General-purpose confidence intervals with safety mechanism: holding confidence in varying sampling scenarios with small sample sizes

Authors:
Ilmari Tamminen, Jari Viik, Jari Hyttinen

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Abstract

Clustered multi-level data are frequently encountered across many disciplines of science. Clusters refer to measurements from shared entities, such as weighed mice from litters or measurement batches from sampling sessions. Risk of misleading results can increase dramatically if between-cluster variation is not dealt with appropriate statistical analyses. Another problem is the established use of p-values with thresholds, which is known to lead to many conclusive errors. Unlike the p-values, confidence intervals communicate the practically more significant effect sizes in the populations by covering them ideally with the accepted uncertainty. Thus, mixed-model confidence intervals are promising tools to solve these issues in the ongoing replication crisis. However, standardized approaches have not been adopted widely, probably due to the demanding utilization and limited applicability of the conventional methods. To solve these issues, we are developing a new general-purpose analysis tool that can produce reliable effect-size confidence intervals in analytical setups dealt frequently across the practices of science. When benchmarked using a diversity of sampling simulations starting from small sample sizes, the prototype confidence intervals sustained the assumed or better than nominal confidence despite a range of exceptions from the usual assumptions, while popular reference methods failed to deliver the same certainty and precision in a substantial number of the sampling scenarios. The computational reproducibility of the new method is secured using state-of-the-art containerization, and easy-to-use user interface is under planning to lower the bar of adoption. The new method is a promising candidate for standardized improvement of the scientific method in general.