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Welch’s Analysis of Variance as Applied to Compare Drug Intoxication Infection across Saudi Health Regions (2019–2023)

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KEYWORDS

Variance,
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ABSTRACT:

This study compares drug poisoning cases across the 20 health regions in Saudi Arabia for the years 2019 and 2023, using official data from the Ministry of Health. Welch's ANOVA was used to assess differences in poisoning rates. The results indicate significant variation in the distribution of cases, with Riyadh, Jeddah, and Hail, 533,254 and 130 respectively showing significantly higher averages, while areas such as Al-Qunfudhah and Al-Baha recorded the lowest rates 15 and 26. The results highlight spatial and temporal disparities, suggesting that population density, urbanization, and access to healthcare may influence reporting and incidence rates. The study recommends the importance of region-specific public health interventions, intensive awareness campaigns, and targeted regulatory measures to mitigate the risks of drug poisoning nationwide.

1. Introduction

Over the last five years, drug poisoning has emerged as a significant public health issue in Saudi Arabia, posing serious risks to both individuals and society, with reported cases rising to 2,446 in 2023 [1] . Drug intoxication occurs when medications are consumed in excessive doses, either accidentally or intentionally, with the severity of the condition depending on the type of medication, dosage, and the individual’s health status. Multiple factors have contributed to the growing prevalence of this issue, including the widespread availability of medications, their easy access in households, and the increased likelihood of misuse. Additionally, a lack of awareness regarding the proper use of medications and insufficient knowledge about potential drug interactions have further exacerbated the problem [2] . To address this critical issue, various organizations in Saudi Arabia have implemented preventive initiatives. The Saudi Food and Drug Authority, for instance, has organized educational campaigns, such as “Drug Poisoning Prevention Week aimed at raising public awareness about the dangers of drug poisoning and promoting effective prevention strategies [3]. Similarly, the establishment of the Saudi Society for Pharmaceutical Education reflects a commitment to promoting the safe and optimal use of medications while challenging common misconceptions surrounding them. In addition to these national efforts, strengthening statistical initiatives remains essential. Conducting recurring studies to evaluate the outcomes of preventive measures and quantitatively assess the impact of drug intoxication on society can provide valuable insights. This research aims to investigate the underlying causes of drug intoxication, analyze its effects on public health and society, and assess the effectiveness of existing preventive measures, such as awareness campaigns and regulatory systems, to identify the most effective strategies for mitigating this escalating issue [5]. The primary data was sourced from the annual health statistical book of the Kingdom of Saudi Arabia for the years 2019 to 2023, encompassing 20 regions within the Kingdom of Saudi Arabia [1]

2. Material and Methods:

In this study, ANOVA was applied using the Statical Package of Social Sciences (SPSS). In statistics, ANOVA is a method used to determine whether there are significant differences between the means of two or more groups, based on the F distribution. This technique involves a numerical response variable "Y" and a single categorical explanatory variable "X", which is why it is referred to as "one-way."[6]. The ANOVA assesses the null hypothesis that all groups come from populations with the same meaning. It does this by calculating two

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estimates of population variance, based on certain assumptions. The outcome of ANOVA is an F-statistic, representing the ratio of the variance between group means to the variance within the groups. If the group means originate from populations with equal means, the between-group variance should be smaller than the within-group variance, as suggested by the central limit theorem. A larger F ratio suggests that the group means likely come from populations with different average values. The reliability of one-way ANOVA results depends on meeting several key assumptions. First, the residuals of the response variable should be normally or approximately normally distributed. Additionally, the variances across the populations being compared must be equal. Lastly, the responses within each group should consist of independent and identically distributed normal random variables, even though they are not required to be drawn from a simple random sample (SRS) [7]. One-way ANOVA is a statistical technique used to evaluate the null hypothesis (H_0) that the means of three or more populations are equal, against the alternative hypothesis (H_a) that at least one of the means differs. In formal statistical notation, for k population means, this is expressed as:

