

Review

Cross-Level Inference Errors in Scientific Interpretation—From Ecological Correlation to the Control of Inference and Communication Levels

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Abstract

Cross-level inference errors constitute a specific source of misleading scientific interpretation. They arise when the meaning assigned to a finding is transferred from one level of analysis to another without sufficient methodological justification. The conceptual aim of this article is to explain how a formally valid statistical association may become misleading when its interpretation or communication goes beyond the level at which the data were collected and the association was estimated. The practical aim is to propose a procedure for checking level alignment. The article is conceptual and review-based in nature. It relies on a purposive, problem-oriented synthesis of literature from research methodology, social epidemiology, multilevel analysis, selection bias, spin and exaggeration in scientific communication, and misinformation in and about science. Its contribution consists of linking the classical methodological problem of ecological and atomistic fallacies with the communicative processes through which scientific findings are reformulated in abstracts, press releases, media reports, and secondary summaries. On this basis, the article proposes a model of alternative pathways leading from a statistical association specific to a given level to a public claim, distinguishing a level-aligned pathway from a pathway leading to a Level-Misaligned Public Claim. The article also introduces the Inference-Level Alignment Procedure as a procedure for checking the alignment between the level of inference and the level of communication. This procedure includes two diagnostic checkpoints: alignment between analysis and inference, and alignment between inference and communication. The article argues that responsible scientific interpretation and communication require not only fact-checking, but also checking whether the level of analysis, the level of inference, and the level of communication or recommendation remain aligned.

Keywords: cross-level inference errors; ecological fallacy; atomistic fallacy; multilevel analysis; level alignment; scientific interpretation; scientific communication; misinformation in science



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1. Introduction

Research integrity requires that data, results, and conclusions be developed and communicated in an honest, responsible manner and in accordance with the principles of good research practice ([ALLEA, 2023](#)). The integrity of scientific knowledge is also grounded in values such as objectivity, honesty, openness, accountability, and stewardship of the reliability of the scholarly record ([National Academies of Sciences, Engineering, and Medicine, 2017](#)). As [Bornmann and Mutz \(2015\)](#) note, contemporary science is characterized

by a long-term increase in the number of publications and cited references, a process that can be analyzed bibliometrically. Fortunato et al. (2018), in turn, emphasize that the growing availability of digital data on publications, citations, funding, productivity, and research collaboration makes it possible to study science as a complex and dynamic network of scholars, institutions, ideas, and publications. These changes increase the possibilities for scrutiny and reuse of findings, but they also create more points at which results may be simplified, decontextualized, and communicated beyond their original methodological boundaries.

Scientific results now function in an environment shaped by open science, digital media, and the accelerated dissemination of research findings. Open science is commonly associated with transparent and accessible knowledge that is shared and developed within networks of collaboration, as emphasized by Vicente-Sáez and Martínez-Fuentes (2018). Fecher and Friesike (2014) similarly indicate that open science should not be treated as a single coherent definition, but rather as a set of different orientations, including infrastructural, public, measurement, democratic, and pragmatic approaches. In this broader context, Nosek et al. (2015) and Munafò et al. (2017) argued that transparency and reproducibility are of fundamental importance for strengthening the integrity and credibility of science, although they emphasized different aspects of this process: the former focused more on supporting an open research culture, whereas the latter stressed reforms of research practices, procedures, and evaluation systems.

As noted above, progress in this area increases access to publications, data, and research procedures, and creates new opportunities for scrutinizing and reusing findings. At the same time, the rapid movement of findings through digital media, institutional communication, and secondary summaries may detach them from the methodological context in which they were produced. This tension between the epistemic benefits of openness and the interpretive risks of rapid decontextualization forms the background of the problem analyzed in this article.

Against this background, the central problem addressed in the article is misleading scientific interpretation, which should be clearly distinguished from intentional misinformation. The article focuses on situations in which valid data or correctly estimated associations are interpreted at a level that they cannot justify. Such distortions may later contribute to misinformation in and about science, but their direct source is not an intention to mislead. Rather, it is the loss of alignment between the level of evidence, the level of inference, and the level of communication or recommendation. This problem becomes particularly important because scientific findings are often encountered through indirect and simplified representations rather than through direct reading of the source articles. Scheufele and Krause (2019) discuss science audiences in the context of misinformation, fake news, motivated reasoning, and science literacy. West and Bergstrom (2021) emphasized that misleading scientific claims may arise not only from false data, but also from the ways in which data are presented, compared, and interpreted. Cacciatore (2021) similarly indicated that scientific and health misinformation may be amplified by imprecise definitions, selective framing, simplifications, and forms of communication that obscure the status of the information being conveyed. Lazer et al. (2018) placed these problems within a broader information ecosystem in which digital platforms, the weakening of institutional gatekeeping, and algorithmic distribution facilitate the spread of misleading content.

It is precisely in this context that the role of cross-level inference errors in the interpretation of scientific findings becomes especially important. The essence of these errors is that a claim formulated at one level of analysis is shifted to another level of reality, most often from aggregate data to the individual level, or in the opposite direction. Classical methodological literature, including Robinson (1950) and Piantadosi et al. (1988), has long

warned that associations observed at one level of data cannot be automatically transferred to another level of inference.

Classical discussions of ecological inference provide model examples of this mechanism, because associations estimated at the collective level were interpreted as if they directly described individuals. Importantly, scientific distortion may arise even when the source data have not been falsified, if the interpretation assigned to them exceeds what the evidence can legitimately justify. The significance of this problem extends far beyond a narrow research area, because methodological, epidemiological, organizational, and communication studies show that similar level shifts occur in many fields of inquiry, including studies of suicide, nutrition, drug policy, quality of health care, and organizational indicators.

The existing literature indicates that research to date has developed across several relatively distinct strands: classical ecological inference and multilevel analysis, errors in causal identification, studies of spin and exaggeration, and research on misinformation in and about science. These strands provide important findings, but they have rarely been integrated into a single explanatory framework showing how a statistically valid association may become scientifically misleading when it is interpreted at a level that the evidence does not justify. It is therefore useful at the outset to cite several examples of works that deepen these research strands. For example, [Achen and Shively \(1995\)](#) treated cross-level inference as a demanding methodological problem that requires strong substantive knowledge and cannot be solved by a single universal statistical procedure. [King \(1997\)](#) developed a statistical approach to ecological inference aimed at reconstructing individual behavior from aggregate data. [Idrovo \(2011\)](#), in turn, proposed useful criteria for identifying ecological fallacy, while [O’Keefe \(2024\)](#) formulated the principle of alignment between the levels of claims and evidence. These contributions are directly relevant to the present article because they show that the problem of moving between levels of analysis has been recognized and addressed in the methodological literature. However, they remain primarily statistical, methodological, or diagnostic in orientation, and do not analyze how an association specific to a given level is subsequently transformed within the communication chain, nor do they treat inference-level alignment as a practical problem of scientific interpretation and communication.

The aim of this article is therefore to reconstruct cross-level inference errors as a methodological and communicative problem of scientific interpretation and to propose a procedure for checking level alignment. The article analyzes how alignment may be lost among four analytically distinct elements: the data level, the level of the estimated association, the inference level, understood here as the claim level, and the communication or recommendation level. This loss of alignment may occur when research findings are reformulated in abstracts, press releases, media reports, and secondary summaries. The author’s intention is to show how ecological and atomistic fallacies, both well established in the methodological literature, may participate in the transformation of valid, level-specific associations into a communication distorted by cross-level errors. On this basis, the article develops a procedure for checking whether the level of analysis, the level of inference (claim), and the level of communication or recommendation remain aligned.

The article is conceptual and review-based in nature. It relies on a purposive, problem-oriented synthesis of literature selected for its relevance to the relationship between the level of data, the estimated association, interpretation, and secondary communication. The review combines classical methodological sources on ecological fallacy, atomistic fallacy, ecological inference, and multilevel reasoning with epidemiological and social research that explains distinctions among individual-level, group-level, contextual, and mixed associations.

To reduce the risk of confirmation bias, the review includes both ecological and atomistic directions of cross-level error and distinguishes them from related but non-identical problems, such as selection bias, collider bias, overadjustment, causal overinterpretation, spin, and exaggeration. The proposed approach should therefore be understood as a heuristic and integrative model that organizes the relationship between the level of inference and scientific interpretation in claims and recommendations. The research procedure adopted in the article is presented schematically in Figure 1.

