Scoping Review Protocol: Statistical Models for Longitudinal Data

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2022-08-11

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1 Background

Longitudinal studies are frequently used in the health sciences (biomedical research, epidemiology, public health, among others) as they allow to examine how the temporal effect of a treatment or an intervention, in contrast to a cross-sectional study, which only allows to examine the effect of the intervention at a single time point. When compared to cross-sectional studies, longitudinal studies allow for increased statistical power and more cost efficient strategies[1,2]. However, the statistical analysis of longitudinal requires to take into consideration factors such as data missingness, correlation, and non-linear trends, which do not occur on cross-sectional data[3,4].

This additional layer of complexity in the analysis of longitudinal data has led to a well documented problem of model misspecification (the use of a statistical model that is not coherent with the data) in the health sciences[4], which can be partly explained by the fact that researchers have a tendency to use the same statistical analysis, methods and tests from other papers without having a clear understanding of the limitations, assumptions, and applicability of the model in each situation[5,6]. For example, in a landmark study Liu et al. showed that in a subset of papers in the biomedical sciences, the most popular model used to analyze longitudinal data was ANOVA (an approach that fails to take into account the correlation between measures over time), and that only 18% of studies used models intended for longitudinal analysis while checking that the assumptions of the model were satisfied by the data[7].

Historically, the repeated measures analysis of variance (rm-ANOVA) has been the preferred method in the health sciences to analyze longitudinal data, despite the fact that frequently, the assumptions required for its use are not satisfied by the data[4]. On the other hand, over the last 30 years the field of Statistics has been able to develop models for longitudinal data that overcome the limitations of rm-ANOVA, such as linear mixed models, generalized additive models, Bayesian models, and generalized estimating equations[8–12]. However, the adoption of these modern statistical techniques has been slow, as showcased by Gueorguieva et al., who showed that by 2001, only 30% of clinical trials reported in the *Archives of General Psychiatry* used linear mixed models to analyze their results and that rm-ANOVA continued to be the preferred method of analysis in most cases[13].

During the last decade, the increased availability of computational tools to analyze longitudinal data has lead to increased adoption of modern statistical methods to analyze longitudinal data in the health sciences[14–17]. Despite this, it is not known how much the adoption of these modern statistical methods has increased over the last 20 years, and what are the reasons that may continue to limit the knowledge and application of these statistical methods by researchers in the health sciences. Because research reproducibility continues

to be at the center of the debate on biomedical research [citation], there is a need to better understand the current status of statistical practices in the health sciences in order to implement changes that can lead to a harmonized used of statistics.

To answer this question, in this study we surveyed the statistical methods used in papers dealing with longitudinal data in health sciences over the last 20 years, in order to gain a better understanding of: 1) the trends in adoption of modern statistical methods, 2) identify the most frequent pitfalls in statistical analysis, and 3) provide a rationale for situations where these methods are still not widely adopted.

2 Objective

This study aims to summarize the different statistical models for longitudinal data that are used in the health sciences, identify the extent of the adoption of modern statistical methods in the field, and determine if in each case, model assumptions are checked by researchers to ensure congruency between the data and the model.

3 Review Question

Summarize the statistical methods used to analyze longitudinal data in the health sciences to identify which methods are most commonly used, the applicability of such methods in the context of each study, and gaps that might exist that prevent the adoption of modern statistical methods that can be better suited to analyze the data. Additionally, identify if studies check for model assumptions, and how this in turn impacts the reported results.

4 Databases

- PubMed
- Web of Science

5 Search Terms

6 Criteria

6.1 Inclusion Criteria

- methods paper see new methods developed
- application

6.2 Exclusion Criteria

7 Additional Resources

8 Comparison (?)

9 Data Extraction

10 Data Synthesis Strategy

11 References

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