total	5428.101	80			
Nurse	Between Groups	36509.300	6	6084.883	3.761	0.003
	Within Groups	119735.036	74	1618.041		
	Total	156244.336	80			

Table 4. Tukey HSD Multiple Comparisons for Dentist variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	13.057**	3.186	0.002
	Eastern Anatolia	9.686*	2.906	0.022
	Central Anatolia	1.675	2.946	0.997
	Aegean	-0.974	3.278	0.999
	Marmara	-3.726	3.046	0.883
	Black Sea	2.569	2.786	0.968
Southeastern Anatolia	Eastern Anatolia	-3.372	2.801	0.891
	Central Anatolia	-11.382**	2.843	0.003
	Aegean	-14.031**	3.186	0.001
	Marmara	-16.784**	2.947	0.000
	Black Sea	-10.488**	2.676	0.004
Eastern Anatolia	Central Anatolia	-8.010*	2.525	0.034
	Aegean	-10.659**	2.906	0.008
	Marmara	-13.412**	2.641	0.000
	Black Sea	-7.117*	2.336	0.048
Central Anatolia	Aegean	-2.649	2.946	0.972
	Marmara	-5.402	2.686	0.416
	Black Sea	0.894	2.386	0.999
Aegean	Marmara	-2.753	3.046	0.971
	Black Sea	3.543	2.786	0.863
Marmara	Black Sea	6.296	2.509	0.171

Multiple comparative post hoc test statistic was adjust to determine the source of this difference between the groups. Because the aim of the study was to determine when the variance were homogenous and when the variance were not homogenous, by compare the post-hoc strategies, Tukey HSD, Scheffe, Tamhane T2 and Games-Howell tests were respectively applied in multiple comparison tests. In addition, the results obtained from each test statistic are compared with each other. However, the results of the Tukey HSD and Scheffe tests were taken into account when the variances were homogeneous, whereas the results of Tamhane T2 and Games-Howell tests were considered where the variances were not homogeneous.

The results of the multiple comparison test statistics set for the groups that generate such differences are given in Table 4-11. Because 7 geographical regions were examined in the study, 7 * (7-1) / 2 = 21 pairwise comparisons were made in 7 groups. According to the Tukey HSD multiple comparison test presented in Table 4, in terms of the number of dentists per 100.000 people; differences between Mediterranean – Southeastern Anatolia, Mediterranean – Eastern Anatolia, Southeastern Anatolia – Central Anatolia, Southeastern Anatolia – Aegean, Southeastern Anatolia – Marmara, Southeastern Anatolia – Black Sea, Eastern Anatolia – Central Anatolia, Eastern Anatolia – Aegean, Eastern Anatolia – Marmara and Eastern Anatolia – Black Sea Regions are

Table 5.Scheffe test for Dentist variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	13.057*	3.186	0.016
	Eastern Anatolia	9.686	2.906	0.101
	Central Anatolia	1.675	2.946	0.999
	Aegean	-0.974	3.278	0.999
	Marmara	-3.726	3.046	0.958
	Black Sea	2.569	2.786	0.990
Southeastern Anatolia	Eastern Anatolia	-3.372	2.801	0.961
	Central Anatolia	-11.382*	2.843	0.021
	Aegean	-14.031*	3.186	0.007
	Marmara	-16.784*	2.947	0.000
	Black Sea	-10.488*	2.676	0.026
Eastern Anatolia	Central Anatolia	-8.010	2.525	0.139
	Aegean	-10.659*	2.906	0.048
	Marmara	-13.412*	2.641	0.001
	Black Sea	-7.117	2.336	0.175
Central Anatolia	Aegean	-2.649	2.946	0.991
	Marmara	-5.402	2.686	0.671
	Black Sea	0.894	2.386	0.999
Aegean	Marmara	-2.753	3.046	0.991
	Black Sea	3.543	2.786	0.949
Marmara	Black Sea	6.296	2.509	0.401

Table 6.Tamhane T2 test for Dentist variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	13.057*	3.166	0.034
	Eastern Anatolia	9.686	3.109	0.192
	Central Anatolia	1.675	3.837	0.999
	Aegean	-0.974	3.865	0.999
	Marmara	-3.726	3.168	0.998
	Black Sea	2.569	3.016	0.999
Southeastern Anatolia	Eastern Anatolia	-3.372	2.094	0.938
	Central Anatolia	-11.382*	3.073	0.033
	Aegean	-14.031*	3.107	0.017
	Marmara	-16.784*	2.180	0.000
	Black Sea	-10.488*	1.953	0.001
Eastern Anatolia	Central Anatolia	-8.010	3.014	0.284
	Aegean	-10.659	3.049	0.101
	Marmara	-13.412*	2.096	0.000
	Black Sea	-7.117*	1.860	0.014
Central Anatolia	Aegean	-2.649	3.788	0.999
	Marmara	-5.402	3.074	0.877
	Black Sea	0.894	2.918	0.999
Aegean	Marmara	-2.753	3.108	0.999
	Black Sea	3.543	2.954	0.998
Marmara	Black Sea	6.296	1.956	0.082