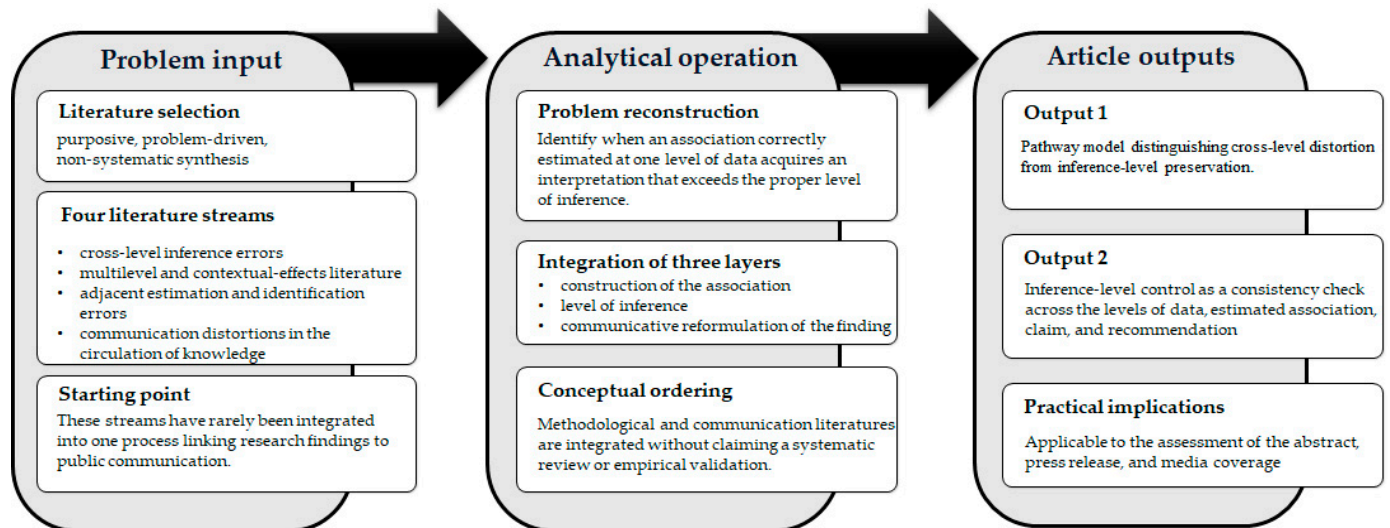


Figure 1. Analytical framework used in the article. Source: Author's own elaboration.

According to the structure adopted in the article, the next two sections discuss the emergence of cross-level inference errors and their methodological and communicative conditions. The article then presents a pathway model showing how a statistical association specific to a given level may be transformed into either a level-aligned public claim or a level-misaligned public claim. The final section develops a procedure for checking the alignment between the level of inference and the level of communication, aimed at determining whether the level of analysis, the level of inference, and the level of communication or recommendation remain aligned.

2. Cross-Level Inference Errors and Their Place in Research Methodology

The literature on cross-level inference errors and related inferential and communicative distortions uses diverse terminology. In this article, *cross-level inference errors* are understood as distortions that arise when the data level, the level of the estimated association, the inference (claim) level, and the communication or recommendation level cease to be aligned. This approach refers to Robinson's (1950) classical distinction between ecological and individual correlations, as well as to later epidemiological warnings against ecological fallacy formulated by Piantadosi et al. (1988). In the present article, this logic is extended to the interpretation and communication of scientific findings. A classical form of such an error is ecological fallacy, in which associations at the group level are interpreted as if they described individuals. The literature has also emphasized the opposite direction of error: atomistic or individualistic fallacy, which consists of the unjustified generalization of individual-level associations to groups, institutions, or populations. Subramanian et al. (2009) particularly clearly stress the bidirectionality of this problem, whereas Oakes (2009) places ecological, individualistic, and multilevel fallacies within the broader discussion of multilevel thinking.

These errors should be distinguished from related inferential distortions that affect the construction or identification of the association itself. Selection bias is understood here as

a distortion introduced when the process by which observations are selected affects the estimated association. [Hernán et al. \(2004\)](#) approach this problem structurally, pointing to the logic of conditioning on a common effect, whereas [Elwert and Winship \(2014\)](#) develop this perspective in their analysis of endogenous selection bias and conditioning on a collider. Conditioning on a collider occurs when an analysis is conditional on a variable that is affected by two other variables, which may create or strengthen a spurious association; this mechanism is illustrated by [Cole et al. \(2010\)](#). Overadjustment bias refers to a situation in which statistical adjustment blocks or removes part of a relationship that should not be adjusted away; [Schisterman et al. \(2009\)](#) describe this problem as overadjustment bias and distinguish it from unnecessary adjustment. These problems may co-occur with cross-level inference errors, but they are not identical with them. They concern primarily whether an association has been appropriately estimated or identified, whereas cross-level inference errors concern whether an association estimated at one level is interpreted as if it referred to another level of reality.

A further distinction concerns communicative distortions. Spin is understood here as reporting practices that make results appear stronger, more favorable, or more conclusive than the empirical material warrants. [Boutron et al. \(2010\)](#) demonstrated this problem in randomized controlled trials with statistically non-significant results for the primary outcome, whereas [Yavchitz et al. \(2012\)](#) analyzed spin in abstract conclusions and press releases. [Boutron et al. \(2014\)](#), in turn, showed that spin in abstracts may influence how readers interpret results. Exaggeration refers to the amplification of claims, causal implications, or recommendations beyond the evidential basis of a study. [Sumner et al. \(2014\)](#) demonstrated a strong association between exaggeration in press releases and exaggeration in health news, whereas [Sumner et al. \(2016\)](#) showed that adding caveats does not necessarily reduce the media appeal of a message. [Bratton et al. \(2019\)](#) partially replicated earlier findings on the association between exaggeration in press releases and exaggeration in media reports, confirming it especially with respect to causal claims. The term “secondary simplification” is used here in a more descriptive sense and refers to the later compression of research findings in abstracts, press releases, news articles, headlines, or social media summaries. [Haneef et al. \(2015\)](#) showed that health news may contain interpretations that go beyond the cautious scope of the source articles, although they do not determine unequivocally at which stage of circulation the distortion arises. [Bossema et al. \(2019\)](#), in turn, indicated that the presence of an expert quote may reduce the risk of exaggeration, although such cases are rare. These communicative processes may amplify cross-level inference errors, but they are not identical to them.

The multilevel perspective emerged as an important development of cross-level thinking. [Diez-Roux \(1998\)](#) argued that the analysis of health outcomes should not be limited to individual characteristics, because group-level, macro-level, and contextual variables may also shape individual health and disease. [Greenland \(2002\)](#) indicated that the central problem of multilevel analysis lies in the inseparability of individual and contextual effects; accordingly, its function is not limited to parameter estimation, but also includes the proper ordering of relationships between levels of analysis.

Research on multilevel analysis and contextual effects has shown that cross-level errors cannot be reduced solely to the classical ecological fallacy. They include a broader set of problems related to the relationship between individuals, contexts, and the way these relationships are modeled. [Blakely and Woodward \(2000\)](#) noted that estimating ecological effects in multilevel studies is subject to numerous methodological threats, such as confounding operating at different levels of analysis, misclassification of individuals, and model misspecification relative to the structure of the data. [Pickett and Pearl \(2001\)](#), in turn, showed that features of the local residential context may be empirically associated

with health outcomes, although these associations are often modest and cannot be reduced solely to individual characteristics. This strengthens the argument for systematically incorporating the contextual level into analysis. Merlo et al. (2009, 2012) emphasized that general contextual effects, measured through variance and clustering, should be considered when interpreting specific contextual effects and small-area variation; otherwise, analyses may provide a misleading picture and overstate the role of administratively defined areas as contextual determinants of individual differences in health or mortality. From this perspective, cross-level error appears not so much as a variant of the classical ecological fallacy, but rather as part of a broader family of inferential errors and multilevel distortions concerning the relationship between the level of observation, the level of the model, and the level of interpretation.

The opposite direction of cross-level error is equally important. Subramanian et al. (2009) emphasized that the atomistic, or individualistic, fallacy is no less consequential than the ecological fallacy, because individual-level associations may be unjustifiably generalized to groups and populations. Oakes (2009), in turn, noted that alongside ecological fallacies, individualistic fallacies and problems specific to multilevel analysis must also be considered. Related errors, such as selection bias, conditioning on colliders, and overadjustment bias, should also be added to this picture. Hernán et al. (2004), and subsequently Elwert and Winship (2014), showed that associations may be distorted not only by an inappropriate level of inference, but also by mechanisms of selection and conditioning embedded in the analysis itself. Contemporary methodological reflection therefore requires attention both to the level of analysis and to the causal structure of the data.

Methodology alone, however, does not yet explain how an inferential error becomes a communicative distortion in scientific interpretation. At this point, the literature on scientific communication becomes particularly important. It often shows that distortion of the meaning of a finding may arise at different stages of its secondary circulation, although individual studies document different links in this process. Yavchitz et al. (2012) focused primarily on spin in the reporting of therapeutic studies, emphasizing the importance of how conclusions are framed and their susceptibility to later overinterpretation. Sumner et al. (2014), in turn, showed that exaggeration in health news was strongly associated with earlier exaggeration in press releases, whereas a later study by the same authors found that including caveats did not reduce the media appeal of the message (Sumner et al., 2016). Haber et al. (2022) empirically demonstrated that causal language or causal implications may appear even in scientific texts that explicitly adopt associational caution. Han and Guyatt (2020) had earlier framed this problem as the subject of a systematic assessment of the use of causal language in systematic reviews of observational studies. Haneef et al. (2015) also provide evidence that interpretive distortions may occur in health news, although these authors explicitly note uncertainty as to the stage of the communication chain at which such distortion arises. Bossema et al. (2019), in turn, show that the presence of an expert quote is associated with a lower risk of exaggeration, although they emphasize that such cases are rare. Taken together, these studies suggest that distortions in scientific communication do not arise only in popular media, but may already appear at earlier stages in the translation of research findings into communicative forms, especially in press releases and other intermediate representations of research.