$H_0: \mu_{(1)}=\mu_{(2)}=\mu_{(3)}=\cdots=\mu_{(k)}$

H_a: not all means are equal

where $\mu_{(i)}$ is the mean of the ith level of the factor [8]. Welch's ANOVA is an adapted version of the ANOVA designed for situations where the assumption of equal variances across groups is violated. It offers greater reliability when group variances or sample sizes differ. This method is appropriate when comparing more than two groups, assuming the data are normally distributed but fail tests for variance equality, such as Levene's or Brown-Forsythe. Unlike standard ANOVA, Welch's ANOVA does not require variance homogeneity, is less affected by unequal sample sizes, and delivers more accurate results under these conditions [9]. It adjusts group comparisons based on within-group variance and generates a modified F-statistic to assess the null hypothesis that all group means are equal against the alternative that at least two differ. A p-value below 0.05 leads to rejecting the null hypothesis, indicating significant differences between groups; if the p-value is above 0.05, no significant differences are concluded [10].

Data and description

This study utilizes data extracted from the official statistical yearbooks published by the Saudi Ministry of Health, covering the period from 2019 to 2023, data was for 20 regions.

Table1: Reported Cases of Drug Intoxication by Health Regions in Saudi Arabia (2019–2023)

Health Region	Drug Intoxication						
	2019	**2020**	**2021**	**2022**	**2023**	Means	Std. Deviation
Riyadh	**367**	**430**	**792**	**394**	**684**	533	192
Holy Capital	**20**	**22**	**51**	**27**	**112**	46	39
Jeddah	**433**	**170**	**167**	**187**	**315**	254	117
Ta'if	**154**	**113**	**127**	**60**	**67**	104	40
Medinah	**57**	**13**	**44**	**154**	**161**	86	67
Qaseem	**38**	**35**	**35**	**41**	**37**	37	2
Eastern	**215**	**94**	**60**	**69**	**194**	126	73
AL-Ahsa	**192**	**97**	**132**	**108**	**77**	121	44
Hafr AL-Baten	**66**	**40**	**25**	**26**	**12**	34	21
Aseer	**63**	**28**	**51**	**69**	**48**	52	16
Bishah	**42**	**27**	**70**	**53**	**29**	44	18
Tabouk	**71**	**60**	**57**	**65**	**121**	75	26
Ha'il	**142**	**108**	**112**	**140**	**146**	130	18
Nourth Borders	**99**	**88**	**60**	**130**	**134**	102	31
Jazan	**23**	**17**	**4**	**6**	**87**	27	34
Najran	**152**	**86**	**80**	**99**	**64**	96	34

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Al Bahaha	**33**	**23**	**44**	**23**	**7**	26	14
Al-Jouf	**5**	**48**	**161**	**216**	**70**	100	86
Qurayyat	**61**	**86**	**42**	**106**	**68**	73	24
Qunfudah	**33**	**7**	**11**	**12**	**13**	15	10
Means	204	172	197	191	213		
Std. Deviation	115	93	168	91	151		

***Source: Statistical Yearbooks, issued by ministry of health in Saudi Arabia (2019-2023).**

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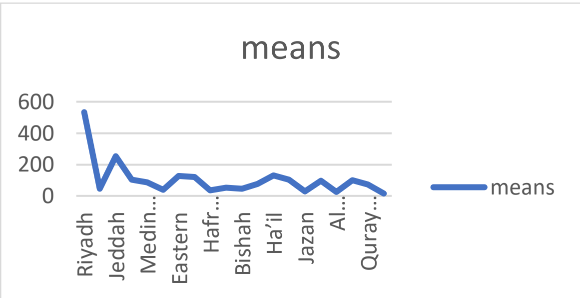

Figure1: average Cases of Drug Intoxication by Health Regions in Saudi Arabia (2019–2023)