Table 7.Games-Howell test for Dentist variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	13.057*	3.166	0.020
	Eastern Anatolia	9.686	3.109	0.101
	Central Anatolia	1.675	3.837	0.999
	Aegean	-0.974	3.865	0.999
	Marmara	-3.726	3.168	0.890
	Black Sea	2.569	3.016	0.972
Southeastern Anatolia	Eastern Anatolia	-3.372	2.094	0.678
	Central Anatolia	-11.382*	3.073	0.022
	Aegean	-14.031*	3.107	0.011
	Marmara	-16.784*	2.180	0.000
	Black Sea	-10.488*	1.953	0.001
Eastern Anatolia	Central Anatolia	-8.010	3.014	0.165
	Aegean	-10.659	3.049	0.055
	Marmara	-13.412*	2.096	0.000
	Black Sea	-7.117*	1.860	0.011
Central Anatolia	Aegean	-2.649	3.788	0.991
	Marmara	-5.402	3.074	0.589
	Black Sea	0.894	2.918	0.999
Aegean	Marmara	-2.753	3.108	0.968
	Black Sea	3.543	2.954	0.879
Marmara	Black Sea	6.296	1.956	0.053

Table 8. Tukey HSD for Nurse Variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	43.343	19.546	0.299
	Eastern Anatolia	11.379	17.828	0.995
	Central Anatolia	-12.650	18.075	0.992
	Aegean	-3.009	20.112	0.999
	Marmara	13.878	18.691	0.989
	Black Sea	-27.409	17.092	0.680
Southeastern Anatolia	Eastern Anatolia	-31.964	17.186	0.513
	Central Anatolia	-55.993*	17.443	0.031
	Aegean	-46.352	19.546	0.225
	Marmara	-29.465	18.080	0.664
	Black Sea	-70.752*	16.422	0.001
Eastern Anatolia	Central Anatolia	-24.029	15.493	0.713
	Aegean	-14.388	17.828	0.984
	Marmara	2.498	16.207	0.999
	Black Sea	-38.788	14.334	0.111
Central Anatolia	Aegean	9.641	18.075	0.998
	Marmara	26.528	16.479	0.677
	Black Sea	-14.759	14.641	0.951
Aegean	Marmara	16.887	18.691	0.971
	Black Sea	-24.400	17.092	0.785
Marmara	Black Sea	-41.287	15.394	0.117

Table 9. Scheffe test for Nurse Variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	43.343	19.546	0.558
	Eastern Anatolia	11.379	17.828	0.999
	Central Anatolia	-12.650	18.075	0.998
	Aegean	-3.009	20.112	0.999
	Marmara	13.878	18.691	0.997
	Black Sea	-27.409	17.092	0.858
Southeastern Anatolia	Eastern Anatolia	-31.964	17.186	0.748
	Central Anatolia	-55.993	17.443	0.129
	Aegean	-46.352	19.546	0.474
	Marmara	-29.465	18.080	0.848
	Black Sea	-70.752*	16.422	0.009
Eastern Anatolia	Central Anatolia	-24.029	15.493	0.876
	Aegean	-14.388	17.828	0.995
	Marmara	2.498	16.207	0.999
	Black Sea	-38.788	14.334	0.306
Central Anatolia	Aegean	9.641	18.075	0.999
	Marmara	26.528	16.479	0.855
	Black Sea	-14.759	14.641	0.984
Aegean	Marmara	16.887	18.691	0.991
	Black Sea	-24.400	17.092	0.914
Marmara	Black Sea	-41.287	15.394	0.317

Table 10. Tamhane T2 test for Nurse Variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	43.343	23.068	0.846
	Eastern Anatolia	11.379	23.983	0.999
	Central Anatolia	-12.650	22.243	0.999
	Aegean	-3.009	20.117	0.999
	Marmara	13.878	22.601	0.999
	Black Sea	-27.409	21.446	0.996
Southeastern Anatolia	Eastern Anatolia	-31.964	18.232	0.875
	Central Anatolia	-55.993	15.873	0.050
	Aegean	-46.352	12.723	0.093
	Marmara	-29.465	16.371	0.860
	Black Sea	-70.752**	14.736	0.004
Eastern Anatolia	Central Anatolia	-24.029	17.177	0.982
	Aegean	-14.388	14.317	0.999
	Marmara	2.498	17.638	0.999
	Black Sea	-38.788	16.132	0.411
Central Anatolia	Aegean	9.641	11.159	0.999
	Marmara	26.528	15.187	0.877
	Black Sea	-14.759	13.409	0.999
Aegean	Marmara	16.887	11.856	0.984
	Black Sea	-24.400	9.471	0.301
Marmara	Black Sea	-41.287	13.994	0.149