3. Methodological Foundations of Cross-Level Inference Errors

3.1. From Ecological Correlation to the Problem of Inference Level

Cross-level inference errors belong to those methodological distortions that may particularly easily remain unnoticed, because they do not necessarily result from an incorrect estimation of a statistical association, but rather from an unjustified shift in the level at

which meaning is assigned to that association. In such cases, the association itself may be correctly estimated, yet its interpretation exceeds the boundaries set by the structure of the data. As Oakes (2009) argued in his commentary, the problem cannot be reduced to the mechanical use of multilevel statistical techniques, but concerns broader multilevel reasoning about individuals, contexts, and levels of explanation.

In this sense, the point of departure remains Robinson's (1950) work, discussed above, which showed that ecological correlations and individual correlations are not identical because they describe different statistical objects. This distinction alone leads to the basic conclusion that one cannot assume that an association observed between aggregates reflects an association operating among the individuals who make up those aggregates. Robinson also demonstrated that the relationship between ecological correlation and individual correlation depends on within-group and between-group variability, which means that levels of analysis are not interchangeable.

Epidemiology further clarified this problem. Piantadosi et al. (1988) emphasized that ecological studies may be useful for population-level analyses, but that moving from group-level observations to etiological or behavioral claims entails a high risk of ecological fallacy. Wakefield (2009) added that ecological data alone cannot be regarded as sufficient to determine whether—and to what extent—ecological bias is present in a given dataset. Von Korff et al. (1992), cited by Diez-Roux (1998), argued in turn that epidemiological studies of chronic disease should include multiple levels of determination, including both micro-level and macro-level factors. From this perspective, the analysis of health phenomena requires attention to both individual characteristics and contextual properties, because only such an approach makes it possible to explain how individual and group-level factors jointly shape the phenomenon under study.

Idrovo (2011) proposed a useful attempt to operationalize the identification of ecological fallacy. He argued that ecological fallacy should not be assumed simply because a study uses ecological or population data rather than individual data. In this context, ecological data mean data in which the units of observation are collectives, such as countries, regions, municipalities, schools, hospitals, organizations, or other population aggregates, rather than individual persons. Variables describing such collective units may take the form of indicators, proportions, percentages, means, indices, or contextual characteristics of the collective unit. According to Idrovo, three conditions must be met in order to confirm the occurrence of ecological fallacy: the results must be based on ecological data, those results must be referred to individuals, and individual-level data must lead to contradictory results.

3.2. Multilevel Analysis, Contextual Effects, and Between- and Within-Group Relationships

One of the most important stages in the development of this debate was the transition from the critique of ecological fallacy to the positive program of multilevel analysis. Diez-Roux (1998) argued that the analysis of social and health phenomena cannot be limited to individual characteristics, because many important determinants are contextual in nature. This argument did not simply privilege the group level; rather, it showed that macrosocial, environmental, and institutional variables should be included in analysis precisely in order to avoid individualistic reductionism. A similar line of reasoning can be found in Greenland (2000, 2001, 2002), who supported the need to distinguish levels by showing that sources of bias at the individual and ecological levels are not identical, and that even studies designed to estimate contextual effects are not free from pitfalls related to aggregation and strong modeling assumptions.

In a similar vein, Blakely and Woodward (2000) argued that multilevel studies aiming to describe ecological effects must continuously distinguish compositional from contextual influences and must also control for numerous sources of error related to the construction

of units of analysis and model specification. [Pickett and Pearl \(2001\)](#), in their critical review of studies on neighborhood effects on health, likewise showed that many studies report significant effects of local environments, while at the same time facing serious interpretive difficulties concerning the choice of contextual unit, the measurement of area-level variables, and the distinction between contextual and compositional effects.

This perspective was subsequently developed in more specialized areas. [Diez-Roux and Aiello \(2005\)](#) discussed the foundations of multilevel analysis in infectious-disease research, emphasizing that individual-level and group-level factors should be examined simultaneously, especially when group-level conditions, social norms, and individual behaviors jointly shape disease transmission. [Merlo et al. \(2003\)](#) analyzed the influence of neighborhood social participation on individual medication use, attempting to separate contextual and individual influences. [Merlo et al. \(2012\)](#) went further, showing that in small-area analyses it is not enough merely to capture geographical variation. Equally important is the question of what proportion of total variability is actually located at the area level, that is, the macro level, and what proportion is located at the household or individual level, that is, the micro level.

It is therefore no coincidence that [Subramanian et al. \(2009\)](#) reminded readers that the risk is bidirectional. Alongside ecological fallacy, there is also the atomistic fallacy, also referred to as the individualistic fallacy, which consists of the unjustified generalization of individual-level associations to populations and institutions. In practice, this means that “between” and “within” relationships are not merely technical variants of a single association, but distinct dimensions in the description of a phenomenon.

In a similar spirit, [Etminan et al. \(2020\)](#) and [Tennant et al. \(2021\)](#) show that explicit causal diagrams can support variable selection and clarify the assumptions underlying model specification and interpretation. This strengthens the broader thesis that cross-level inference errors should be analyzed not only as statistical errors, but also as failures to align the research question, data structure, model specification, and permissible interpretation.

3.3. Related Errors: Selection, Colliders, and Inferential Paradoxes

Although cross-level inference errors are the main subject of this article, it is useful to place them within the broader landscape of errors in causal identification, while maintaining clear conceptual boundaries. Cross-level error primarily concerns a misalignment between the data level, the level of the estimated association, and the level at which the result is interpreted. The psychologistic and sociologistic fallacies mentioned above are not treated here as basic forms of cross-level inference error, because they concern an inadequate type of causal explanation rather than the direct transfer of an estimated association between levels of inference. Selection bias, collider bias, and overadjustment bias should also be considered, but they have a different methodological status. They distort the estimation or identification of an association already at the stage of sample construction, selection of observations, or model specification. These problems may co-occur with cross-level errors and may even facilitate their emergence, but they are not identical with them. In other words, selection bias and collider bias primarily concern whether an association has been correctly estimated or identified under conditions of selection or conditioning on an inappropriate variable, whereas overadjustment bias usually refers to adjusting for a variable located on the causal pathway between exposure and outcome. Cross-level error, by contrast, concerns whether an association estimated at one level has been interpreted as if it referred to another level of reality. [Hernán et al. \(2004\)](#) proposed an influential structural account according to which different forms of selection bias can be reduced to the common logic of conditioning on a common effect. In a similar direction, [Elwert and Winship \(2014\)](#) used causal graphs to show that endogenous selection bias may arise when

an analysis conditions on a variable affected by causes associated with both the exposure and the outcome. Their argument is important for the present discussion because it shows that some distortions may arise not only when findings are interpreted, but already when the sample is constructed, observations are selected, inclusion criteria are defined, or the analytical model is specified.

Other errors are connected with this problem as well. [Cole et al. \(2010\)](#) showed how conditioning on a collider may generate spurious associations. [Schisterman et al. \(2009\)](#) described overadjustment bias, showing that excessive adjustment may distort an effect instead of clarifying it, while also distinguishing this problem from unnecessary adjustment. [Westreich and Greenland \(2013\)](#), in turn, drew attention to the so-called *Table 2 fallacy*, that is, the unjustified attribution of causal meaning to coefficients for variables included in a model only as control variables. [Rohrer \(2018\)](#) emphasized that statistical control requires an explicit causal rationale, because controlling for third variables without proper justification—especially under the assumption that ‘more control’ is always better—may worsen rather than improve causal inference.

Methodological literature also shows that similar difficulties arise in classical pseudo-paradoxes of inference. [Berkson \(1946\)](#) drew attention to the limitations of hospital data analysis, thereby laying the foundations for what later became known as Berkson’s bias. [Simpson \(1951\)](#) described the phenomenon of stratification effects, later misleadingly referred to as Simpson’s paradox, consisting in a discrepancy between conditional and marginal interpretations of data, which may sometimes lead to a reversal in the direction of an association. [Lord \(1967\)](#), in turn, formulated the paradox of group comparisons, showing that two analytically correct procedures may lead to apparently contradictory conclusions. Later analyses, especially [Holland and Rubin \(1982\)](#) and [Pearl \(2016\)](#), showed that resolving Lord’s paradox requires a clear specification of the causal question, not merely a mechanical choice of statistical procedure. [Arah \(2008\)](#) argued that Simpson’s paradox, Lord’s paradox, and suppression effects reveal the perils of relying on statistical criteria to guide causal analysis. In his view, these phenomena are best understood as problems of covariate selection and adjustment in the causal analysis of non-experimental data, and their explanation requires causal reasoning based on background knowledge rather than statistical criteria alone. [Wang et al. \(2018\)](#), in turn, use simple examples to show that Simpson’s paradox is not a marginal peculiarity, but a real source of misinterpretation of conditional and marginal data.

