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Does Chocolate Consumption Really Boost Nobel Award Chances? The Peril of Over-Interpreting Correlations in Health Studies[1,2]

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Abstract

A correlation observed between chocolate consumption and the number of Nobel laureates has recently led to the suggestion that consuming more chocolate would increase the number of laureates due to the beneficial effects of cocoa-flavanols on cognitive functioning. We demonstrate that this interpretation is disproved when other flavanol-rich nutriment consumption is considered. We also show the peril of over-interpreting correlations in nutrition and health research by reporting high correlations between the number of Nobel laureates and various other measures, whether cogently related or not. We end by discussing statistical alternatives that may overcome correlation shortcomings. J. Nutr. 143: 931–933, 2013.

A recent note in the *New England Journal of Medicine* reports a high correlation between chocolate consumption and the number of Nobel laureates, taken as a proxy of a population's global cognitive level, in 23 countries all over the world (1). This, the author argues, would be due to the beneficial effect of the flavanols contained in cocoa. This subclass of polyphenol-flavanoids present in various plant-based foods (2) would indeed play a preventive role against neurodegenerative diseases and, more globally, might have a positive impact on cognitive functioning (3–5). As a direct consequence of this surprising correlation, the author of the note suggests increasing the quantity of chocolate intake to improve cognitive abilities at the individual level, which will in turn increase the number of Nobel laureates at the national level. Whereas the second part of this provocative conclusion may have been made humorously, the first one was taken very seriously in recent scientific publications [e.g., (6,7)] and has received wide coverage in the popular media. However, as appealing and intriguing as it may sound, this conclusion must be taken very cautiously, as it goes in fact far beyond the data. In the following discussion, we show that it must be questioned on methodological, statistical, and logical grounds.

At the methodological level, it is worth noting that the observed correlation is in fact based on country-averaged chocolate consumption and not on the actual consumption of Nobel laureates themselves. This causes a major interpretation problem known as ecological inference fallacy, where conclusions about individual behaviors are drawn from data about aggregate behaviors, with no guarantee that the relationships observed at the group level necessarily hold for individuals (8) [for an application of this problem to health-environmental exposure issues, see (9)]. Moreover, the correlated data concern the last 2 y for chocolate consumption, whereas they spread over more than a century for Nobel laureates. This temporal gap clearly limits the pertinence of this correlational analysis, as chocolate consumption habits have radically changed over the past decades [e.g., the worldwide production of cocoa has quadrupled between 1960 and 2010 (10)], and recent consumption thus cannot be taken as a good estimator of past periods. More importantly, chocolate is only one of the many nutriments containing flavanoids. Should the quantity of flavanoids in nutriments indeed be the crucial explanatory factor, then the number of Nobel laureates should also correlate with the consumption of other flavanoid-rich nutriments. We, however, did not observe such a correlation with the mean annual tea ($r = 0.03$; $P = 0.88$) (**Fig. 1***A*) and wine ($r = 0.16$; $P = 0.47$) (Fig. 1*B*) consumption per capita in the same 23 countries (11) even though these nutriments both present very high flavanoid concentrations (12). Thus, flavanoid concentration does not fully explain the high chocolate–Nobel laureate correlation.

At the statistical level, it is worth recalling that correlation never implies causation. There are many examples of correlations for which causal interpretations do not make sense [e.g., (13)]. Let us prove again this caveat by reducing it to the absurd within the present context. We found an incredibly high correlation between the number of IKEA furniture stores (14) and Nobel laureates ($r = 0.82$; $P < 0.0001$) (Fig. 1*C*), although we could not come up with any mutual causal relationship - and we doubt that someone would seriously claim that IKEA mainly limits its market to countries awarded the Nobel prize or that the need to understand and apply IKEA's furniture assembly instructions improves cognitive functioning at the population level.