Table 11.Games-Howell test for Nurse variable

		Mean Difference (I-J)	Std. Error	Sig.
Mediterranean	Southeastern Anatolia	43.343	23.068	0.527
	Eastern Anatolia	11.379	23.983	0.999
	Central Anatolia	-12.650	22.243	0.997
	Aegean	-3.009	20.117	0.999
	Marmara	13.878	22.601	0.995
	Black Sea	-27.409	21.446	0.847
Southeastern Anatolia	Eastern Anatolia	-31.964	18.232	0.591
	Central Anatolia	-55.993*	15.873	0.032
	Aegean	-46.352*	12.723	0.049
	Marmara	-29.465	16.371	0.565
	Black Sea	-70.752**	14.736	0.003
Eastern Anatolia	Central Anatolia	-24.029	17.177	0.797
	Aegean	-14.388	14.317	0.945
	Marmara	2.498	17.638	0.999
	Black Sea	-38.788	16.132	0.242
Central Anatolia	Aegean	9.641	11.159	0.973
	Marmara	26.528	15.187	0.595
	Black Sea	-14.759	13.409	0.922
Aegean	Marmara	16.887	11.856	0.780
	Black Sea	-24.400	9.471	0.180
Marmara	Black Sea	-41.287	13.994	0.092

statistically important (P<0.01 and P<0.05). In terms of the number of dentists, it is understood that the Marmara Region is in the best condition and the Southeastern Anatolia Region is in the worst condition. According to the Scheffe multiple comparison test given in Table 5; In terms of the number of dentists per 100.000 people; the difference between the Mediterranean – Southeastern Anatolia, Southeastern Anatolia – Central Anatolia, Southeastern Anatolia – Aegean, Southeastern Anatolia – Marmara, Southeastern Anatolia – Black Sea, Eastern Anatolia – Aegean and Eastern Anatolia – Marmara regions is important statistically. (P<0.01 and P<0.05). The Scheffe multiple comparison test showed similar results to the Tukey HSD. The Tamhane T2 and Games-Howell multiple comparison tests given in Table 6 and Table 7 showed different results than the Tukey HSD and Scheffe tests. Here, the variances are homogeneous, the results of the Tukey HSD and Scheffe tests are valid. As a result of Tukey HSD and Scheffe tests, it is seen that Marmara and Aegean Regions are in the best condition and Southeast Anatolia Region is in the worst condition in terms of dentist.

The Tukey HSD test results given in Table 8 and the Scheffe test results given in Table 9 is different from the Tamhane T2 results given in Table 10 and the Scheffe test results given in Table 9 and the results of the Games-Howell multiple comparison test in Table 11. Here, the variances are not homogeneous but the results of Tamhane T2 and Games-Howell tests are valid. According to the Tamhane T2 multiple comparison test given in Table 10; In terms of number of nurses per 100.000 people; There is only a difference between the Southeastern Anatolia Region and the Black Sea regions(P<0.01). There is no significant difference in the number of nurses among the other geographical regions. According to the Games-Howell multiple comparison test given in Table 11; in terms of number of nurses per 100.000 people; when Southeastern Anatolia region compared to other geographical regions, there is a difference between the number of nurses per 100.000 people of this region and the number of nurses per 100.000 people of Central Anatolia, Aegean and Black Sea regions. (P<0.01 and P<0.05). In this case, the test results of Games-Howell and Tamhane T2 show differences among themselves.

As a result of the Games-Howell and Tamhane T2 tests, it is seen that Black Sea Region is in the best condition and Southeast Anatolia Region is the worst in terms of nurse. It is seen that the Southeastern Anatolia Region is inadequate in terms of health. Urgent measures for health should be taken for this region.

Conclusion

In this study, it was researched which of the multiple comparison tests were appropriate when the variances were homogeneous or not. 21 in pairwise comparison; In terms of the number of dentists per 100.000 people; in Tukey HSD test 10, in Scheffe and Tamhane T2 tests 7, in Games-Howell test 2 pairwise comparisons were found important. Number of nurses per 100.000 people; in Tukey HSD test 2, in Scheffe and Tamhane T2 tests 1, in Games-Howell test 3 pairs of comparisons were found important. In multiple comparisons, the Tukey HSD and Scheffe tests are clearly appropriate to be used when the variances are homogeneous, and Tamhane T2 and Games-Howell tests are appropriate when the variances are not homogeneous.

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