Referring to table 1 and figure1 , Riyadh recorded the highest mean number of drug intoxication cases at 533, significantly exceeding all other regions, followed by Jeddah with 254 cases and Ha'il with 130. In contrast, the lowest mean was observed in Qunfudah with just 15 cases, closely followed by Al Bahaha (26) and Jazan (27). This suggests that Riyadh may be a major hotspot for drug intoxication, possibly due to its large population or urban factors contributing to higher incidence. In terms of variability, Riyadh also showed the highest standard deviation at 192, along with Jeddah (117) and Al-Jouf (86), indicating substantial fluctuations in case numbers over time. On the other hand, Qaseem had the lowest variability with a standard deviation of just 2, reflecting very consistent reporting, although its average number of cases remained low at 37. These differences in variability hint at underlying instability or inconsistencies in more urban regions, compared to more stable patterns in others. Moderate case numbers were observed in regions like AL-Ahsa, the Eastern Region, Ha'il, and the Northern Borders, where both the means (ranging between 100 and 130) and standard deviations remained moderate. This indicates a relatively steady level of drug intoxication incidents in those areas. When looking at geographic patterns, drug intoxication cases appear to be more concentrated in the central and western parts of the country, such as Riyadh, Jeddah, and Ta'if. In contrast, lower concentrations were found in southern and peripheral areas like Al Bahaha, Jazan, and Qunfudah. These trends may be influenced by factors such as urbanization and population density, which tend to be higher in major cities, potentially leading to increased exposure and reporting of such incidents.

4- Results and discussion:

The Kolmogorov–Smirnov (K–S) and Shapiro–Wilk (S–W) tests were employed to determine whether the data in each regional group follow a normal distribution. Both tests assess the null hypothesis (H_0) that the data are normally distributed. A significance value ($p < 0.05$) indicates a notable deviation from normality, implying that the data do not meet the assumption of normality.

Table 2-Tests of Normality for Regional Data Using Kolmogorov–Smirnov and Shapiro–Wilk Methods

	Kolmogorov-Smirnov[a]		Shapiro-Wilk	
Groups	**Statistic**	**Sig.**	**Statistic**	**Sig.**
Riyadh	0.305	0.145	0.843	0.173
Holy Capital	0.292	0.190	0.775	0.050
Jeddah	0.318	0.111	0.817	0.111
Ta'if	0.224	.0200*	0.923	0.551
Medinah	0.265	.0200*	0.858	0.222
Qaseem	0.212	.0200*	0.895	0.384
Eastern	0.272	.0200*	0.838	0.159
AL-Ahsa	0.248	.0200*	0.924	0.559
Hafr AL-Baten	0.205	.0200*	0.950	0.740

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Aseer	0.203	.0200*	0.927	0.574
Bishah	0.203	.0200*	0.927	0.574
Tabouk	0.357	0.036	0.734	0.021
Ha'il	0.317	0.111	0.808	0.094
Nourth Borders	0.217	0.200*	0.932	0.608
Jazan	0.351	0.043	0.750	0.030
Najran	0.267	0.200*	0.879	0.306
Al Bahaha	0.213	0.200*	0.970	0.874
Al-Jouf	0.236	0.200*	0.941	0.676
Qurayyat	0.175	0.200*	0.988	0.973
Qunfudah	0.385	0.015	0.757	0.035

As shown in the table, the majority of the regions yielded p-values above 0.05, suggesting that their data can be considered normally distributed. However, three regions, Tabuk, Jazan, and Qunfudhah, produced p-values below the 0.05 threshold in both tests, indicating statistically significant departures from normality. For these groups, normality assumptions are violated, and alternative statistical methods such as Welch's ANOVA or non-parametric approaches like the Kruskal-Wallis test are recommended for further analysis. In such cases, especially when comparing means across groups with unequal variances, Welch's ANOVA is recommended as a more appropriate statistical method.

Table 3:Welch's ANOVA Test for Degrees Across Groups

Degrees	Statistica	df1	df2	Sig.
Welch	10.914	19	28.515	0.000

Referring to table 3, The associated p-value of 0.000 is well below the conventional significance level of 0.05, indicating a statistically significant difference in mean degree scores across the groups. This outcome provides strong justification for rejecting the null hypothesis that all group means are equal. It suggests that at least one region's average number of drug intoxication cases differs significantly from the others. Given that Welch's ANOVA adjusts for variance inequality, these results are considered robust and reliable even in the presence of heterogeneity.

5- Conclusion and Recommendations:

This study analyzed regional drug intoxication patterns in Saudi Arabia (2019–2023) using ANOVA, revealing data inconsistencies and regional differences. Some areas required Welch's ANOVA due to non-normal data. Findings emphasize the need for targeted, data-driven public health strategies. Recommendations include focusing education on high-incidence areas like Riyadh and Jeddah, standardizing data reporting nationwide to reduce underreporting, creating region-specific interventions considering local factors, and conducting regular advanced statistical studies to monitor trends and guide policies**.**

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