Statistical paradoxes obviously have a different methodological status than cross-level errors, but they are important because they help clarify the place of cross-level errors within the broader landscape of inferential distortions. Selection bias, Berkson’s bias, Simpson’s paradox, and Lord’s paradox primarily concern the deformation of the association itself through the selection of observations, conditioning, or inappropriate adjustment. Cross-level error, by contrast, concerns the breakdown of alignment between the data level and the inference level. In practice, however, these two classes of distortion may combine. Aggregate data may be affected by selection bias and then further overinterpreted through a shift from the group level to the individual level. In such a configuration, the resulting public communication becomes doubly flawed.

In the context of the publication-related distortions discussed here, it is useful to distinguish three layers of distortion. The first includes errors in the construction of associations and in causal identification, such as selection bias, conditioning on colliders, overadjustment bias, and inferential paradoxes. The second includes inference-level errors, in which alignment between the data level and the inference level breaks down, with ecological fallacy and atomistic fallacy as classical examples. The third includes communicative distortions, such as spin, exaggeration, and secondary simplification occurring in abstracts,

press releases, and media reports. These layers are not identical, but they may co-occur and mutually reinforce one another. The order of these layers is analytical and corresponds to the transition from the construction of a finding to its interpretation and communication.

3.4. From Methodological Error to Communicative Distortion

Cross-level error does not remain only a methodological problem; it may be amplified in scientific communication. The literature on spin, exaggeration, and misinformation does not describe cross-level errors as a distinct class of communicative distortions, but it provides grounds for the hypothesis that a shift in the level of inference may become stabilized or amplified when research findings circulate in abstracts, press releases, leads, and secondary summaries. To the positions already discussed in the introduction, including [Lazer et al. \(2018\)](#), [Scheufele and Krause \(2019\)](#), and [Cacciatore \(2021\)](#), which identify sources of contemporary communicative erosion, one more warning should be added. At a more general level, [Lewandowsky et al. \(2012\)](#) formulated such a warning by showing that misinformation not only spreads widely in the contemporary media environment, but also continues to exert cognitive influence even after formal correction.

Metascientific literature also devotes considerable attention to the fallibility of the publication and interpretation process itself. [Ioannidis \(2005\)](#) indicated that several features of scientific studies may increase the probability that published findings are false or exaggerated, especially in heavily explored fields in which designs are small, flexible, and susceptible to various forms of selection. [Anglemyer et al. \(2014\)](#) found that, on average, effect estimates from observational studies and randomized trials differed little in the methodological reviews they examined, while also emphasizing the need to consider study design features, risk of bias, and effect-size interpretation. The updated review by [Toews et al. \(2024\)](#) further supports a cautious, methodologically nuanced comparison between observational and randomized evidence. Their analyses take into account, among other factors, heterogeneity, review quality, and methods of evidence synthesis. From the perspective of the present article, this supports the cautious conclusion that the formal correctness of a research design does not in itself eliminate the later risk of interpretive overreach in scientific communication.

Studies on spin and communicative exaggeration deserve particular attention. [Yavchitz et al. \(2012\)](#) showed that the presentation of results in abstract conclusions and press releases may facilitate later overinterpretation. [Boutron et al. \(2010\)](#) demonstrated that even in randomized controlled trials in which the primary outcome is statistically non-significant, results are sometimes presented in a way that suggests the effectiveness of the intervention. In another study, the same authors also showed that spin in abstracts may influence how readers interpret the communicated content ([Boutron et al., 2014](#)). [Sumner et al. \(2014\)](#) found a strong association between exaggeration in press releases and exaggeration in health news, while [Sumner et al. \(2016\)](#) found no evidence that adding caveats reduced the media appeal of a message. These findings suggest that a substantial part of distortion may arise already at the stage of preparing the press release, rather than only in the media report itself.

More recent analyses support this line of interpretation. [Bossema et al. \(2019\)](#) showed that the presence of an expert quote in a press item may reduce the risk of exaggeration, although the authors noted that such cases are rare. [Bratton et al. \(2019\)](#) partially replicated earlier findings concerning the association between exaggeration in press releases and exaggeration in media reports, confirming it for causal claims but not for exaggeration in advice. [Haneef et al. \(2015\)](#) observed that health news often contains interpretations that go beyond the cautious scope of the source articles, although the authors themselves did not determine unequivocally at which stage of circulation the distortion arises. [Haber](#)

et al. (2022), Han et al. (2022), and Olarte Parra et al. (2021) showed that in observational studies and systematic reviews, causal language may be inconsistent with the scope, aim, or intention of inference, which may blur the boundary between associational and causal reasoning. Olarte Parra et al. (2021), in particular, examined the consistency of causal claims in abstracts of observational studies and pointed to the need for clearer guidance on formulating and justifying such claims. This problem had previously been formulated as the subject of systematic assessment in the protocol by Han and Guyatt (2020). Similar problems of inconsistency between study aim, method, research intention, and interpretive language were noted by Gleadhill et al. (2023) in an analysis of observational studies on low back pain and osteoarthritis.

An open question remains how these errors resonate in the broader media environment and on online platforms. Del Vicario et al. (2016) showed that misinformation spreads online according to its own network dynamics, closely linked to polarization and confirmation bias. Pennycook and Rand (2021) showed that poor truth discernment in relation to false or misleading news is associated less with politics alone than with lack of careful reasoning, relevant knowledge, and reliance on heuristics such as familiarity. They also emphasized a disconnect between what people believe and what they share on social media, with sharing often driven by inattention rather than by deliberate misinformation. Pennycook and Rand (2019), in turn, demonstrated the usefulness of crowdsourced ratings of information-source quality as a potential tool for counteracting misinformation. Broader reviews, such as those by Aimeur et al. (2023), Cacciatore (2021), and, from a public health perspective, Swire-Thompson and Lazer (2020) as well as Garrett and Young (2021), show that scientific and health misinformation now operates within a complex media environment in which platform architecture, communicative simplifications, and modes of knowledge mediation facilitate the spread of epistemically problematic content. As a result, this environment may facilitate communicative transformations in which a finding obtained at the aggregate level is secondarily read as the basis for conclusions formulated at the individual level.

In this context, open science has an ambivalent status. It increases accessibility and the possibility of independent scrutiny of findings, but at the same time facilitates their secondary use outside the original methodological context. Vicente-Sáez and Martínez-Fuentes (2018) define open science as transparent and accessible knowledge shared and developed through collaborative networks, while Fecher and Friesike (2014) describe open science as a set of distinct schools of thought rather than a single unified concept. In the argument developed here, however, increased accessibility also creates additional points at which findings may be reused outside their original methodological context, simplified, or incorporated into secondary circuits of communication. Limiting misleading scientific interpretation therefore does not require limiting openness, but rather developing more precise standards for interpreting and communicating findings at the appropriate level of inference.

3.5. Classical and Methodological References to Cross-Level Inference Errors

In classical sociology, one of the most frequently cited cases remains Durkheim's interpretation of the relationship between the religious structure of a population and variation in suicide rates. The contemporary significance of this example does not lie in a simple refutation of Durkheim's (1897/1951) hypothesis, but in its role as a methodological reminder: an association observed between regions cannot be automatically equated with a mechanism operating at the individual level. Freedman (1999) treated Durkheim's case as a classical warning for research based on aggregate data, while van Poppel and Day (1996) attempted to test Durkheim's religion-suicide hypothesis using Dutch data in a way

that avoided the ecological fallacy. Their analysis suggested that the Catholic–Protestant difference in suicide rates could be explained by differences in the classification of deaths rather than by the individual-level mechanism inferred from aggregate data. This example clearly illustrates that the dispute over interpretation concerns not only the strength of the association, but above all the level at which it may be legitimately explained.

This problem is not limited to classical sociology. Mossholder and Bedeian (1983) showed that cross-level inference in organizational research involves the risk of fallacious reasoning whenever conclusions are transferred between units of analysis, and that such transfers require a sound theoretical rationale, especially when individual measures are used as surrogates for macro-level constructs. Qian and Shen (2007), discussing ecological applications of multilevel analysis of variance, illustrated how multilevel variance decomposition can be used to organize variation across levels of ecological data. In both cases, the core of the problem remains the same: the risk arises when the transition from estimation to interpretation blurs the boundaries between the level of observation and the level of meaning assigned to the result.

