Developing Calibration Weights and Variance Estimates for a Survey of Drug-Related Emergency-Room Visits

Phillip S. Kott
RTI International
Charles D. Day
SAMHSA

Outline

- The DAWN Survey
- Calibration for Nonresponse
- Calibration for Variance Reduction
- Variance Estimation
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The Drug Abuse Warning Network

DAWN is a stratified simple random sample of US hospitals used to estimate annual drug-related emergency-room visits and related statistics.

Run by RTI International for the Substance Abuse and Mental Health Services Administration (SAMHSA).

Stratified by location, size, and ownership (public *vs.* private).

Oversampled within 13 metropolitan areas, for which domain estimates are published.

There is some sampling and nonresponse within hospitals, but we will treat hospital-level data as complete here.

There are currently three rounds of hospital reweighting:

- Frame adjustments within strata
- Nonresponse adjustments within cells
- Poststratification

The latter two use the same characteristics as in the stratification but can employ updated frame data from the American Hospital Association.

Calibration Weighting for Nonresponse

Let d_k be the frame-count-adjusted design weight of a sampled hospital k. A good nonresponse-adjusted weight has the form:

$$a_k = d_k \left[1 + \exp(\mathbf{g}^T \mathbf{x}_k) \right] \qquad \text{(ADJFACTOR in red)}$$

where $\mathbf{x}_k$ is a vector of the respondent's characteristics (e.g., size, ownership, location), and $\mathbf{g}$ is determined so that the calibration equation

$$\sum\nolimits_R a_j \mathbf{x}_j = \sum\nolimits_R d_j \left[1 + \exp(\mathbf{g}^T \mathbf{x}_k) \right] \mathbf{x}_j = \sum\nolimits_S d_j \mathbf{x}_j$$

holds.

Unit response is treated as a second phase of random sampling with Poisson (independent) selection.

The value $p_k = p(\mathbf{g}^T\mathbf{x}_k) = 1\Big/\left[1 + \exp(\mathbf{g}^T\mathbf{x}_k)\right]$ implicitly estimates the probability that k is a respondent.

Although this is a logistic function, the solution is neither maximum-likehood nor quasi-maximum likelihood.

When $\mathbf{x}_k$ is composed of class-membership indicators, this is the same as the weighting-class-adjustment estimator.

The Nonresponse Models for DAWN

Separate models for, 1, the combined 13 oversampled *metro* areas and, 2, the *remainder* sample.

Determined using SUDAAN'S WTADJUST

Since response is assumed to be Poisson, we ignore the strata and treat sampling as if it were with replacement.

PROC WTADJUST DESIGN = STRWR; CLASS DOMAIN;

ADJUST = NONRESPONSE ; NEST _ONE_; WEIGHT D;

LOWERBD 1; CENTER = 2;

MODEL RESPONDENT = *the* **x** *variables* (including DOMAIN)

Any CENTER > 1 produces the same nonresponse-adjusted weights.

For metro (**x**-*variables*):

DOMAIN

(effectively dummy variables for each of the 13 metropolitan areas)

dummy for a public hospital

log of the American Hospital Association (AHA) *er* visits

interaction between dummy for one area and log of AHA *er* visits

log of the population density within the zipcode

METRO RESULTS

	Beta Coeff.	SE Beta	Lower 95% Limit Beta	Upper 95% Limit Beta	T-Test B=0	P-value T-Test B=0
Intercept	-4.85	2.08	-8.94	-0.76	-2.33	0.0203
DOMAIN						
1	2.18	1.09	0.05	4.32	2.01	0.0450
2	3.14	1.15	0.87	5.41	2.72	0.0069
3	3.13	1.05	1.07	5.18	2.99	0.0030
4	1.39	1.10	-0.77	3.55	1.27	0.2058
5	2.87	1.07	0.76	4.98	2.68	0.0077
6	3.74	1.17	1.44	6.04	3.19	0.0015
7	3.08	1.15	0.82	5.33	2.68	0.0076
8	3.60	1.09	1.46	5.74	3.31	0.0010
9	2.05	1.13	-0.18	4.27	1.81	0.0716
10	2.94	1.07	0.84	5.05	2.75	0.0063
11	4.23	1.20	1.87	6.59	3.53	0.0005
12	3.83	1.17	1.53	6.12	3.28	0.0012
13	0.00	0.00	0.00	0.00	.	.
LOG(SIZE)	0.46	0.21	0.06	0.87	2.25	0.0251
PUBLIC	-2.25	0.48	-3.20	-1.31	-4.70	0.0000
PUBL × DOM 13	3.65	1.36	0.98	6.32	2.69	0.0076
LOG(DENSITY)	-0.32	0.14	-0.60	-0.05	-2.32	0.0210

