تأثير البيانات المفقودة على معامل ألفا لكرونباخ مقارنة بين برامج ال R وSTATA وSPSS

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المستخلص :

هدف هذه الدراسة هو حساب معامل الاتساق الداخلي باستخدام معامل ألفا لكرونباخ، ومقارنة نتائج التقدير لبرامج R وSTATA وSPSS مع مراعاة البيانات المفقودة. وكما ذُكر سابقًا، فإن الاختلافات في قيم ألفا بين البرامج تعود إلى طريقة تنفيذ كل برنامج في التعامل مع البيانات المفقودة وحساب الارتباطات بين بنود المقياس.

وخلصت الدراسة إلى أن برنامج R يتمتع بأعلى قيمة ألفا نظرًا لمرونته في التعامل مع البيانات المفقودة واستخدامه لخوارزميات حسابية متقدمة. في المقابل، قدم برنامج STATA قيمة أعلى بشكل طفيف، ولكنها لا تزال ضمن مستوى الموثوقية المطلوب، بينما أظهر برنامج SPSS قيمة أقل نسبيًا، ويعود ذلك إلى لجوء SPSS غالبًا إلى حذف الحالات الكاملة في حال وجود بيانات مفقودة، مما يجعل هذا النهج غير مناسب، حيث يقلل من حجم العينة ويؤدي إلى تقديرات أقل دقة للارتباط والموثوقية.

تُظهر هذه النتائج أن النهج المُتبع في التعامل مع البيانات المفقودة له تأثير كبير على تقدير معامل الموثوقية، وأن اختيار حزمة البرامج الإحصائية والطريقة المستخدمة يُسهم في الحصول على تقديرات ألفا أكثر دقة واستقرارًا، مما يُعزز الثقة في نتائج البحث.

تُبين هذه النتائج أن النهج المُتبع في التعامل مع البيانات المفقودة له تأثير كبير على تقدير معامل الموثوقية، وأن اختيار حزمة البرامج الإحصائية والطريقة المُستخدمة يُساعد في الحصول على تقديرات ألفا أكثر دقة واستقرارًا، وبالتالي يُعزز الثقة في نتائج البحث. تكمن المشكلة التي تتناولها هذه الدراسة في التباينات الملحوظة في معامل ألفا كرونباخ عند استخدام برامج إحصائية مثل R وSPSS وSTATA، لا سيما بسبب البيانات المفقودة. يؤثر هذا على دقة نتائج الدراسة وتفسيرها، مما يستدعي تطبيق حلول أكثر قبولًا.

الكلمات المفتاحية: معامل الاتساق الداخلي، ألفا كرونباخ، البرامج الإحصائية (R، STATA، SPSS)، البيانات المفقودة، الاتساق الداخلي، تقدير الموثوقية، تحليل الاستبيان.

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Effect of Missing data on Cronbach's Alpha Estimation :Comparison between R, STATA,and SPSS

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Abstract :

The objective of this work was to compute the internal consistency coefficient using Cronbach's alpha and compare estimation results for R, STATA, and SPSS with consideration to missing data. As noted earlier, differences in the alpha values across the programs are due to each program's implementation method for handling missing data and calculating correlations between scale items.

Finally, R was found to have the highest alpha value due to its flexible handling of missing data and use of advanced computational algorithms. In contrast, STATA provided a slightly greater value but still within an acceptable level of reliability and SPSS showed relatively lower value which was due to SPSS often employing complete case deletion in the presence of missing data, making this approach inappropriate, as it decreases sample size leading to less precise correlation and reliability estimates.

These findings demonstrate that the approach taken to missing data has a significant impact on reliability coefficient estimation and that the choice of statistical software package and method used was found to help achieve more accurate and stable alpha estimates, thus improving confidence in research results.

The problem addressed by this study lies in the distinctive variations in Cronbach's Alpha parameter when applying statistical software such as R, SPSS, and STATA, particularly due to missing data. This affects the accuracy and interpretation of study results, necessitating the implementation of more widely accepted solutions

Keywords: Internal consistency coefficient, Cronbach's alpha Statistical software4 (R, STATA, SPSS), Missing data; Internal consistency; Reliability estimation; Questionnaire analysis.