A similar concern appears in political science. Sprinz (2000) discussed cross-level inference in political science as a problem of relating findings across levels of aggregation and reconstructing individual-level relationships when only aggregate data are available. His examples concerning electoral aggregation and climate negotiations show that aggregation rules may distort relationships among individual preferences, collective outcomes, and institutional decisions. This supports the broader claim that cross-level errors are not limited to ecological health studies, but concern the movement of inference and interpretation across levels of analysis in different fields of research.

A particularly important contemporary treatment of this problem can be found in communication research. O’Keefe (2024) argues that claims about messages require analyses conducted at the message level, and that individual-level correlations by themselves cannot justify message-level claims. His examples show that even a strong positive association between two variables measured at the individual level does not justify the conclusion that messages differing in one of these properties will also differ in the other. O’Keefe explicitly links this reasoning error to the atomistic fallacy and distinguishes it from Simpson’s paradox. This argument is important because it highlights the general principle of alignment between the level of evidence and the level of the claim. At the same time, it is worth extending this problem toward the preservation of such alignment in the broader process through which scientific findings are interpreted, reformulated, and translated into public claims or recommendations.

In contemporary methodological literature, cross-level error is treated as a problem of inconsistency between the level of observation and the level of inference. Harris et al. (2015) formulate its basic form by showing that relationships observed at the state level do not allow inference about relationships at the individual level. Kim (2019) shares this caution, but at the same time explains that it does not imply the uselessness of ecological studies, because aggregate data remain epistemically valuable provided that conclusions are formulated at the same level to which the data refer. Saunders et al. (2016) develop this position by showing that ecological fallacy is only one of the risks in studies of health-care organizations, alongside problems of reliable measurement of organizational characteristics and limited statistical power. Salkeld and Antolin (2020), in turn, provide an empirical demonstration of the problem, showing that correlations derived from aggregate data may be spurious and may simultaneously constitute an example of ecological fallacy and Simpson’s paradox. Taken together, these studies indicate that associations observed at the aggregate level require cautious interpretation, and that claims about mechanisms

operating at the individual level or about causal relationships require additional empirical justification and explanation of mechanism.

Finally, it is worth noting that the literature also includes comments, reanalyses, and methodological polemics concerning the risk of overinterpreting aggregate correlations and illegitimately moving between levels of analysis. These works are not discussed here because the aim of this section is to capture the general mechanism rather than to reconstruct disputes surrounding particular publications.

Overall, the works of [Idrovo \(2011\)](#), [King \(1997\)](#), [Sprinz \(2000\)](#), [O’Keefe \(2024\)](#), and the broader literature on ecological and multilevel inference provide important methodological points of reference. They show that cross-level inference has been addressed as a statistical, diagnostic, and aggregation-related problem. At the same time, they point to the need for a complementary perspective focused on what happens after an association specific to a given level has been estimated. It is therefore worth asking how such an association is interpreted, reformulated, communicated, and potentially translated into claims or recommendations referring to another level of analysis. This need justifies studying the alignment of the level of inference not only within the research design itself, but also at subsequent stages of scientific interpretation and communication.

For this reason, rather than developing an extensive catalogue of cases, it is more useful to present a synthetic overview of key studies that organizes different forms of cross-level errors and related phenomena. Table 1 shows that, although the cited studies come from different research areas, they share a common methodological concern: the loss of alignment between the unit of observation, the level of the estimated association, and the level of the claim or recommendation. At the same time, the table distinguishes the core literature on cross-level inference errors from related inferential and communicative distortions. This structure justifies the transition from a catalogue of examples to a more general model showing how methodologically valid findings may be transformed into a *Level-Misaligned Public Claim*.

Table 1. Core literature on cross-level inference errors and related studies used to reconstruct the transition from an estimated association to a public claim.

Analytical Block	Function in the Article	Key Concept/Problem	Representative Sources
Core: cross-level inference errors	Defines and organizes misalignments between the data level and the inference level	ecological fallacy; atomistic fallacy; ecological inference; level of analysis; ecological inference diagnostics; aggregation bias; cross-level inference; claim–evidence alignment; message-level claims	Robinson (1950) ; Piantadosi et al. (1988) ; Oakes (2009) ; Subramanian et al. (2009) ; Harris et al. (2015) ; Kim (2019) ; Saunders et al. (2016) ; Salkeld and Antolin (2020) ; Achen and Shively (1995) ; King (1997) ; Idrovo (2011) ; Sprinz (2000) ; O’Keefe (2024)
Multilevel literature and contextual effects	Shows that relations across levels cannot be reduced to the classical ecological fallacy alone	contextual effects; multilevel analysis; between/within; compositional vs. contextual effects	Diez-Roux (1998) ; Greenland (2000, 2002) ; Blakely and Woodward (2000) ; Pickett and Pearl (2001) ; Merlo et al. (2009, 2012)
Related inferential distortions	Distinguishes level-of-inference errors from distortions affecting estimation or causal identification	selection bias; collider bias; overadjustment; <i>Table 2 fallacy</i> ; inferential paradoxes	Hernán et al. (2004) ; Elwert and Winship (2014) ; Schisterman et al. (2009) ; Westreich and Greenland (2013) ; Arah (2008)
Communicative distortions in the circulation of science	Shows how a methodologically valid finding may be transformed into a claim that exceeds what the data support	spin; exaggeration; causal overstatement; misinformation in and about science	Yavchitz et al. (2012) ; Boutron et al. (2010, 2014) ; Sumner et al. (2014, 2016) ; Haneef et al. (2015) ; Bossema et al. (2019) ; Haber et al. (2022)

Source: Author’s own elaboration.

4. The Mechanism of Transition from a Cross-Level Error to Communicative Distortion

The review of studies on cross-level inference errors reveals an important research gap. Although many of the works discussed above addressed the problem of distortions in information or research findings, there is still no account showing the overall mechanism through which cross-level errors may be translated into published and publicly communicated conclusions. Meanwhile, Swire-Thompson and Lazer (2020) already emphasized that combating online misinformation requires not only correcting errors, but also strengthening the understanding of what evidence and uncertainty actually are. Del Vicario et al. (2016), in turn, showed that simplified content spreads particularly easily in environments that reinforce belief congruence, which further increases the importance of precisely describing the level to which a finding refers. Both studies indicate how important it is to explain the mechanism through which distortions arise. Therefore, the adopted systematization of the research problem leads to the formulation of the key conceptual proposal of this article: a simplified framework explaining how cross-level inference errors—both atomistic and ecological—may transform scientific interpretation by shifting it across levels of data.

The proposed model combines three layers of the problem under consideration. The first layer is the data level and the construction of the observed association. The second layer is the key point in the inferential mechanism, at which the observed association is interpreted correctly or incorrectly. The third layer is the public claim, whose reliability depends on whether the meaning assigned to the finding remains aligned with the level at which the association was estimated. The problem, therefore, does not concern only the truth or falsity of the data, but rather the alignment between the data level, the level of the estimated association, the inference (claim) level, and the communication or recommendation level. A framework showing how cross-level inference distortions arise should also take into account the related errors discussed above, as well as communicative distortions. Moreover, it should show how these phenomena may interact when a research finding is transformed into a public claim that exceeds the limits of permissible interpretation.

The first element of the framework is the identification of the original data level, that is, the level from which the collected observations originate. For the sake of simplicity, a dichotomous distinction is adopted between individual-level and aggregate-level data, since it is precisely the direction of a possible inferential shift between these categories of data that determines the type of error. The second element of the first layer of the analyzed problem consists of associations estimated at the data level. The association itself may be correctly estimated on the basis of the available data. The fundamental problem emerges only at the central point of the inferential process, when the researcher assigns interpretive meaning to the obtained result. From this point onward, two analytically distinct pathways are possible. For clarity, they are referred to here as the pathway of inferential consistency (A) and the pathway of cross-level distortion (M). Along both pathways, the research conclusion may be subject to communicative compression and amplification, for instance in the title, abstract, or official press release. However, the scope of the framework may also be expanded to include promotional social media posts, which are often formulated subsequent to the press release.

In the pathway of inferential consistency, the meaning assigned to the finding remains aligned with the level at which the association was estimated. This occurs when an aggregate-level association is communicated as a claim concerning groups, organizations, regions, or populations (A_1), or when an individual-level association is also interpreted at the individual level (A_2). Communicative compression may still occur, for example in the title, abstract, press release, or media coverage, but the level of inference is preserved. The

resulting public claim is therefore inferentially consistent, and any possible errors have a source other than cross-level shifts.

In the pathway of distortion, an additional mechanistic, practical, or quasi-causal meaning is assigned to the finding, and the finding is then transferred to another level of inference without sufficient justification. When an aggregate-level association is reformulated as a claim about individuals (M_1), the distortion takes the form of an ecological fallacy. When an individual-level association is generalized to groups, organizations, regions, or populations (M_2), the distortion takes the form of an atomistic fallacy. Communicative compression, spin, exaggeration, and secondary simplification are not, in themselves, cross-level inference errors, but they may amplify or legitimize such errors once a level shift has already occurred.

