Funnel method of detecting divergent health care providers

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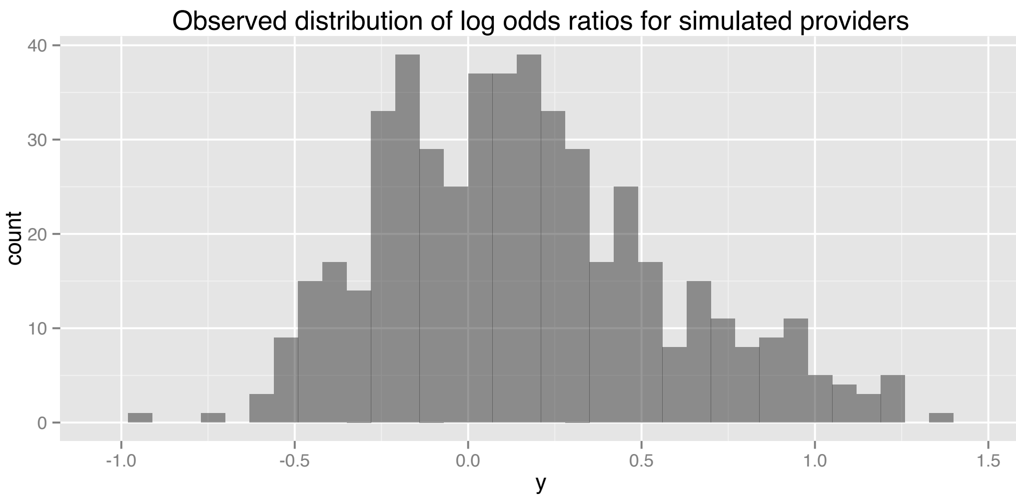
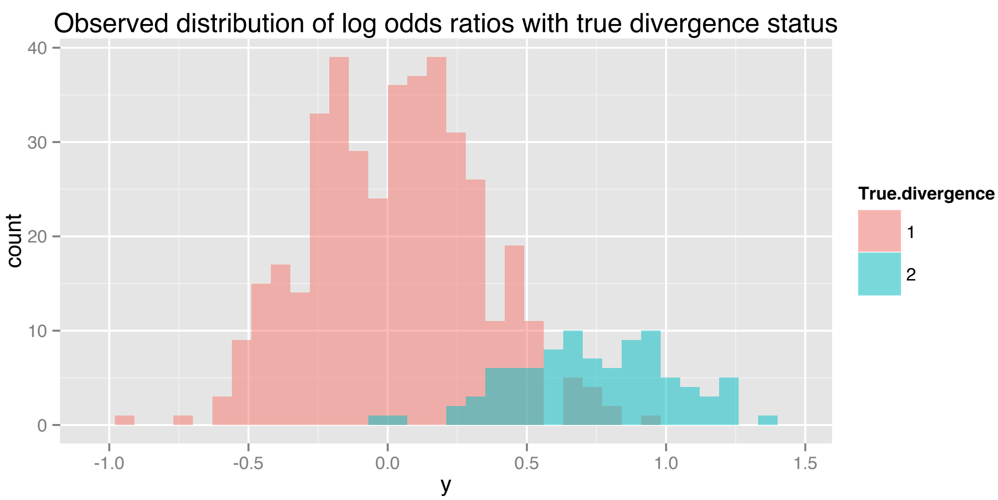
January 16, 2014

1 Introduction

To illustrate, using a computer I generated some hypothetical, synthetic data on health care providers. The outcome y represents the excess risk of adverse events (see next section below).



These providers have been simulated such that some are truly divergent and others are simply variable. Which providers are divergent? Can we detect the true divergence status? If we knew the true divergence status, the histogram would look like this:



The blue providers come from a random distribution with a mean that is nonzero. That is, these providers come from a distribution in which the number of adverse events is higher than can be expected based on the buckets.

But, of course, the problem is that we do not know the true divergence status but would like to detect it.

2 Procedure

Here is a procedure to do so, mostly following the recommendations of Ohlssen et al. (2007).

Suppose there are N providers, each with n_i treatments and o_i adverse events observed for the i-th provider. So o_i/n_i is the observed event rate for provider i, say r_i, and $\text{logit}(r_i) = \ln[r_i/(1-r_i)]$ the log-odds of the adverse events.

