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LETTERS TO THE EDITOR

Caustics and steroids: A case of Simpson's Paradox

To the Editor:

The recent article by Fulton and Hoffman provides an excellent example of Simpson's Paradox (1,2). Simpson's Paradox states that "It is not necessarily true that averaging the averages of different populations gives the average of the combined population" (3). In fact, comparing the average of the combined populations and the average of the averages of the individual populations can lead to conclusions which are quite the opposite.

For example, a comparison of Derek Jeter's batting average and David Justice's batting average during 1995 and 1996 seasons reveals that David Justice had a better batting average each year (see Table 1). However, if all the at-bats in both years were pooled for the two years, then Derek Jeter would have the better batting average. Conversely, if the mean batting average for the two seasons is compared, then David Justice has the better average (4).

To demonstrate this paradox in the case of steroids and second degree caustic esophageal injuries, we can use the author's data to create an analysis that compares the average of the combined population (the rate of stricture formation from the pooled data) to the average of the averages of the different populations (the mean of the rate of stricture formation from each of the studies) (see Table 2).

If the two populations are compared as the author have, that is by pooling the data without a weighting variable or statistical treatment, then the rate of stricture formation without steroids (19%) is greater than the rate of stricture formation with steroids (12%). This would appear to support the use of steroids. Paradoxically, if we compare the arithmetic means of the rates of stricture formation from each of the individual studies, the mean rate of stricture formation without steroids is 15% and the mean rate of stricture formation with steroids is 20% - leading to quite the opposite conclusion. Neither of these approaches is statistically valid because studies cannot be combined without a weighting process such as meta-analysis. Furthermore, because only three of the studies have a control group, a strict meta-analysis can only include those three studies. One prior meta-analysis of those three studies found when steroids were used to prevent stricture formation, despite the pooled analysis suggesting a possibly protective effect. (5) also found steroids offered no protection. Another study that attempted to pool data (6).

Since prior meta-analysis of the three investigations with both a control and a treatment group failed to support the use of steroids in second degree esophageal burns, the authors conclusions that the existing data fail to support the use of steroids is reasonable. However, the pooled data appear to demonstrate a benefit to steroids where the mean data appear to demonstrate harm from steroids and this is an example of Simpson's Paradox.

Table 1. A comparison of Derek Jeter's batting average and David Justice's batting average during the 1995 and 1996 seasons illustrating Simpson's paradox prepared from reference (4)

		Derek Jeter		David Justice	
		hits/at bats	batting average	hits/at bats	batting average
By Season	1995	12/48	.250	104/411	.253
	1996	183/582	.314	45/140	.321
Pooled		195/630	.310	149/551	.270
Mean			.282		.287

Table 2. Comparison of stricture formation rates using pooled data and mean data extracted from Table 1 of ref. (1)

	Steroid-treated	not steroid-treated
Study no.	# strictures/ total # patients (%)	# strictures/ total # patients (%)
1	1/15 (7)	0/5 (0)
2	4/18 (22)	No control group
3	7/19 (37)	No control group
4	1/6 (17)	No control group
5	1/25 (4)	No control group
6	0/91 (0)	No control group
7	No control group	2/32 (6)
8	5/9 (56)	No control group
9	2/9 (22)	4/11 (3)
10	1/6 (17)	No control group
11	3/28 (11)	No control group
12	5/18 (28)	0/3 (0)
13	No control group	10/33 (30)
Stricture formation rates		
Pooled rate	30/244 (12)	16/84 (19)
Mean rate	(20)	(15)

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Gaseous emissions at the site of the Delphic Oracle: Assessing the ancient evidence

To the Editor:

In a recent paper by Foster and Lehoux (1), the two authors comment on the results of our team's study of evidence for gaseous emissions at the site of the ancient Delphic Oracle in central Greece. Judging from their comments, Foster and Lehoux appear to be insufficiently familiar with the ancient sources, with scientific method, and with the site of Delphi itself. Their paper attempts to reassert the orthodox position of 20th century classical scholars, who have routinely maintained that there is no truth to the ancient tradition of unusual geological phenomena and activity at the oracle site.

With regard to the ancient sources, it is misleading for them to state that "almost no ancient sources" mention the fissure and the intoxicating *pneuma* (a Greek term that can mean gas, wind, breath, or vapor, depending upon its context) in the oracular temple. Only a small fraction of ancient literature survives: there is, for example, only one reference to the Parthenon at Athens in the entire literature of the 5th century BC, when the temple was constructed. What counts is not quantity but quality, and in the case of the Delphic Oracle we are fortunate to have three essays by the Greek writer Plutarch, who served as priest at Delphi for many years and was an eye-witness to the oracular sessions. Plutarch makes it clear that from time to time, there was a sweet-smelling emission from the *adyton* or oracular chamber. He attributes the weakness of the emission in his own time to such geological activity as earthquakes that sealed up the vents in the rock, or limited amounts of the "vital essence" in the rock itself. Plutarch records routine oracular trances, after which the woman who spoke the oracles appeared like a runner after a race or a dancer after an ecstatic dance. And he contrasts these with extraordinary cases in which the woman raved and flung herself about in a delirium. Throughout his writings, Plutarch makes it clear that the oracle's power was believed to derive from a physical, geological source.

Foster and Lehoux also misunderstand the process of standard scientific method, which starts with a hypothesis and then tests the hypothesis against data. This may appear "circular", but it is the opposite of circular reasoning, since the hypothesis is not accepted unless it is confirmed by the evidence. In the case of our research, we tested the hypothesis that ancient reports about the oracle were accurate by conducting geological and archaeological surveys at Delphi and analyzing gases in ground water from modern springs at and in travertine rock laid down by the springs at the time the oracle was active. The data confirmed that the rock beneath the temple was fractured by geological faults, and that the spring water, ancient and modern, contained intoxicating light hydrocarbon gases in higher than atmospheric concentrations. These findings confirmed the accuracy of the ancient tradition, which Foster and Lehoux wish to deny.

A serious error occurs in Foster and Lehoux's statements about ethylene. They use a figure of 2.2 for the atmospheric destruction of ethylene, the sweet-smelling hydrocarbon which we identify with Plutarch's sweet-smelling emission. This short time, according to them, would not allow sufficient concentrations of ethylene to develop in the temple crypt. However, if they had read their own source with attention, they would have discovered that the process is photochemically driven and depends on sunlight (2). There was no sunlight in the depths of the temple where the *adyton* was located, and therefore ethylene could have lasted considerably longer as a free gas.

It is not surprising that ethylene was not detected in the travertine rock around the temple. Ethylene is highly reactive. Rather than surviving through the centuries, the original ethylene would be chemically altered to form ethane and/or methane, also intoxicating hydrocarbons, which were found in the travertine.

A second geological study of the Delphic Oracle site was published by Etiope et al. in *Geology* 2006 (3). A team of five Italian and Greek geologists confirmed the presence of active faults and gaseous emissions at Delphi. They suggest that benzene was the sweet smelling gas that triggered the oracular trance. Whatever the exact identification of the gas