Figure 2 does not present a chronological sequence of stages. Rather, it distinguishes alternative pathways of transition from a statistical association specific to a given level to a public claim. It shows distortion pathways involving a cross-level shift (dashed arrow) and consistency pathways involving the preservation of the level of inference (bold solid arrow).

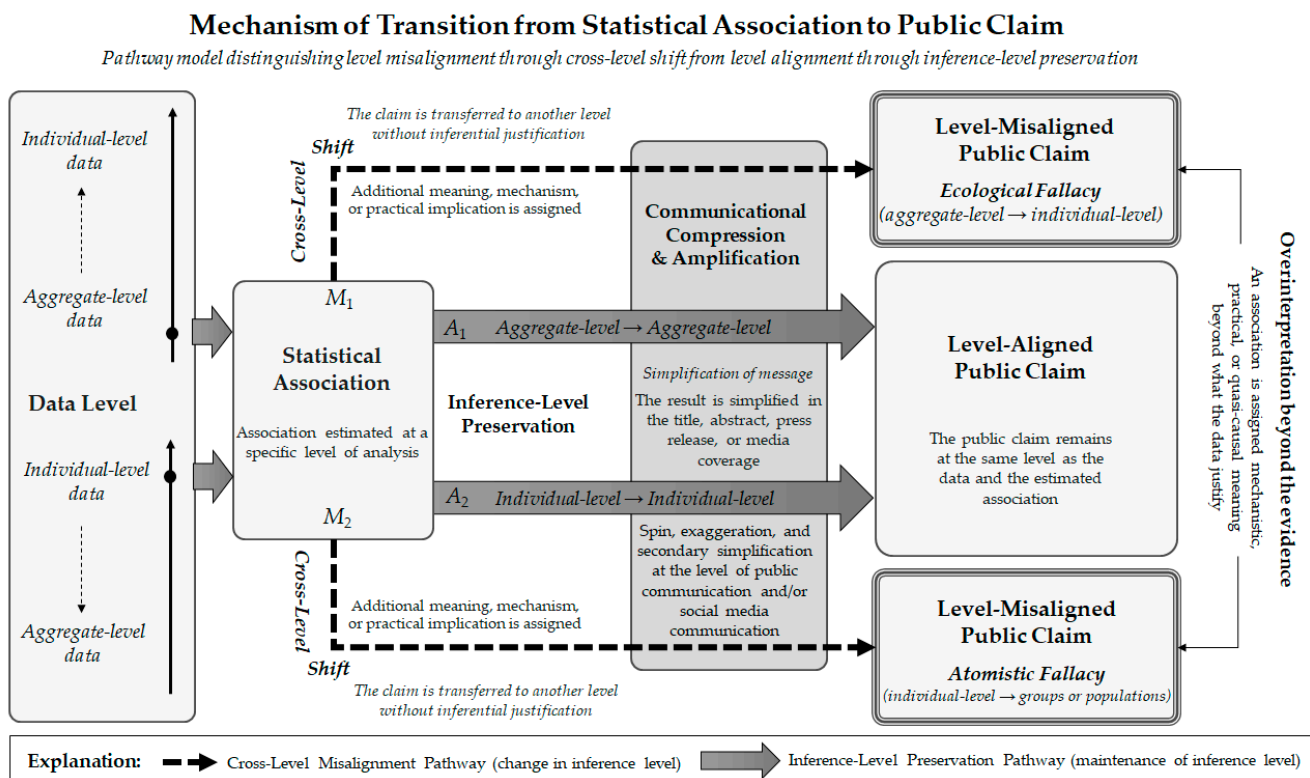


Figure 2. Mechanism linking a statistical association specific to a given level with a public claim: cross-level distortions—atomistic and ecological—and consistency pathways preserving the level of inference. Source: Author's own pathway model developed on the basis of the methodological literature discussed in the text.

The pathway model proposed here should be treated as a heuristic framework that organizes observations derived from different strands of literature. Future research should examine whether this proposal can be empirically verified and operationalized. The mechanism described here, however, has not only descriptive but also critical significance. It makes it possible to connect the classical literature on ecological and atomistic fallacies with more recent metascience and research on scientific communication. Of particular importance here is the view of Ioannidis (2016), who indicated that the usefulness of clinical research depends on such features as the proper embedding of the research problem, context, information gain, pragmatism, relevance to patients, cost-effectiveness, feasibility,

and transparency. This supports the cautious conclusion that the formal validity of a study does not eliminate the risk of a later interpretive overstepping of the scope of justification. Nosek et al. (2015) and Munafò et al. (2017) developed a similar intuition within the framework of open and reproducible science, indicating that improving the credibility of research requires not only methodological reforms, but also changes in research culture, reporting practices, dissemination of findings, and incentive structures. From this perspective, cross-level inference error appears as one of the points at which weaknesses in research design, interpretation, reporting, and the public circulation of findings may intersect.

The consequence of this line of reasoning is the need to formulate a practical tool for limiting this type of distortion. For this reason, the next section of the article introduces a control tool whose task is to help avoid false conclusions.

5. Control of the Level of Inference and Communication

Knowledge of how cross-level inference errors arise is not yet sufficient to avoid misleading interpretations of one's own research findings. What is also needed is an instrumental control of inference and of the point at which it is applied.

5.1. Diagnostic Checkpoints in the Publication Chain

The control of conclusions and of the final communication is directly linked to its diagnostic function, which makes it possible to identify where potential distortions arise. However, this appears to be only an auxiliary function in relation to the analysis of links between research and publication processes.

O'Keefe (2024) shows that individual-level correlations cannot justify message-level claims and argues that claims about messages require analyses conducted at the message level. This point is directly relevant to the problem considered here because it emphasizes the need to align the level of evidence with the level at which a claim is formulated. However, there appears to be a need for a broader, complementary, and diagnostic approach that extends this issue to the relationship among the data level, the level of the estimated association, the inference level, and the communication or recommendation level, thereby further strengthening researchers' diagnostic capacities. In this approach, the claim is treated as the operational expression of the inference level, whereas recommendation is treated as a specific applied form of communication.

It is therefore proposed to adopt a direct control of the level of inference and communication, located at the final stage of publication preparation. In its simplest form, this may be understood as the habit of checking whether the publicly communicated meaning of a result does not transform it into a level-misaligned claim by assigning to it a level of reference different from the one at which the data were collected and the associations were estimated. The rationale for implementing such a conceptual tool of analysis is that an operational formulation of the problem may facilitate the transition from the analysis of individual cases to broader recommendations for authors, editors, journalists, and fact-checkers.

One form of such communication is overinterpretation, understood as going beyond the permissible scope of generalization or explanation. It is not yet identical with the concept of scientific misinformation, which should be used more cautiously and reserved for cases in which a public claim becomes stabilized or disseminated in the public sphere in a way that systematically produces a false picture of the state of knowledge, regardless of whether there was an intention to mislead. Moreover, checking the consistency of a single claim with its source is necessary but insufficient. A message may be misleading even when it correctly cites a finding, if it wrongly transfers it from the group level to the individual

level, or vice versa. Distortions of this kind are often difficult to detect because the result itself may be cited correctly while at the same time being interpreted at the wrong level.

If cross-level inference errors may constitute an important mechanism of scientific information distortion, whereby a credible scientific finding is transformed into an erroneous claim, the response to this problem cannot be limited to classical fact-checking. In this article, the inference level denotes the level at which the meaning of the estimated result is formulated as a claim. The claim level is therefore treated as the operational expression of the inference level, not as a separate stage of the process. A level-misaligned inference occurs when the meaning assigned to the result exceeds or changes the level at which the data were collected and the association was estimated. Its communicative outcome is what this article terms a *Level-Misaligned Public Claim*: a public claim that appears to be consistent with the source but assigns to the result a meaning that exceeds or changes its proper level of inference. Its opposite is a *Level-Aligned Public Claim*, in which the meaning assigned to the result remains at the proper level of inference.

However, inference-level alignment alone does not explain all distortions. It is therefore necessary to propose a procedural approach that includes not only checking alignment between analysis and inference, but also checking alignment between inference and public communication. A recommendation is understood here as a practical, clinical, policy-related, organizational, or educational indication derived from the claim. It belongs to the level of communication and application of the result. Thus, recommendation is not a synonym for communication as such, but a specific applied form of communication. This justifies including the communication or recommendation level in the assessment, that is, classifying the latter part of the publication-preparation process as either *level-aligned communication* or *level-misaligned communication*.

