

The Claim Comes First: Descriptive, Causal, Mechanistic and Predictive Claims Need Different Evidence

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Abstract

A scientific result is interpretable only relative to the claim it is intended to support. Description, prediction, causal effect estimation and mechanistic explanation answer different questions and therefore require different evidence. Conflating them creates category errors: an accurate predictor can lack causal meaning; a causal intervention can establish an effect without identifying its mechanism; a mechanistic narrative can remain weak if it does not generate discriminating predictions; and a descriptive estimate can be valid without supporting extrapolation beyond its target population. This article defines a claim-first discipline for scientific inference. It proposes that every analysis begin by stating the claim class, target population or system, contrast or outcome of interest, temporal and spatial scope, and evidential standard required. It then maps common evidence types to the claims they can and cannot support. The central rule is non-compensatory: stronger statistics cannot substitute for evidence of the wrong kind. The article provides the claim taxonomy used by the INF series and establishes boundaries for later articles on causal structure, rival explanations, evidential strength, discriminating experiments, uncertainty, robustness and generalisation.

Keywords: scientific claims; description; prediction; causality; mechanism; evidence; inference; model; validation

1. Why the claim must be stated before the analysis

Scientific workflows often begin with available data or a familiar statistical method. That order is convenient but inferentially dangerous. The same data can support a descriptive estimate, a predictive model, a causal analysis or a mechanistic hypothesis only under different assumptions. Shmueli distinguished explanatory and predictive modelling and showed that predictive and explanatory goals lead to different modelling choices [1]. Causal inference adds a further requirement: causal effects concern hypothetical interventions or contrasts and cannot be read directly from association without identifying assumptions [2,3]. Mechanistic claims impose still another burden because a mechanism concerns the process or structure producing an outcome, not merely the existence of an effect [4].

INF therefore adopts a claim-first rule: define what is being claimed before deciding whether the evidence is adequate. A method can be technically correct and still answer the wrong scientific question.

2. Four claim classes

- **Descriptive claim** : states what was observed or measured in a defined population, sample, specimen set, condition or time window. Its central threats concern measurement, sampling, missingness and representation of the target quantity.
- **Predictive claim** : states that a model or procedure can predict an outcome under specified conditions. It requires performance evaluation on data not used to fit or choose the model, or an equivalent honest validation design. Prediction does not by itself establish cause or mechanism.
- **Causal claim** : states the effect of changing an exposure, treatment or intervention relative to a defined alternative. It requires a target causal contrast and assumptions or design features sufficient to identify that contrast.
- **Mechanistic claim** : states something about the process or structure through which an outcome is produced. It requires evidence capable of distinguishing that mechanism from plausible alternatives, not only correlation, prediction or intervention response.

3. Evidence is claim-relative

Evidence is not intrinsically “causal”, “mechanistic” or “predictive”. Its relevance depends on the inferential link to the stated claim. Randomisation can strengthen causal identification for a defined intervention contrast, but it does not automatically identify mediating mechanisms. Out-of-sample prediction can demonstrate predictive transport within a validation domain while leaving causal direction unresolved. High-resolution observation can describe temporal or spatial structure while remaining compatible with multiple mechanisms.

Claim	Evidence that can directly bear on it	What that evidence does not automatically establish
Descriptive	Qualified measurement and sampling for a stated target	Cause, mechanism or prediction outside the observed domain
Predictive	Honest out-of-sample or prospective predictive performance	Causal effect or true mechanism
Causal	Randomisation or observational identification under explicit causal assumptions	Mechanistic uniqueness or external validity beyond the target contrast
Mechanistic	Rival mechanisms plus discriminating predictions/interventions	Universal operation of that mechanism across untested contexts

4. Mixed claims and escalation of evidential burden

Real studies commonly make nested claims. A sequence may begin with a descriptive difference, proceed to prediction, then suggest a cause and finally propose a mechanism. The evidential burden changes at each transition, and for causal and mechanistic claims it adds requirements that earlier evidence does not meet. Evidence adequate for an earlier level is not invalid; it is simply insufficient for the stronger claim. This distinction prevents two opposite errors: dismissing useful descriptive or predictive work because it is not causal, and promoting descriptive or predictive success into causal or mechanistic certainty.

5. Claim target, contrast and scope

A claim is incomplete without a target. Descriptive claims need a target population or specimen domain. Predictive claims need a deployment distribution and outcome definition. Causal claims need an intervention or exposure contrast and a target population. Mechanistic claims need a defined system state and competing process descriptions. Temporal horizon, scale and operating conditions are part of the claim rather than optional metadata. INF-012 later owns the separate problem of generalising from studied conditions to another target.

6. Common category errors

- Treating a statistically significant association as a causal effect.
- Treating prediction accuracy as evidence that the predictive variables are causal.
- Treating a causal effect as proof of one unique mechanism.
- Treating goodness of fit as mechanistic identification.
- Treating successful replication in one domain as proof of transport to another.
- Treating a null or non-detected result as evidence of absence without considering test capability.

Misinterpretation of p values and confidence intervals is sufficiently common that significance language must not be used as a shorthand for evidential strength [5]. The claim-first discipline separates the scientific question from the statistical summary used within a particular inferential framework.

7. Ownership within INF

INF-001 owns claim taxonomy only. INF-002 owns causal variable roles and identification; INF-003 owns selection, missingness and survivorship; INF-004 owns rival explanations and identifiability; INF-005 owns evidential strength; INF-006 owns prior knowledge and base rates; INF-007 owns discriminating experiments; INF-008 owns structural versus parametric uncertainty; INF-009 and INF-010 own robustness and analytic multiplicity; INF-011 owns evidence integration; and INF-012 owns transfer to a target. INF-001 therefore defines the question that those later articles answer, but does not absorb their methods.

8. Operational claim-first checklist

- State the claim class.
- Define the target population or system and the relevant time/scale.
- For causal claims, define the intervention or exposure contrast.
- For predictive claims, define the deployment domain and validation design.
- For mechanistic claims, state at least one credible rival mechanism.
- Specify what evidence would count against the claim.
- State explicitly what the present evidence does not establish.

References

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Data and materials statement

No new experimental dataset was generated for this article. The article is a methodological analysis based on the cited literature and the frozen ownership architecture of the INF series.