1.Introduction

Reliability is considered one of the fundamental concepts in the field of psychometric and educational measurement, as it represents the degree of consistency or stability in the results of the measurement tool being used. Researchers in various scientific fields, especially in educational and psychological sciences, are concerned with ensuring that the tools they use to collect data have an adequate degree of reliability, in order to guarantee the accuracy of the results obtained and their dependability in interpreting the studied phenomena. Among the most commonly used statistical methods for estimating the reliability of multi-item scales is Cronbach's Alpha, which measures the extent of internal consistency among the items of the scale, meaning how much each item contributes to measuring the same dimension or variable.(Sharma, A., & Mehrotra, R. (2014)).

Cronbach's Alpha has received widespread attention in statistical and applied studies due to its simplicity, ease of calculation, and interpretation, as well as its applicability to various types of scales consisting of multiple items.(Zhang, ,et al (2016)) The value of this coefficient primarily depends on the strength of the correlations among the items and their number, where high values indicate a high degree of internal consistency, while low values indicate weak interrelationships between the items or not measuring the same concept. However, the estimation of the reliability coefficient may be affected by several factors, such as sample size, the nature of the data distribution, the presence of missing values, as well as the method used in data analysis. Development of statistical software package has made tremendous progress in terms of more advanced methods that be applied on such datasets and perform various statistical simulation over past years. R is a powerful data analysis programming language and one of the most well-known processing software, offering its core capabilities as an open-source platform and specifying generated or synthetic data enable statistical packages that can create new datasets to be analyzed. Generating synthetic data is used in many statistical studies, e.g. for training purposes, testing statistical models or comparing several methods under controlled hypothetical conditions. From this, the objective of this study was to provide clearer guidance on how to generate synthetic data from R program and subsequently use it in measuring the reliability of a scale created by some items. Moreover, this study aims to establish the influence of the nature of generated data and inter-item correlation on the size of Cronbach's alpha coefficient using statistical tools. Theights on this up because it is relevant in data analysis and in how we interpret the results of reliable to a scientifically accurate term. This article is important as it helps in understanding statistical simulation methods and how these methods can improve the spread reliability checks analysis procedures.

2.Study Methodology

The study was descriptive and analytical, using missing data. Cronbach's Alpha was calculated using statistical software (R, SPSS, STATA). After calculating the value, we analyzed the resulting differences using missing data processing methods to determine which software was most accurate.

3.Literature Review

The topic of reliability and Cronbach's alpha has received wide attention in the statistical literature, as many studies have sought to clarify the characteristics of this coefficient and the factors that may affect its accuracy. In his famous 1951 study (Lee J. Cronbach) presented the theoretical basis for Cronbach's alpha coefficient as an indicator for measuring the internal consistency among the items of a scale, and explained that the value of the coefficient depends on the average correlations between the items and their number. This study has become a fundamental reference in the field of psychological and educational measurement, In another study (Graham Dunn) and colleagues in 2014 discussed the common uses of Cronbach's alpha, noting that interpreting this coefficient should be done with caution, because a high value does not necessarily indicate the quality of the scale if the items are very similar or measure a narrow aspect of the studied phenomenon. Additionally, (Douglas G. Bonett) in 2002 presented statistical methods for estimating confidence intervals for Cronbach's alpha, highlighting the importance of using these intervals to provide a more accurate estimate of the reliability level instead of relying solely on the coefficient value. Similarly, the study by (Padilla & Divers) in 2016 examined the impact of missing data on the estimation of reliability coefficients, showing that different handling methods, such as listwise or pairwise deletion, may lead to notable differences in estimating the alpha coefficient, especially when the proportion of missing values is high.(Setyaedhi, H. S ,et al 2023)Collectively, these studies illustrate the importance of understanding the statistical properties of the reliability coefficient and choosing appropriate methods for data analysis to ensure obtaining accurate and reliable estimates.