1. Create buckets
2. Obtain expected number of events in bucket b per provider i, e_{bi}
3. Calculate total expected per provider $e_i = \sum_b e_{bi}$

   —— *(Up till here it is the same as before)* ——

4. Calculate $y_i = \text{logit}(o_i/n_i) - \text{logit}(e_i/n_i)$, the excess log-odds ratio for each provider
5. Calculate

$$s_i = \sqrt{\frac{1}{o_i} + \frac{1}{n_i - o_i}},$$

   the standard error of y_i (excess log-odds ratio), and let the individual weight $w_i = 1/s_i^2$.

6. Now we need to estimate τ, the "true" between-provider standard deviation from a random effects model. Following Borenstein et al. (2007, pp. 14–5), estimate $\tau^2 = (Q - df)/C$, where

$$Q = \sum_{i=1}^{N} \left[w_i (T_i - \bar{T}_\cdot)^2 \right],$$

   and $df = N - 1$, and

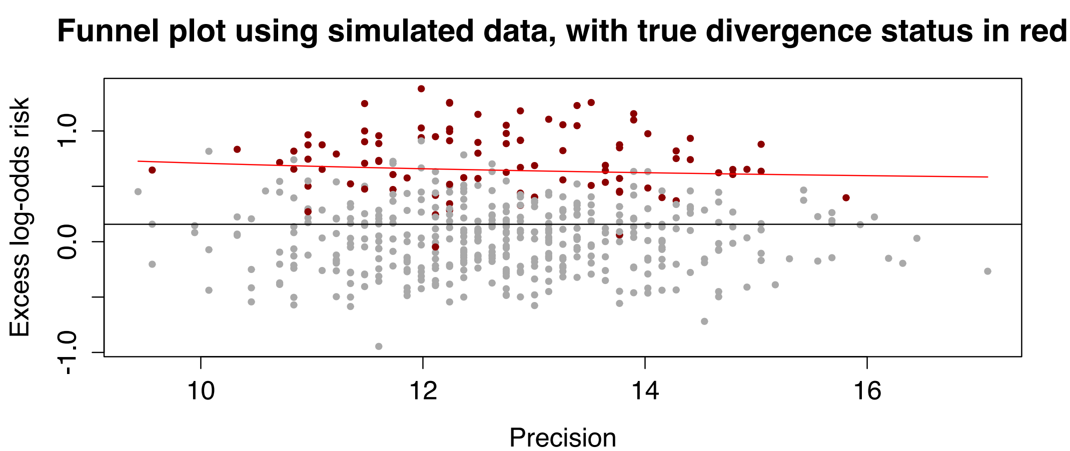
$$C = \sum_{i=1}^{N} w_i - \frac{\sum_{i=1}^{N} (w_i^2)}{\sum_{i=1}^{N} w_i}.$$

   (Note: If τ^2 estimated this way becomes negative, set it to 0)

7. Calculate $w_i^* = 1/(s_i^2 + \tau^2)$.
8. Estimate the overall mean μ as the weighted mean $\mu = w_i^* y / \sum_{i=1}^{N} w_i^*$.

   —— *(Now we have everything we need: specifically, we need μ, τ, s_i, and of course y_i).* ——

Funnel plot: (Spiegelhalter, 2005) Plot w_i versus y_i, with "funnel lines" corresponding to quantiles of $N(\mu, s_i^2 + \tau^2)$. That is, draw the lines as $\mu \pm 3\sqrt{s_i^2 + \tau^2}$



Divergence test: The test of divergence is simply whether the provider exceeds the funnel lines. That is, the test is whether $y_i > \mu + 3\sqrt{s_i^2 + \tau^2}$. Above I took 3 as a critical value. This is based on the number of providers (500 in this case), and the desire to detect the worst providers. I think 3 is a good compromise, but if there are many more providers (say, 5000), this will give more false positives. A better choice is then up to 4.5. Higher than 4.5 is not recommended.

References

Borenstein, M., Hedges, L., and Rothstein, H. (2007). Meta-analysis: Fixed effect vs. random effects. http://www.meta-analysis.com/downloads/Meta-analysis%20fixed%20effect%20vs%20random%20effects.pdf. [Online; accessed 16-January-2014].

Ohlssen, D. I., Sharples, L. D., and Spiegelhalter, D. J. (2007). A hierarchical modelling framework for identifying unusual performance in health care providers. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 170(4):865–890.

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