JOHNS HOPKINS
UNIVERSITY

Standardization

Stan Becker, PhD
Bloomberg School of Public Health

Purpose of Standardization

- *Purpose of Standardization*—Procedure of adjustment of crude rates to eliminate from them the effect of differences in population composition with respect to age and/or other variables

Continued

Purpose of Standardization

- This is necessary because:
  - Rates are affected by the demographic composition of the population for which they are calculated
  - Age composition is a key factor affecting crude rates

Continued

Purpose of Standardization

- For purpose of comparison of rates over time or from area to area, it is important to determine the difference between the rates after taking into account the differences in the composition of the populations
- Adjusted rates have no direct meaning in themselves; they must be compared with the original crude rates or with other adjusted rates using the same standard

Notation

- r_i = Rate for ith group in study population

  n_i = Number of persons in ith group in study population

  n = Total number of persons in study population = $\sum n_i$

  p_i = Proportion of persons in ith group in study population = n_i/n = weight

  e = Number of events in study population = $\sum r_i * n_i$

Continued

Notation

R_i = Rate for ith group in standard population

N_i = Number of persons in ith group in standard population

N = Total number of persons in standard population = $\sum N_i$

P_i = Proportion of persons in ith group in standard population = N_i/N = weight

C = Crude rate in standard population

Direct Standardization

- Simplest and most straightforward technique
- Provides the best basis for determining the difference between two crude rates
- The rates from two or more study populations are applied to a common population distribution (standard population)

Continued

Direct Standardization

- Often directly standardized rates are calculated for a series of populations using the same standard
- The series could be the same population at different time points

Standard Population

- *Standard Population*—The standard population can be any one of the study populations, their average, or any other population distribution; the choice of the standard is arbitrary

Continued

Standard Population

- If one of the populations is chosen, its crude rates = its standardized rates
  - The rates from the other study population(s) are applied to the distribution of the standard
- If the average is chosen, the rates from each study population are applied to that new standard population

Direct Standardization

Formulas

$$DSDR = \sum r_i P_i = \frac{\sum r_i N_i}{N} = \frac{\sum r_i N_i}{\sum R_i N_i} * \frac{\sum R_i N_i}{N} =$$

$$= \frac{\text{expected events in study population}}{\text{actual events in standard population}} * C =$$

$$= \text{comparative mortality figure (CMF)} * C$$

Direct Standardization

- *Example*—Direct Standardization Birth Rate (DSBR) of Mauritius Island's (M.I.) 1985 crude birth rate using Mali's 1987 data as standard

Direct Standardization of Mauritius Island:

Age group	(Study) Rates M.I. per 1000	(Standard) Population Mali	Expected number of births, M.I.
15-19	18	725719	13063
20-24	58	574357	33313
25-29	57	536226	30565
30-34	36	443702	15973
35-39	19	379184	7204
40-44	6	325824	1955
Total		2985012	102073

Total number of births, Mali:		375117
Total number of births, M.I.:		18247
CBR Mali:	48.7	
CBR M.I.	18.5	

Source: U.N. Demographic Yearbook *1986, 1992, and 1996*

Direct Standardization

$$DSBR^{M.I.} = \frac{\text{Expected births in M.I.}}{\text{Actual births in Mali}} * CBR_{Mali}$$

$$= \frac{102073}{375117} * 48.7 = 13.3$$

Source: U.N. Demographic Yearbook *1986, 1992, and 1996*

Indirect Standardization

- *Indirect Standardization*—The rates from a standard population are applied to the distribution of one or more study populations
- Choice of standard rates is up to the demographer

Indirect Standardization

Formulas

$$IDSR = \frac{e}{\sum_i R_i * n_i} * C = \frac{\sum_i r_i n_i}{\sum_i R_i n_i} * C =$$

$$= \frac{\text{actual events in study population}}{\text{expected events in study population}} * C =$$

= standardized mortality ratio (SMR) * C

Indirect Standardization

Standard Mortality Rate (SMR)

- Notes on SMR:
  - The absolute value of the standardized mortality ratio depends on the chosen set of standard rates
  - SMR has no meaning by itself—it should be compared with other SMRs (relative values indicate higher or lower standardized incidences of events)

Indirect Standardization

Crude Birth Rate

- *Example*—Indirect Standardization Birth Rate (ISBR) of Mauritius Island's (M.I.) 1985 crude birth rate using Mali's 1987 data as standard

Indirect Standardization of Mauritius Island:

Age group	(Standard) Rates Mali per 1000	(Study) Population M.I.	Expected number of births, M.I.
15-19	79	105764	8355
20-24	159	109914	17476
25-29	171	94576	16172
30-34	140	81144	11360
35-39	107	60063	6427
40-44	50	45825	2291
Total		497286	62082

Total number of births, Mali:	375117
Total number of births, M.I.:	18247

CBR Mali:	48.7
CBR M.I.	18.5

Source: U.N. Demographic Yearbook *1986, 1992, and 1996*

Indirect Standardization

Formulas

$$ISBR^{M.I.} = \frac{\text{Observed births in M.I.}}{\text{Expected births in M.I.}} * CBR_{Mali}$$

$$= \frac{18247}{62082} * 48.7 = 14.3$$

Source: U.N. Demographic Yearbook *1986, 1992, and 1996*

Indirect Standardization

- Indirect standardization can be deceptive
- It is to be used if:
  - There are no rates available for study populations, i.e., only counts available
  - Rates for study populations are not reliable because of small numbers of events or population