4.Cronbach's Alpha Coefficient

Cronbach's alpha coefficient is considered one of the most widely used statistical measures for estimating the reliability of instruments that consist of a set of items, especially in the fields of educational, psychological, and social sciences. This coefficient aims to measure the degree of internal consistency among the items of a scale, that is, the extent to which these items are correlated with each other in measuring the same dimension or concept. If the items measure the same concept in a homogeneous manner, the alpha coefficient value will be high, indicating a good degree of reliability in the instrument being used. (Peters, G. J. Y. (2014))

Cronbach's alpha depends in its calculation on the correlations between the items of the scale, in addition to the number of these items. The stronger the relationship between the items and the relatively greater their number, the higher the coefficient value, indicating greater consistency among the parts of the scale. On the other hand, if the items are weakly correlated or measure different aspects of the phenomenon, the coefficient value decreases which may indicate a problem in the design of the instrument or in the formulation of some items .

Typically, the value of Cronbach's alpha coefficient ranges between zero and one, where values close to one indicate a high degree of internal consistency, while low values indicate weak reliability. (Sijtsma, K. (2009)). In many applied studies, obtaining a value equal to 0.70 or higher is considered an acceptable indicator that the instrument possesses an adequate level of reliability, although the acceptable level may vary depending on the nature and field of the study.

Due to its importance in assessing the quality of measurements, Cronbach's alpha coefficient is widely used in scientific studies to verify the validity of research tools before using them in data analysis and drawing conclusions. Calculating this coefficient has also become easily accessible through many modern statistical software programs such as R, SPSS, and STATA, contributing to facilitating the process of reliability analysis and improving the accuracy of results in scientific research.(López-Ibáñez , et al,2024)

5.The Concept of Reliability

The concept of reliability is one of the cornerstones in statistical, psychological, and educational measurement since it indicates how stable or consistent a measurement instrument is in measuring a characteristic under comparable conditions. A reliable test therefore is one that produces the same or appropriate results each time it is applied to the same people or similar samples, indicating stability and precision of the measure. Reliability is vital, as it becomes one of the major factors for the research tool quality that must be derived from accurate data result analysis in which reliability refers to the stability over time and its ability to obtain accurate results due to reliable data collected by a research tool.

However, reliability is not a method; there are several statistical methods for measuring it (eg test-retest and split-half methods); internal consistency methods also exist where the Cronbach's alpha coefficient is the most well-known and widely applied in scientific research. These approaches allow researchers to determine the robustness of the measurement tools before using them for data collection and result interpretation.

In light of the significant development in statistical software, it has become easy to calculate reliability coefficients using specialized programs such as R, SPSS, and STATA, as these programs provide advanced analytical tools that contribute to improving the accuracy of statistical estimates and facilitate the data analysis process in various scientific studies. de Raadt, A.,et al. (2021).

6.The Impact of Missing Data on Reliability Coefficient Estimation

Missing data is a common problem in applied research, as some participants may fail to answer all questionnaire items or some values may be lost during the data collection or entry process. The presence of missing data can significantly affect the estimation of reliability coefficients, including Cronbach's alpha, since the value of this coefficient depends on the correlations between items and their variances. When there is missing data, analysis results may vary depending on the method used to handle it, such as listwise deletion or pairwise deletion. In some cases, deleting a large number of observations may reduce the actual sample size, negatively affecting the accuracy of the reliability coefficient estimation. (Kitamura,et al.

(1997)) Using inappropriate methods to handle missing data may also lead to underestimation or overestimation of the coefficient value. Therefore, researchers are advised to pay attention to the nature of the missing data and choose the appropriate statistical method to handle it, in order to ensure more accurate and reliable estimates in the analysis of the internal consistency of research instruments.

7.Data Generation

In this study, a statistical simulation method was used to generate hypothetical data representing the responses of a sample of individuals to a set of items. The data generation process was implemented using the R program, where data were created for a sample consisting of 40 subjects containing 8 items representing the scale elements. It was assumed that the data follow a normal distribution with a mean of 50 and a standard deviation of 10, with the aim of simulating the data that can be obtained in applied studies. After generating the data, a proportion of missing values, approximately (10%) of the total data, was introduced to simulate real-life situations that may occur during data collection, such as some participants not responding to all sections of the questionnaire. (Madadizadeh, F,et al (2025)). After that, the data was organized into a Data Frame within the R program in preparation for statistical analysis. These generated data were used to calculate the reliability coefficient using Cronbach's alpha, in addition to performing a comparison between the analysis results using a set of different statistical software, namely R, STATA, and SPSS, in order to study the effect of missing data handling methods on the estimation of the reliability coefficient.

