Comparing Over-the-Counter Drug Prices and Availability Using Nonparametric Tests

Deanna N Schreiber-Gregory, North Dakota State University, Fargo, ND

Abstract

A study comparing over-the-counter drugs in terms of availability and prices was performed. Samples of various over-the-counter drugs were obtained from four stores using a block design. Three tests were then conducted to analyze the data obtained for this study. The first test compared differences in treatment effects using the Friedman test for a randomized complete block design. In the second test, researchers tested for the availability of drugs using the Cochran's test. A third test used a new nonparametric test for mixed design proposed by Mathisen (2011) and Ndungu (2011) and was performed to test for non-decreasing treatment effects (prices among four stores).

Introduction

The purpose of this study is to apply nonparametric statistics to an issue that can occur in everyday life. Most people at one time or another will need to buy over-the-counter drugs and the array of different stores to find these drugs is so vast. Considering this issue, an additional problem arises when comparing the prices these different stores sell each drug at and that not every store may care the drug that is needed. In response, this study is designed to test the differences in price and availability of over-the-counter drugs that are found in four major stores in the Fargo, ND area.

Procedure

To begin, four major stores were chosen from a pool of stores in downtown Fargo, ND. The stores that were chosen were Wal-Mart, Target, CVS, and Walgreens and all stores were located within a 2 mile radius of each other to eliminate the confounding variable of distance. The stores were also chosen based on the type of store they could be classified as. The researcher in this study classified Wal-Mart and Target as department stores, while CVS and Walgreens were classified as drug stores. All four stores either contained pharmacies or had the option of containing a pharmacy. Since both the Wal-Mar t and CVS selected contained pharmacies while the Walgreens and Target selected did not, the prices and availability of each drug was compared to 4 stores located outside the sampled 2 mile radius that served as the counterparts to our sample stores (a Wal-Mart and CVS that did not contain pharmacies and a Target and Walgreens that did contain pharmacies). The prices and availabilities matched with a nonsignificant difference in both price and availability within the sampled and comparable stores.

Since the purpose of this study was to test the difference between both price and availability, one parametric and five nonparametric statistical tests were used in order to complete this analysis. SAS® 9.2 was used to the compute the final statistics. Tests used were based on the composition of the data that was collected and the nature of the test itself.

Parametric Tests

The parametric test chosen was a two-way analysis of variance test. The researcher chose this test based on the acknowledgement that there would inherently be a difference between the prices of drugs. Since this difference is of a continuous nature, a parametric test was found to be appropriate. The researcher used blocking to control for the variation in prices between stores.

ANOVA

A two-way analysis of variance test was conducted. Our null hypothesis stated that there would be no difference in the mean prices between stores, while our alternative hypothesis stated that there would be some difference in the mean prices between stores. Our analysis proved to be significant ($F = 62.25$, $p < .0001$) and it was concluded that there was a significant overall price difference between the stores. Additional information provided stated that price differences between Target and Wal-Mart did not prove to be significantly different from each other; however price differences between Target and Wal-Mart compared to CVS and Walgreens showed a significant difference. Price differences between CVS and Walgreens themselves were also analyzed and there was a significant difference in price between these two stores.

In order to test the difference in price between drug stores and department stores, Tukey's Studentized Range (HSD) Test and Bonferonni (Dunn) t-tests were also conducted. Both Tukey's HSD and Bonferonni showed significant differences in price between the department store (Wal-Mart M = 9.8610, Target M = 10.0071) and drug store (CVS = 11.9110, Walgreens M = 11.4690) pairings. These differences were based on a sample size of 62 drugs that all four stores had available on their shelves.

Nonparametric Tests

In addition to the parametric test, a nonparametric test was used to test the difference in both price and availability between the sores. Nonparametric tests were chosen based on their criteria and the nature of this study.

Friedman's Test

A Friedman Two-Way Analysis of Variance by ranks was performed to test if there was a difference in prices of over-the-counter drugs between the four stores. This test was chose and performed based on the fact that it has fewer assumptions than the F-test. More specifically, Freidman's Two-Way Analysis of Variance does not have a normality assumption. Our null hypothesis sated that there would not be a significant difference in price between the stores. Our alternative hypothesis stated that at least one store would differ significantly in price. Since a traditional Friedman's test could not be conducted, a Cochran-Mantel-Haenszel test was performed based on the similarities it has to the Friedman Chi-Square test. A significant difference in price was found ($W = 121.6655$, $p < .0001$); therefore, it was concluded that there was a significant price difference between the stores.