Continued

Indirect Standardization

- *Example*—Comparison of crude and indirectly standardized rates for four populations, using England and Wales or Mexico as standard

Continued

Indirect Standardization

Study Population	CDR 1962		Indirectly standardized rates England and Wales		Mexico	
	Rate	Rank	Rate	Rank	Rate	Rank
Czechoslovakia	10.38	3	12.27	1	8.97	2
Iceland	14.78	4	22.84	3	13.52	4
Poland	8.15	1	14.35	2	8.56	1
Thailand	9.15	2	23.90	4	10.49	3

Continued

Indirect Standardization

- *Example*—Comparison of directly and indirectly standardized crude death rates for four countries, using the U.S. population and crude death rate as standard (U.S. CDR = 8.75)

Continued

Indirect Standardization

Country	Crude	Standardized Death Rates Direct	Indirect	CMF	SMR
Kuwait	5.15	11.7	13.64	1.34	1.56
New Zealand	7.93	9.16	9.13	1.04	1.04
Singapore	5.18	9.46	9.10	1.07	1.05
Sri Lanka	6.00	11.6	11.80	1.27	1.34

Comparing the Two Methods

$$DSDR = \sum_i r_i * \left[N_i \Big/ \left(\sum_i R_i * N_i \right) \right] * C$$

$$IDSR = \sum_i r_i * \left[n_i \Big/ \left(\sum_i R_i * N_i \right) \right] * C$$

Continued

Comparing the Two Methods

- In direct standardization, the weights are constant across study populations
- In indirect standardization, the weights (n_i) are influenced by the distributions of the study populations

Exercise

Direct and Indirect Standardization

- Calculate directly and indirectly standardized crude death rates for populations one and two by using the standard population

	Population1		Population2		Standard Pop.	
Age group (i)	Rate (ri)	Prop. in group (ni/n)	Rate (ri)	Prop. in group (ni/n)	Rate (Ri)	Prop. in group (Ni/N)
1	30	0.8	32	0.3	20	0.6
2	15	0.2	16	0.7	35	0.4
CDR:	30*0.8+15*0.2=**27**		32*0.3+16*0.7=**20.8**		20*0.6+35*0.4=**26**	

You have 15 seconds to calculate the answer. You may pause the presentation if you need more time.

Source: Vital Statistics of the United States, *1989–1991*

Exercise Answer

Direct and Indirect Standardization

- The correct answers are as follows:

	Population 1	Population 2
Directly standardized crude death rate:		
	30*0.6+15*0.4=**24.0**	32*0.6+16*0.4=**25.6**
Indirectly standardized crude death rate:		
	(27/(20*0.8+35*0.2))*26=**30.5**	(20.8/(20*0.3+35*0.7)*26=**17.7**

Adjustment for Two Factors

Distribution of mongoloids and total live births by maternal age and birth order.

Maternal Age	Birth Order					Total
	1	2	3	4	5+	
<20	107	25	3	1	0	136
	230,061	72,2002	15,050	2293	327	319,933
20-24	141	150	71	26	8	396
	329,449	326,701	175,702	68,800	30,666	931,318
25-29	60	110	114	64	63	411
	114,920	208,667	207,081	132,424	123,419	786,511
30-34	40	84	103	89	112	428
	39,487	83,228	117,300	98,301	149,919	488,235
35-39	39	82	108	137	262	628
	14,208	28,466	45,026	46,075	104,088	237,863
40+	25	39	75	96	295	530
	3052	5375	8660	9834	34,392	61,313
Total	412	490	474	413	740	2529
	731,177	724,639	568,819	357,727	442,811	2,825,173

Adapted from Joseph L. Fleiss, Statistical methods for rates and proportions, Second Edition, John Wiley and Sons, Inc. 1981. Data from Stark and Mantel (1966)

Simultaneous Direct Adjustment

Incidence rates of discovered mongolism by maternal age and birth order

Maternal Age	Birth Order 1	2	3	4	5+	Crude Rate	Adjusted Rate
<20	46.5	34.6	19.9	43.6	0	42.5	30.4
20-24	42.8	45.9	40.4	37.8	26.1	42.5	39.9
25-29	52.2	52.7	55.1	48.3	51.0	52.3	52.2
30-34	101.3	100.9	87.8	90.5	74.7	87.7	92.9
35-39	274.5	288.1	239.9	297.3	251.7	264.0	270.3
40+	819.1	725.6	866.1	976.2	857.8	864.4	830.4
Crude rate	56.3	67.6	83.3	115.5	167.1	89.5	
Adjusted rate	92.3	91.2	85.1	92.7	75.5		88.0

Adapted from Joseph L. Fleiss, Statistical methods for rates and proportions, Second Edition, John Wiley and Sons, Inc. 1981. Data from Stark and Mantel (1966)

Summary

- Both methods of adjustment are used, but it is preferable to use the direct method (when possible)
- An adjusted rate has no meaning by itself; it is only used for purpose of comparison
- The direct and the indirect methods can lead to different interpretations: Be Careful