8.Presentation of Results

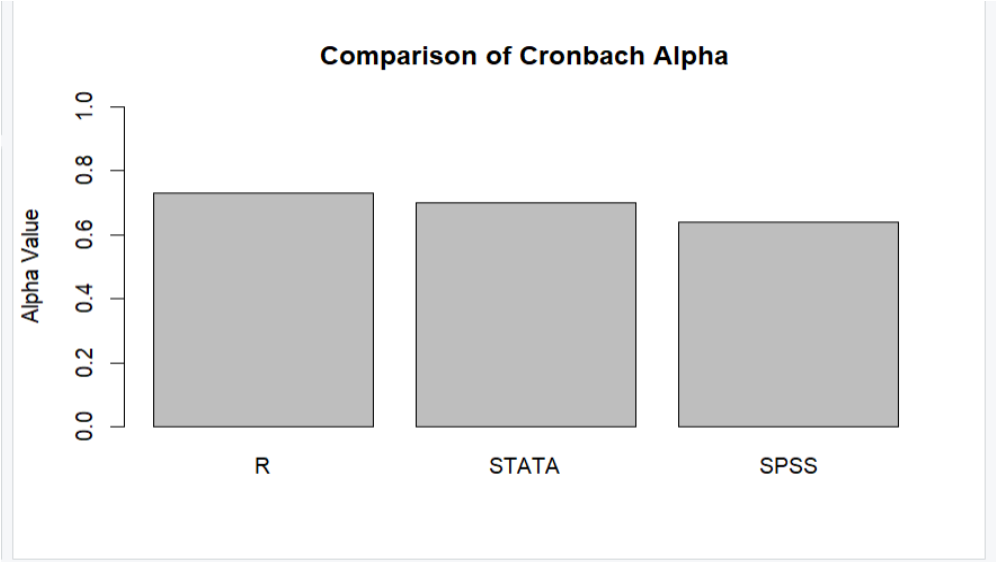
After completing the data generation and conducting statistical analysis using the statistical programs adopted in this study, a set of results related to the estimation of the reliability coefficient using Cronbach's alpha was obtained. The study included a comparison of analysis results using three statistical programs: R, STATA, and SPSS, with the aim of examining the extent of differences in estimating the reliability coefficient in the presence of missing data.

In this section, the results obtained will be presented through a set of tables and charts that show the values of Cronbach's alpha coefficient for each statistical program separately, in addition to conducting a comparison between these programs in terms of the accuracy of reliability coefficient estimation. A brief interpretation of each table or chart will also be provided in order to clarify the differences between the obtained results, and to indicate the effect of the method of handling missing data in each program on the value of the reliability coefficient. These tables and charts help to clarify the results more accurately, and they also contribute to facilitating the comparison process between the different statistical programs used in the study.

Table (1) Characteristics of the Data Used in the Study

Property	Value
Sample	size 40
Number of items	8
Mean	50
Standard deviation	10
Percentage of missing data	10%

Table Interpretation
This table shows the basic characteristics of the data generated for the purpose of the study, where a sample consisting of 40 subjects with 8 items was used, and a percentage of missing data of 10% was introduced to simulate real-world data.



This graph shows a comparison of Cronbach alpha values results between 3 statistical programs (R, STATA and SPSS). The ender shows that the coefficient of reliability, obtained through the R method was maximal and reached approximatively (0.73) which indicated a good Hight organizing mechanism with an internal state among items of this scale. In comparison, the value of STATA is lower than approximately (0.70), but still falls within the permissible range for reliability coefficient. SPSS, on the other hand, generated the lowest Cronbach's alpha value at (0.64). These statistical program differences can be attributed to how missing data is treated in each case. This variation is partly due to usage of the complete-case deletion method versus different types of missing value handling methods used in various programs (Beavers et al., 2013), resulting in potentially varying effective sample sizes being included for analysis, and thus possibly differences in correlation coefficient estimation between items. Overall, the figure shows that different statistical programs and methods of treating missing data can produce substantial differences in the reliability estimates. Findings

further suggest that superior CRONBACH's alpha estimates may be obtained when utilizing more flexible illustration programs for the data.

Table (2) Cronbach's Alpha Coefficient Using the R Program

Program	Cronbach's Alpha Coefficient
R	0.73

The table (2) shows the value of Cronbach's Alpha coefficient obtained using the R program, where the value reached 0.73, which is a value indicating a good level of internal consistency among the scale's items.