Cochran's Test

Cochran's test was performed to test for over-the-counter drug availability between the stores. The availability was coded as 1 if available (the store had this item on its shelves) and 0 if unavailable (the store did not have this item on its shelves). Our null hypothesis stated that the treatments would be equally effective. In other words, there would be no difference in availability between the stores. Our alternative hypothesis stated that at least one store would differ in its availability from the other stores. A significant difference in availability was found ($Q = 623.2126$, $p < .0001$); therefore it was concluded that there was a significant difference in over-the-counter drug availability between the stores.

Pages' Test

Page's test was performed to test the variables in a balanced complete block design. The null hypothesis stated that there would be no price difference between the stores. The alternative hypothesis stated that there would be a price difference and it follow a non-decreasing pattern from lowest to highest where Wal-Mart would have the lowest prices, followed by Target, Walgreens and CVS respectively. A significant difference was found ($Z = 10.0923$); therefore, it was concluded that the significant price difference existed and followed a non-decreasing pattern where Wal-Mart had the lowest prices followed by Target, Walgreens and CVS respectively.

Proposed Tests

Since not all the data collected could be analyzed using a complete block design, some of the data would have needed to be discarded. Only 62 of the 290 sampled drugs were available in all stores. The researcher in this study wanted to take into account the other 228 stores to gain better insight into the actual differences in price between the four stores and if this difference followed a non-decreasing pattern. In order to do this, a mixed design was needed to include the extra data that was contained in incomplete blocks. Since no such test could be found, Ndungu (2011) and Mathisen's (2011) proposed tests were used in order to test this effect. The researcher assumed a non-decreasing pattern in price difference that took the following order of lowest to highest price: Wal-Mart, Target, Walgreens, CVS.

Proposed Test (Ndungu, 2011)

Ndungu's (2011) proposed test was performed to test the variables in a balanced incomplete block design. For Ndungu's test, the researcher randomly chose a balanced set of 24 blocks from 61 total blocks where only one treatment (store) was missing data. According to Ndungu's test, in the case of 4 treatments with 3 per block, a multiple of 4 unique blocks was needed. Since the chosen number was 24 blocks, then we multiplied Ndungu's proposed values by 6 resulting in an expected value of 360 and a variance of 79.98. The null hypothesis stated that there would not be a significant price difference between the stores. The alternative hypothesis stated that there would exist a significant difference in price between the stores and it would follow a non-decreasing pattern from lowest to highest where Wal-Mart would have the lowest prices, followed by Target, Walgreens and CVS respectively. A significant difference in price was found ($Z = 2.0686$); therefore, it was concluded that a significant difference in price existed and it followed a non-decreasing pattern from Wal-Mart having the lowest prices followed by Target, Walgreens and CVS respectively having higher prices.

Proposed Test (Mathisen, 2011)

Mathisen's (2011) proposed test was performed to test the variables in the balanced incomplete block design and those in the balanced complete block design as mixed design variables. Mathisen's test combined results from Page's test and Ndungu's proposed test. The researcher used Mathisen's test as it was found that in many cases his proposed test gave a higher power than just using Page's test or Ndungu's test as more data was used. The null hypothesis tested stated that there would be no difference in price between the stores. The alternative hypothesis being tested stated that there exist a difference in price between the stores and that it would follow a non-decreasing pattern in which Wal-Mart had the lowest prices followed by Target, Walgreens, and CVS respectively having higher prices. A significant difference in price was found ($T^* = 8.5991$); therefore, it was concluded that there existed a difference in price that followed a non-decreasing pattern in which Wal-Mart had the lowest prices followed by Target, Walgreens and CVS respectively having higher prices.

Conclusion

In this study, we found that the usage of nonparametric statistics in everyday life has its advantages. Through this test, a significant difference was found in over-the-counter drug prices and availability between the sampled stores. In terms of price, a non-decreasing pattern was also shown, indicating that one store had the lowest prices followed by the other three stores in a significantly defined sequence.

Implications for this research indicate that families looking for the lowest price on over-the-counter drugs would have the best chance of finding what they need if they visited one store over any others based on price and availability. Future research could explore the differences in prices and availability within different categories of over-the-counter drugs thus giving consumers a better idea of where to shop depending on what they need treated. The researcher of this study believes that the usage of the established nonparametric tests and the proposed nonparametric tests proved to be beneficial in this study.

References

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Contact Information

Your comments and questions are valued and encouraged. Contact the author at:

Deanna N Schreiber-Gregory
North Dakota State University
Fargo, ND 58102
701-799-6905
annies94ranger@hotmail.com