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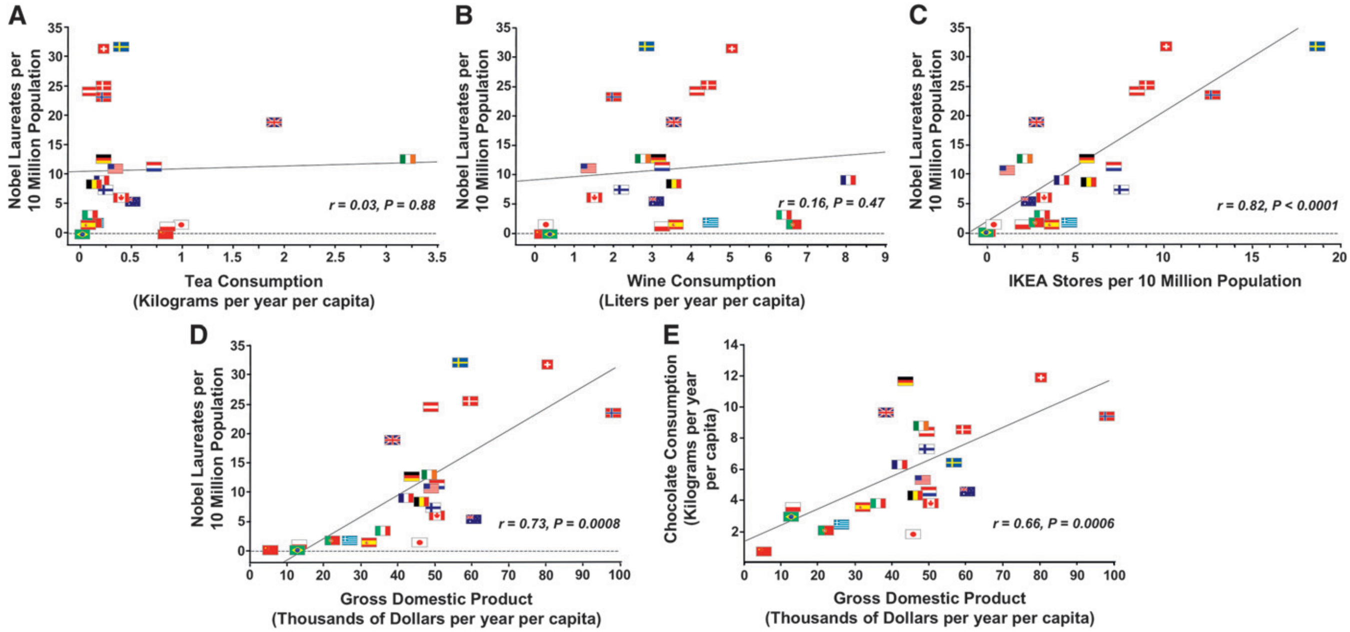

FIGURE 1 Correlations between countries' (*A*) number of Nobel laureates per ten million population and annual per capita tea consumption; (*B*) number of Nobel laureates per ten million population and annual per capita wine consumption; (*C*) number of Nobel laureates and number of IKEA stores per ten million population; (*D*) number of Nobel laureates per ten million population and annual per capita gross domestic product; and (*E*) annual per capita chocolate consumption and annual per capita gross domestic product.

At the logical level, even when keeping in mind that correlation does not mean causation, it is tempting to infer some loose directionality between factors when high correlations come along with sound interpretations. After all, a beneficial effect of flavanoid consumption on cognitive functioning on populations is plausible and certainly sounds more logical than the reverse effect of Nobel awards possibly leading to greater consumption of chocolate. Accordingly, although the author of the note acknowledges that the observed correlation cannot be directly interpreted as reflecting a causal link, the discussion tends to exclude alternative explanations and proposes that higher chocolate consumption will increase the number of Nobel laureates. However, even with an apparently meaningful relation, such an interpretational drift from correlation to directionality must never be allowed, because, as hidden factor(s) influencing both variables separately cannot be excluded, a third cause fallacy could always be involved. In the present case, e.g., we reasoned that the Gross Domestic Product (GDP; i.e., country market value of all final goods and services per year per capita) taken as an indicator of a country's standard of living could mediate both luxury food consumption and the level of scientific research. As we suspected, it turned out that the GDP (15) strongly correlated both with the number of Nobel laureates ($r = 0.66$; $P < 0.001$) (Fig. 1*D*) and chocolate consumption ($r = 0.73$; $P < 0.001$) (Fig. 1*E*). Moreover, using the Fisher r-to-z transformation that allows statistical comparison of the strength of different correlations, we found that the original chocolate-Nobel correlation ($r = 0.79$; $P < 0.0001$) is not significantly stronger than the GDP-Nobel (Fisher z-test = 0.49, NS) or than the GDP-chocolate (Fisher z-test = 0.9, NS) correlations observed here.

Experimental designs or intervention trials should always be preferred when researchers want to examine cause-to-effect relationships. When this is not possible and a correlational design is the only solution, 2 mathematical methods, Granger causality and Convergent Cross Mapping (CCM) tests, have been specifically developed to approach causality. The Granger causality test assesses whether a sequence of data points is useful to predict another based on linear regression modeling of stochastic processes (16,17): if a X_1 "Granger-causes" X_2, then past values of X_1 should contain information that helps predict X_2 above and beyond the information contained in past values of X_2 alone. Concretely, once a correlation is found, the Granger causality test can be used to strengthen the case that there is a causal link at work (18). However, when causality runs both ways (e.g., in the relation between sport and excess weight, limited physical activity favors weight increase and excess weight leads to reduced physical activity), CCM can be used instead of the Granger causality test. Based on nonlinear state space reconstruction, CCM mathematically transforms each data set to create a 3-dimensional shape called a manifold (19). Points on one manifold are used to predict points on the other, but not necessarily the other way round, allowing causal relationships of one direction or another to be measured separately. Although the application of these methods has just begun [see e.g. (20)], we think that they constitute a good alternative when experimental designs are not possible.

Correlations tell the researchers the degree of relationship between factors; no more, no less. They prove useful in understanding which factors are related and in generating hypotheses for further experimental testing. Our discussion of a recent report attributing beneficial effects to chocolate consumption shows the peril of over-interpreting correlations. In nutrition research, such erroneous inferences may have dramatic effects, as they may lead to attributing beneficial (or harmful) effects to a wrong cause, hence representing a real danger for health. We hope we have helped readers to correctly situate the relevance of the initial report and to avoid misinterpretations of correlations that hamper nutrition and health research.

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