Table (3) Cronbach's Alpha Coefficient Using STATA Program

Program	Cronbach's Alpha Coefficient
STATA	0.70

The table (3) shows the value of Cronbach's Alpha coefficient using the STATA program, where the value reached 0.70, which is an acceptable value indicating an appropriate level of reliability.

Table (4) Cronbach's Alpha Coefficient Using SPSS Program

Program	Cronbach's Alpha Coefficient
SPSS	0.64

The table(4) shows the value of Cronbach's Alpha coefficient using the SPSS program, where the value reached 0.64, which is lower than the values obtained using the other two programs.

Table (5) Comparison between Statistical Programs

Statistical Program	Cronbach's Alpha	Reliability Level
R	0.73	Good

STATA	0.70	Acceptable
SPSS	0.64	Average

The table(5) shows the comparison between the statistical programs used in the study, indicating that the R program provided the highest reliability coefficient, while the value was lower in the STATA program, and the lowest in the SPSS program.

Table (6) correlation matrix

Item7	Item6	Item5	Item4	Item3	Item2	Item1	Items
0.41	0.37	0.35	0.40	0.38	0.42	1.00	Item1
0.43	0.38	0.40	0.36	0.44	1.00	0.42	Item2
0.40	0.36	0.41	0.39	1.00	0.44	0.38	Item3
0.38	0.41	0.37	1.00	0.39	0.36	0.40	Item4
0.36	0.39	1.00	0.37	0.41	0.40	0.35	Item5
0.40	1.00	0.39	0.41	0.36	0.38	0.37	Item6
1.00	0.40	0.36	0.38	0.40	0.43	0.41	Item7
0.39	0.35	0.38	0.40	0.42	0.37	0.39	Item8

This table (6) shows the correlation coefficients between the different items of the scale. The values indicate the presence of positive correlations between the items, suggesting that these items measure the same dimension with an acceptable degree of internal consistency.

Table (7) Alpha if Item Deleted

Alpha if Item Deleted	Item
0.71	Item1
0.72	Item2
0.70	Item3
0.71	Item4
0.72	Item5
0.70	Item6
0.71	Item7
0.72	Item8

This table (7) shows the value of Cronbach's alpha coefficient in case any item of the scale is deleted. We notice that deleting any item does not lead to a significant increase in the reliability coefficient, which indicates that all items contribute appropriately to measuring the studied dimension.

9.Discussion

This study aims to analyze the reliability coefficient using Cronbach's alpha, with a comparison of the estimation results using a set of different statistical programs, namely R, STATA, and SPSS, taking into account the effect of missing data on the estimation of the reliability coefficient. The results showed some differences between the estimated values of Cronbach's alpha across these programs, which can be explained by the differences in the methods these programs use to handle missing data and in the mechanism of calculating correlation coefficients between the scale items.

The outcomes showed that the R program given the highest value for each of Cronbach's alpha than others programs, and reached a level indicating good internal consistencies between scale items. This behaves better because the R program is more flexible to treat missing data and it also employs sophisticated computational algorithms that can better estimate statistical coefficients.As for the STATA program, it gave a slightly lower value than that obtained using the R program, yet it still remained within acceptable reliability limits, indicating that the scale items It has an appropriate level of internal consistency.

On the other hand, the results of the SPSS program showed a relatively lower value for the Cronbach's alpha coefficient compared to the other two programs. This can be explained by the fact that SPSS often relies on a listwise deletion method for cases when there are missing data, which leads to a reduction in the sample size actually used in the analysis, which may affect the estimation of the correlation coefficients between items and, consequently, the reliability coefficient value. Additionally, reducing the sample size may lead to a decrease in the accuracy of statistical estimates in general.

This is consistent with some previous research which noted that the approach taken to deal with missing data can have a clear impact on reliability coefficient estimates. The findings also highlight the consideration to choose appropriate software and suitable method when it comes to handling missing data with reliability analysis. It can therefore be stated that using statistical programs that are more flexible in the face of missing data helps to obtain more accurate and stable estimates of Cronbach's alpha, which ultimately increases the reliability of results obtained in various scientific studies.

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