Online Appendix – Discussion of residual confounding with indirect standardization

Indirect standardization, rather than direct standardization, is used to compare HAI data because the low number of observed events (infections) makes direct standardization infeasible. Indirect standardization consists of the following steps:

1. Divide the population to be standardized into strata. For example, CLABSI data are stratified by ICU type within hospitals.
2. Calculate the expected number of infections within each stratum: multiply the number of observed units (e.g. central line-days (CLD) for CLABSI) by a standard rate obtained from a reference population (e.g., the national CLABSI rate for that ICU type).
3. Calculate the SIR:
    a. Sum the observed number of infections in each stratum,
    b. Sum the expected number of infections in each stratum, and
    c. Divide observed (a) by expected (b).

	Reference	Hospital 1				Hospital 2			
ICU type	**Rate**	**# CLD**	**# observed CLABSI**	**Observed rate**	**# expected CLABSI**	**# CLD**	**# observed CLABSI**	**Observed rate**	**# expected CLABSI**
Medical	0.1	100	20	0.2	10	900	180	0.2	90
Surgical	0.8	900	180	0.2	720	100	20	0.2	80
Total		1000	200		730	1000	200		170
SIR		200 / 730 = 0.27				200 / 170 = 1.18			

(CLD = central line days; CLABSI = central line-associated blood stream infection)

The table above shows an example of residual confounding caused by differences in the distribution of observed units (central line-days, or CLD) within strata (ICU type) of two hypothetical hospitals. Although the observed infection rates are identical for each ICU type in both hospitals (0.2) the SIRs are dramatically different (0.27 vs. 1.18). Thus, a comparison of the SIRs between these two hospitals gives biased results, suggesting that Hospital 2 has a higher infection rate than Hospital 1. This type of residual confounding is sometimes called *shifting base distortion*.[1]

It is important to note that bias from shifting base distortion occurs only when the distribution of units among strata differs markedly between the hospitals for which SIRs are compared. If the distribution of units is similar in hospitals, then the SIR will not yield a comparison biased by shifting base distortion. (However, other sources of bias, such as unmeasured confounders due to differential comorbidity and differential severity of illness may still exist.)

[1] Rothman KJ, Greenland S, Lash TL. Modern Epidemiology. Philadelphia: Wolters Kluwer / Lippincott Williams & Wilkins; 2008.