Reporting Life Sciences Research

This non-exhaustive list summarizes several elements of methodology that are frequently poorly reported. Inconsistent reporting may lead to incorrect interpretation of results and a lack of reproducibility. To improve the transparency and the reproducibility of published results, we ask that authors include in their manuscripts relevant details about these elements of their experimental design. During peer review, authors confirm via the Reporting Checklist For Life Sciences Articles that this information is reported.

Reporting Experimental Design

Sample size: When confirming an effect of known size, it is considered best practice to estimate before conducting the experiments what sample size is needed to ensure statistical power of detection. If no sample size calculation was performed, the authors should report why they think the sample size is adequate to measure their effect size. For animal studies, authors must report whether statistical methods have been used to predetermine sample size. When performing an interim evaluation of the results, investigators should use statistical methods that take into account multiple looks at the data. For all experiments, the sample size (*n*) must be reported as an exact number (not a range). Investigators should define the criteria for identifying and dealing with outliers before running the experiments. When reporting the results, they must explain any discrepancy between sample size at the beginning and end of each analysis due to attrition or exclusion.

Randomization: Whether samples are randomly assigned to experimental groups, to processing order, or to positions in a multi-well device may influence experimental outcome. Ideally, data also should be collected randomly or the samples appropriately blocked. A statement about randomization methods should be included in the experiment description (in the figure legend or methods section) whenever relevant. It is required for all animal experiments, as knowing whether the animal studies were randomized or not may influence interpretation. For *in vitro* experiments, the absence of a statement is taken to mean that there was no randomization.

Blinding: Whenever possible, the investigator should be unaware of the sample group allocation during the experiment and when assessing its outcome. Although we realize that blinding is not always possible, we require a statement describing the level of blinding for all animal experiments (even if simply to state that blinding was not possible). For *in vitro* experiments, the absence of statement is taken to mean that there was no blinding.

Replication: It is often unclear whether replicates represent biological or technical replicates. In reporting their results, authors should provide enough details about the sample collection to distinguish between independent data points and technical replicates. Depending on the experimental design, technical replicates will reflect the variation of the assay and/or sample preparation by assaying a sample from the same source multiple times. Biological replicates are intended to reflect the biological variability and require processing samples from different sources. Experimental design should be taken into account to define biological replicates – for example, they may require animals from different litters. Therefore, careful reporting of the experimental conditions and nature of replicates is essential. When showing a representative experiment, authors must specify the number of times this experiment was successfully repeated and discuss any limitations in repeatability.

Reporting Statistics

Authors must describe the statistical tests used during the analysis and justify their choices. Many statistical tests require that the data be approximately normally distributed; when using these tests, authors should explain how they tested their data for normality, which may be difficult if sample sizes are small. If the data do not meet the assumptions of the tests, then a nonparametric alternative should be used instead. If the distribution is not normal, mean and standard deviation calculations are not appropriate. Authors should specify whether the tests are one-sided or two-sided. They should also estimate the variation within each experimental group and ensure that the variance is similar for groups that are being statistically compared.

When making multiple statistical comparisons on a single data set, authors should explain how they adjusted the alpha level to avoid an inflated Type I error rate, or they should select statistical tests appropriate for multiple groups (such as ANOVA rather than a series of *t*-tests).

Statistical measures, such as 'center' (mean, median) and error bars (standard duration, standard error of the mean), used to describe a dataset must be stated. The *P* value for each test must be reported regardless of overall significance.

When the sample size is small, authors should use tests appropriate to small samples or justify their use of large-sample tests. Mean and standard deviation are not appropriate with small sample sizes, and bar graphs are often misleading. Plotting independent data points is usually more informative. When technical replicates are reported, error and significance measures reflect the experimental variability, not the variability of the biological process; it is misleading not to state this clearly.

Describing Reagents

Antibodies: Antibodies should have been profiled to determine their sensitivity, specificity and range of reactivity in the assay being considered. Authors must report a catalog number (and/or clone number) or primary citation for each antibody. If these sources do not provide validation data in the specific assays and species, investigators must report the validation that they have conducted as supplementary information or as a submission to databases of antibody profiles (such as Antibodypedia or 1DegreeBio).