Ultimately, the proposed *Inference-Level Alignment Procedure* should answer the question of whether the data level and the level of the estimated association (*analysis*), the inference level, operationalized as the claim level (*inference*), and the communication or recommendation level (*communication and application of the result*) remain aligned. The assessment process should include two checkpoints: the *Analysis–Inference Alignment Check* (CP_I) and the *Inference–Communication Alignment Check* (CP_{II}). It is not an overarching procedure that integrates all practices of cautious scientific communication, but rather a specialized test for assessing consistency among the elements of the mechanism used to identify cross-level distortions. Its specificity lies in the fact that it does not primarily ask whether the message is exaggerated, whether it uses causal language, or whether it sufficiently highlights the study's limitations. Instead, it addresses the narrower issue of consistency between two pairs of levels: (a) the level of analysis and the inference level, operationalized as the claim level, and (b) the inference level and the communication or recommendation level, understood as the level at which the claim is communicated, applied, or translated into a practical implication. It therefore seeks to answer the following question: has the meaning assigned to the result remained at the same level of analysis at which the result was estimated, and does the public message or recommendation remain at the same level as the inference derived from the analysis? This means that the problem of level difference does not concern only the relationship between analysis and inference or only the relationship between inference and communication. It is an approach covering the entire chain of actions (Figure 3), in which a level shift detected at any segment of that chain makes the final public claim a *Level-Misaligned Public Claim*.

The separation of the process into two checkpoints also follows from diagnostic needs. This approach makes it possible to indicate at which stage of the process the distortion arose: whether at the moment of formulating conclusions at the final stage of analysis, or at the moment of formulating a press release after the conclusions had already been

established. In this way, issues of spin, causal language, and disclosure of limitations remain important, although they are analytically distinct from the direct control of the level of inference.

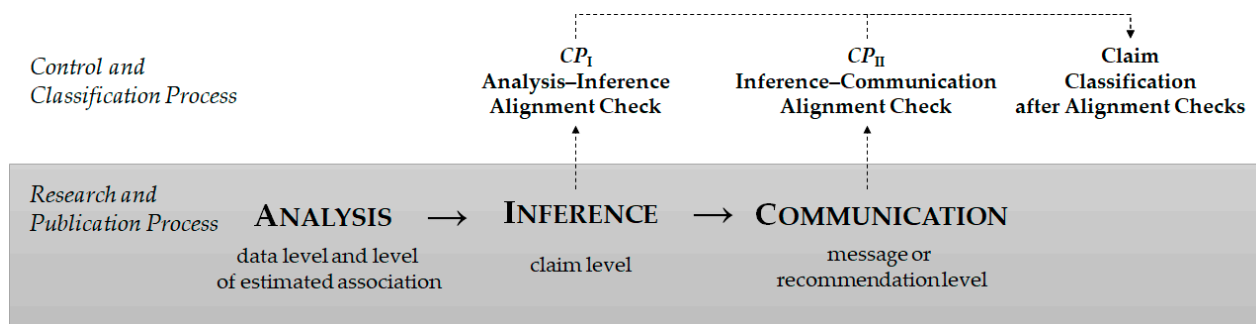


Figure 3. Inference-level alignment framework: two diagnostic checks across the chain from analysis to inference and communication. Source: Author's own conceptual framework.

The procedure begins with the identification of the unit of observation and the data level at which the exposure and outcome were measured: whether this is the level of the individual, household, group, organization, or territorial aggregate, such as a region or country. The nature of the estimated association is then determined, especially whether the relationship is within-individual, between-individual, contextual, or mixed. In practice, one of the key elements of the control procedure is the researcher's knowledge of the level of the data at their disposal. This knowledge should also serve as a point of reference at every stage of the procedure. The core of the proposed control procedure is a structured assessment of the relationship among evidence, interpretation, and recommendation. The next step is therefore to examine whether the claim level is consistent with the data level and the level of the association. The procedure ends with an assessment of whether each practical, policy-related, or clinical recommendation falls within the permissible scope of inference. It may include an assessment of whether the title, abstract, and main claim remain at the same level of inference as the conclusions drawn from the analysis of the association.

This approach may be supplemented by a transparency component concerning the disclosure of limitations, uncertainty, and alternative explanations. However, this component does not in itself determine inference-level consistency. It only helps assess whether communication creates conditions for an unjustified extension of the meaning of the result. Understood in this way, control of the level of inference may function as an ordered procedure for assessing consistency between the level of evidence and the level of scientific interpretation and public communication.

Figure 4 translates the procedure for checking the alignment between the level of inference and the level of communication into a four-step pre-publication procedure that verifies consistency among the level of analysis, the type of estimated association, the level of inference, and the level of communication or recommendation.

Nevertheless, it should be noted that the proposed procedure should distinguish descriptive coding from inferential classification. Assuming consistency demonstrated at the first checkpoint, that is, consistency between the claim level and the data and association levels, the second checkpoint becomes decisive. A message can be consistent only when both the first and the second checkpoint show no cross-level shift. A level shift detected at the first checkpoint determines that the final public claim cannot be regarded as level-aligned. This does not mean, however, that the second checkpoint loses its diagnostic significance. It makes it possible to determine whether the message merely repeats the earlier shift or additionally amplifies it or extends it to the recommendation level. At the same time, the absence of a shift at the first inference checkpoint does not yet mean that

the final message is correct, because distortion may arise at the stage of creating the public message on the basis of correctly obtained conclusions from the analysis. This is why the second checkpoint is also crucial.

Inference-Level Alignment Check Before Publication

A four-step procedure for verifying alignment among the level of analysis, the type of association, the level of inference, and the communication or recommendation level

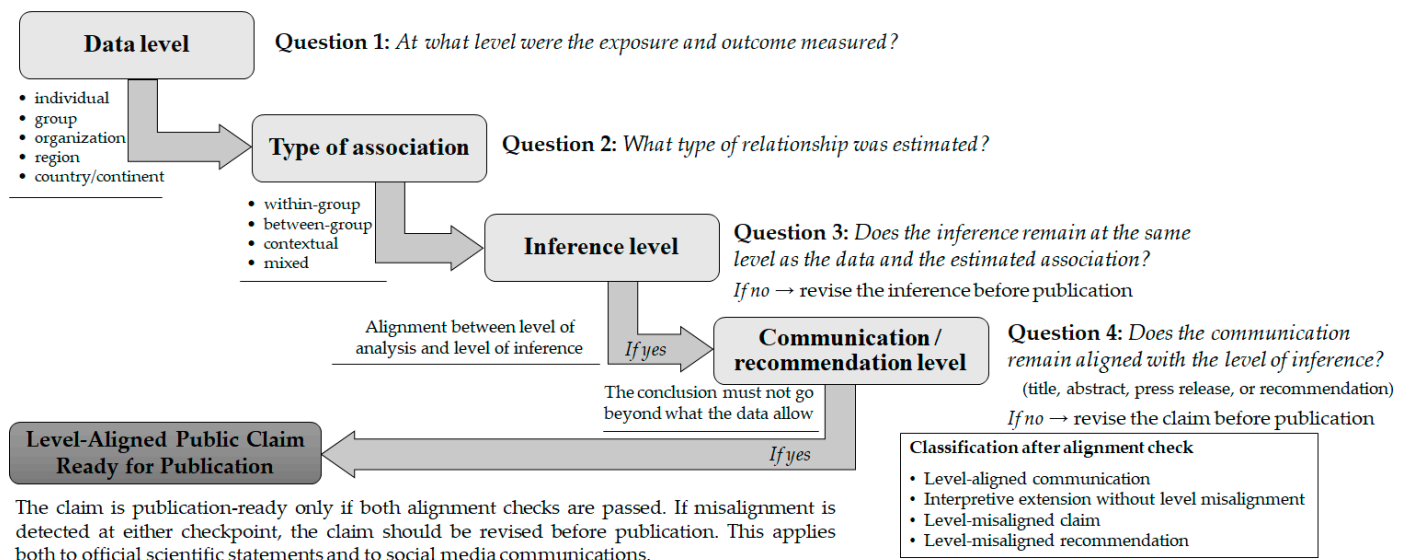


Figure 4. Pre-publication Inference-Level Alignment Procedure: a four-step procedure for verifying consistency among the level of analysis, the type of estimated association, the level of inference, and the level of communication or recommendation.

The control of the transformation of conclusions into a public message requires identifying the basic elements of the submitted communication and then comparing them with the results of the first checkpoint, and thus with the data level. This activity should lead to the classification of the final communication into one of four categories:

- inferentially consistent communication;
- interpretive extension without a cross-level shift;
- cross-level shift in the claim;
- cross-level shift extended to the recommendation.

It is worth noting that the mechanism of inference distortions shown in Figure 2 has a symmetrical structure, which demonstrates that it not only reproduces the classical ecological fallacy but also makes it possible to detect the atomistic fallacy. Therefore, the control procedure shown in Figure 4 can also be applied symmetrically to the two opposite directions of cross-level inference error. This makes it possible to supplement the category of cross-level shift with the type of shift involved, indicating either an ecological or an atomistic fallacy. The disclosure of limitations, uncertainty, and alternative explanations should not be treated as a separate category of level consistency. Rather, it should serve as a transparency modifier that may reduce the risk of communicative overinterpretation.