Wald F for DOMAIN: 2.69 P-value: 0.0017

WTADJUST creates for every respondent:

ADJFACTOR which is $1 + \exp(\mathbf{g}^T \mathbf{x}_k)$ here

WTFINAL which is $a_k = d_k [1 + \exp(\mathbf{g}^T \mathbf{x}_k)]$ here

The former needs to be renamed before proceeding.

Calibration Weighting for Variance Reduction

Following Kott (2011), we set the final weights at

$$w_k = a_k \frac{\ell_k (u_k - 1) + u_k (1 - \ell_k) \exp(B_k [a_k - 1] \mathbf{h}^T \mathbf{z}_k)}{(u_k - 1) + (1 - \ell_k) \exp(B_k [a_k - 1] \mathbf{h}^T \mathbf{z}_k)},$$

where $\mathbf{z}_k$ is a vector of the respondent's characteristics known for the entire frame , and $\mathbf{h}$ is determined so that the calibration equation $\sum_R w_j \mathbf{z}_j = \sum_U \mathbf{z}_j$ holds.

$[a_k - 1]\mathbf{z}_k$ is an *instrumental variable* in an instrumental-variable calibration.

This is asymptotically equivalent to pseudo-optimal calibration.

The weights were computed using SUDAAN 11’s WTADJX.

We set a **lower bound** of 1 on the weights themselves (with LOWBD 1/*A*; *A* being the nonresponse-adjusted weight);

And an **upper bound** on each hospital’s weighted number of AHA *er* visits (so that WTFINAL * SIZE ≤ MAX).

SIZE = Number of AHA *er* visits

MAX = bound for the weighted number of AHA *er* visits

The **z**-vector was chosen by fitting a linear model for drug-related *er* visits using PROC REGRESS and ignoring the strata.

We keyed on *drug-related visits*/*frame visits* as a function of variables.

PROC WTADJX DESIGN = STRWR ADJUST = POST ;

NEST _ONE_; WEIGHT *A*;

LOWERBD 1/*A*; CENTER 1 /* the default */ ; [requires some removing]

UPPERBD *U* /* U = MAX/(A*SIZE) */ ;

MODEL RESPONDENT = (*A*-1) × *the* **z** *variables*/NOINT;

CALVARS *the* **z** *variables*/NOINT;

POSTWGT *the frame totals for the* **z** *variables*;

For metro (**z**-*variables* – regression variables × size):

size × dummy variables for each of the 13 metropolitan areas

size × dummy for a public hospital

size × dummy for a public hospital × each of two area dummies

size × log of size

size × log of size × each of three area dummies

size × log of zipcode density

1

No intercept.

Variance Estimation

By ignoring the regression-like effect of nonresponse adjustment, this simpler and reasonably good estimator for the variance can be deduced:

$$\tilde{v}(t_y) = \sum_{h=1}^{H} \frac{n_h}{n_h - 1}\left(1 - \frac{n_h}{\tilde{N}_h}\right)\left[\sum_{k \in R_h} (w_k e_k)^2 - \frac{\left(\sum_{k \in R_h} w_k e_k\right)^2}{n_h}\right],$$

where $e_k = y_k - \mathbf{z}_k \left(\sum_R a_j [a_j - 1] \mathbf{z}_j \mathbf{z}_j^T\right)^{-1} \sum_R a_j [a_j - 1] \mathbf{z}_j y_j,$

n_h is the *original* sample size in stratum h, and $\tilde{N}_h = n_h \frac{\sum_{R_h} w_k (size_k)^2}{\sum_{R_h} w_k^2 (size_k)^2}.$

Concluding Remarks

WTADJUST makes complex weight adjustment for nonresponse easy.

The DAWN has many survey variables, not just US-level drug-related *er* visits. This can make the prediction model shakey, especially at the domain level.

That is why we approximate quasi-optimal calibration with the new WTADJX – but we can bound weights without it.

With some work (i.e., after returning the nonrespondents to the data set with their instrument values set to zero) SUDAAN 11 will be able to compute $\tilde{v}(t_y)$.