Cell lines: To help curb the inadvertent use of cross-contaminated or misidentified cell lines, authors are asked to check their reagents against the list of commonly misidentified cell lines maintained by the International Cell Line Authentication Committee (ICLAC; http://iclac.org/databases/cross-contaminations/), also accessible through the NCBI BioSample database (http://www.ncbi.nlm.nih.gov/biosample/). If using a cell line that is on this list, authors should provide a scientific justification and state the identity issue in the Methods section. Editors reserve the right to demand that the data be removed from the paper if the justification is deemed unsatisfactory. In addition, authors must identify the source of cell lines (with catalog number if obtained from vendor or cell bank) and report whether the cell lines have been authenticated, including the method used, the results and when authentication testing was last performed for that cell line. Authors should be able to provide the test results upon request. Mycoplasma contamination testing status must also be reported. These requirements will be emphasized for cancer research where the issue of cell line misidentification has been well documented, but authors in all disciplines are strongly encouraged to comply with these reporting criteria. It is good practice to obtain cell lines from reputable repositories and to routinely authenticate cell line stocks and test them for mycoplasma contamination. Resources on cell line authentication are available here.

Describing Methods

To allow for more space, the methods sections of original research articles, with associated references, will appear online only. In addition, authors are encouraged to deposit the step-by-step protocols used in their study to Protocol Exchange, an open resource maintained by Nature Publishing Group. Links to these protocols will appear in the Online Methods section of the published article.

Reporting Randomized Clinical Trials

Authors reporting phase II and phase III randomized controlled trials should refer to the CONSORT Statement for recommendations to facilitate the complete and transparent reporting of trial findings. Authors must submit the CONSORT checklist with their submission.

Prospective clinical trials must be registered before the start of patient enrollment in www.clinicaltrials.gov or a similar public repository that matches the criteria established by ICMJE (International Committee of Medical Journal Editors.) The trial registration number must be reported in the paper. (Trials in which the primary goal is to determine pharmacokinetics are exempt.)

Data Deposition Policy

A condition of publication in a Nature journal is that authors are required to make materials, data and associated protocols promptly available to readers without undue qualifications. Any restrictions on the availability of materials or information must be disclosed to the editors at the time of submission. Any restrictions must also be disclosed in the submitted manuscript, including details of how readers can obtain materials and information. If materials are to be distributed by a for-profit company, this must be stated in the paper.

Supporting data must be made available to editors and peer reviewers at the time of submission for the purposes of evaluating the manuscript. Peer reviewers may be asked to comment on the terms of access to materials, methods and/or data sets; Nature journals reserve the right to refuse publication in cases where authors do not provide adequate assurances that they can comply with the journal's requirements for sharing materials.

For details of how to make data available, see the Nature journals policy statement.

Presenting Electrophoresis and Gel Data

Positive and negative controls, as well as **molecular size markers**, should be included on each gel and blot. Cropped gels presented in the paper must retain all important bands and retain at least six band widths of space above and below the bands of interest.

Loading controls (e.g., actin, GAPDH) are run on the same blot. Sample processing controls run on different gels must be identified as such, and distinctly from loading controls.

Vertically sliced images that juxtapose lanes that were non-adjacent in the gel must have a clear separation delineating the boundary between the gels.

Quantitative comparisons between samples on different gels/blots are discouraged; if this is unavoidable, the samples must derive from the same experiment and the gels/blots must have been processed in parallel, and the figure legend must clearly state these details. Appropriate reagents, controls and imaging methods with linear signal ranges must be used.

Exposures should generally be such as to produce gray backgrounds. High-contrast gels and blots are discouraged, as overexposure may mask additional bands. Multiple exposures should be presented in supplementary information if high contrast is unavoidable.

Additional Guidelines

Please note that additional guidelines on performing and reporting specific experiments are also available from *Nature* journals and other sources. Useful examples include:

- Animal preclinical studies: *A call for transparent reporting to optimize the predictive value of preclinical research*, ARRIVE guidelines
- Biomarker studies: REMARK guidelines
- Description of biospecimen: BRISQ guidelines
- Molecular structure determinations: Nature journals templates for tables describing NMR and X-ray crystallography data
- Chemical compound characterization: *Nature Chemical Biology* guidelines
- Flow cytometry: good general practice in the description of flow cytometry experiments can be found in this *Nature Immunology* article and at the MIFlowCyt Standards section of SourceForge.
- Electrophoresis and gel guidelines
- Microscopy guidelines