It should also be emphasized that the proposed control procedure is grounded in previous research, because it draws on several strands of methodological guidance already discussed in the review section, although it is not identical with them. Idrovo's (2011) criteria clarify when ecological fallacy can be identified, whereas Subramanian et al. (2009) emphasize that cross-level error is bidirectional and includes both ecological and atomistic fallacies. O'Keefe's (2024) already cited argument concerning message-level claims highlights the principle that claims should be formulated at the same level as the evidence supporting them. The STROBE recommendations, in turn, provide a broader reporting

framework for transparent and cautious interpretation of observational studies (von Elm et al., 2007; Vandembroucke et al., 2007). In this way, the procedure does not reproduce any of these approaches, but integrates them into a practical test of level alignment among analysis, inference, and communication.

The proposed procedure may serve a heuristic function and may also provide the basis for a preliminary coding protocol designed to assess inference-level consistency in the author's own research. At the present stage, however, it should be treated as a provisional analytical tool that organizes the assessment of the relationship among the unit of observation, the type of estimated association, the level of the main claim, and the recommendation level, while integrating principles and claims encountered in the literature. The next stage should be validation of the measurement instrument.

5.2. Scope of Control

The primary site for applying control of the level of inference and communication should be the scientific publication itself, broadly understood. Authors of observational or ecological studies should explicitly indicate the unit of analysis, the level of aggregation of the variables, and the interpretive limits imposed by the research design. Haber et al. (2022) showed that even texts explicitly adopting associational language may imply stronger causal conclusions than their design warrants. In practice, this means that the estimated finding must be clearly distinguished from the explanatory hypothesis, mechanistic speculation, and practical implication.

The next critical site is the abstract. It is the abstract that most often becomes the basis for the secondary circulation of information, while also being especially vulnerable to compression and spin, as shown by the previously cited studies by Boutron et al. (2010, 2014), Yavchitz et al. (2012), and Haneef et al. (2015). From the perspective of the model proposed here, this means that control of the level of inference should be a mandatory element of abstract assessment rather than an optional addition at the final editing stage.

The third link requiring particular attention is the press release prepared by academic institutions and publishers. Such releases not only inform about research findings but often also perform a promotional function, presenting the achievements of researchers, teams, or institutions in a form attractive to the media. Under such conditions, there is a risk that the meaning of results will be exaggerated, especially when the release strengthens the practical, social, or health-related implications of the study beyond what its design and level of inference justify. In this context, it is worth recalling the previously discussed studies by Sumner et al. (2016) and Bossema et al. (2019), which concerned exaggeration in health news and the role of expert quotations in limiting this risk. A press release should therefore not only popularize the finding but also preserve alignment between the data level and the level of interpretation by clearly indicating the limits of permissible generalization.

Another area of application for the proposed model is editorial practice. Editors and reviewers usually assess the adequacy of methods, the state of the literature, and the formal correctness of the manuscript. Much less often, however, do they conduct a systematic assessment of alignment between the data level and the level of the interpretive claim. This is precisely where an explicit procedure should be introduced. The STROBE recommendations (von Elm et al., 2007; Vandembroucke et al., 2007) help structure the reporting of observational studies by emphasizing the need for an informative and balanced abstract and cautious interpretation of results. These recommendations may, however, be supplemented by a specifically inferential question: do the final claims exceed the level to which the data actually refer? This proposal is consistent with the broader agenda of reforms in open and reproducible science discussed by Nosek et al. (2015) and Munafò et al.

(2017), who emphasize that the credibility of science depends not only on methodological procedures but also on norms of reporting, evaluation, and dissemination of findings.

It also seems that published informational texts should specify whether the finding concerns individuals, organizations, regions, countries, or other aggregated units. This recommendation is consistent with existing attempts to improve the labeling of medical and scientific press releases. Following the recommendations of the [Academy of Medical Sciences](#) (2018), the Science Media Centre implemented a system for labeling press releases according to peer-review status, study type, and the nature of the empirical material. Such systems could be extended by adding a label indicating the level of inference, specifying whether the main finding concerns individuals, groups, organizations, regions, or populations. As [van der Bles et al. \(2020\)](#) showed, communicating uncertainty does not necessarily undermine public trust.

The introduction of control of the level of inference and communication may also have systemic significance for open science. Open access to publications and data strengthens the possibility of independent critique, but at the same time increases the number of points at which findings may be stripped of context and used in an overly simplified manner. The works of [Nosek et al. \(2015\)](#), [Munafò et al. \(2017\)](#), and [Vicente-Sáez and Martínez-Fuentes \(2018\)](#) are relevant here. Openness, however, does not automatically eliminate inferential errors. It must be supplemented by more transparent communication standards concerning the level at which findings may be legitimately interpreted.

Ultimately, in line with the general concern for alignment discussed by [O’Keefe \(2024\)](#), the proposed approach can be summarized in the form of a synthetic principle: a finding should not be communicated as if it referred to a different level of reality than the one at which it was estimated. This requires a clear distinction between the data level, the level of the estimated association, the inference (claim) level, and the communication or recommendation level, so that an observation concerning a collective is not presented as if it directly justified conclusions about individuals, nor vice versa. Extending this principle makes it possible to treat control of the level of inference as a specialized tool for assessing consistency between the data level and the level of conclusions, and between the level of conclusions and the level of the communicated meaning assigned to the findings. In this sense, it may serve the early detection of the type and location of distortions, supplementing existing practices for identifying ecological fallacy, assessing causal language, and detecting spin.

6. Conclusions

The analysis presented in this article shows that cross-level inference errors should not be understood solely as technical problems of statistical interpretation. They may also become problems of scientific interpretation and communication when a finding estimated at one level of analysis is communicated as if it referred to another level of reality. In such cases, the empirical data may be correct, and the statistical association may be formally valid, yet the meaning assigned to the finding in public communication may still be misleading. The central problem, therefore, is not necessarily the falsification of results, but the loss of alignment between the level at which evidence is produced and the level at which claims or recommendations are formulated.

This distinction is particularly important because ecological and atomistic fallacies operate in opposite directions but have the same inferential structure. Aggregate-level associations should not be translated into claims about individuals without additional justification, just as individual-level associations should not be generalized to groups, institutions, regions, or populations if the research design does not support such inference. The same principle applies to practical recommendations. A policy, clinical, organizational, or

educational recommendation should remain within the boundaries of the level of inference justified by the data and the estimated association. When this alignment is broken, a finding may retain the appearance of scientific validity while at the same time functioning as a *Level-Misaligned Public Claim*.

The main contribution of the article consists of linking the classical methodological literature on ecological and atomistic fallacies with research on spin, exaggeration, science journalism, press releases, and misinformation in and about science. This connection makes it possible to treat cross-level inference errors not only as errors occurring within a research design or statistical interpretation, but also as mechanisms through which scientific findings may be transformed during communicative circulation. The proposed model distinguishes two possible outcomes of communicating a statistical association specific to a given level: one aligned with the data level and one misaligned with it. The model does not assume that every distortion follows the same sequence. Rather, it provides a heuristic framework for identifying where and how level alignment is lost in the chain: *analysis* → *inference* → *communication*.

The *Inference-Level Alignment Procedure* has been proposed as a practical response to this problem. It is understood as a procedure for checking the alignment between the level of inference and the level of communication, comprising two diagnostic checkpoints. The first checks whether the conclusion remains aligned with the data level and the level of the estimated association. The second checks whether the message, abstract, title, press release, or recommendation remains aligned with the level of the conclusion obtained on the basis of the analysis. The aim is not to replace existing standards for assessing causal language, uncertainty, spin, exaggeration, or the quality of evidence, but to supplement them by asking whether the level of analysis, the level of inference, and the level of communication remain aligned. In this sense, responsible scientific communication requires not only fact-checking, but also the control of level alignment throughout the chain from research finding to public claim.

The argument developed here also has practical implications for authors, editors, reviewers, press officers, journalists, fact-checkers, and audiences. Authors should explicitly indicate the unit of analysis, the level of aggregation, and the limits of interpretation. Editors and reviewers should assess not only whether the statistical analysis is correct, but also whether the title, abstract, conclusions, and recommendations remain aligned with the level of evidence. Press officers and journalists should avoid transforming aggregate-level associations into advice for individuals, or individual-level findings into claims about populations, unless such transitions are justified by the research design. For audiences, a basic form of inference-level checking may provide an additional safeguard against misleading cross-level interpretations.

Finally, the limitations of this article should be emphasized. It is based on a purposively selected, problem-oriented body of literature and does not constitute a systematic review. The proposed model should therefore be treated as a conceptual and heuristic model rather than as an empirically validated measurement instrument. Future research should empirically examine at which stages of knowledge circulation shifts in the level of inference most often occur. Another important direction would be to evaluate the proposed procedure across different fields and genres of scientific communication. Beyond cross-level inference errors, further research could address related explanatory distortions that are not the focus of this article, such as psychologistic and sociologistic fallacies, by clarifying their boundaries, conditions of occurrence, and possible ways of preventing them in scientific interpretation and communication.

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