

**First Printing**  
**Errata as of December 9, 2004**  
**Biostatistical Methods: The Assessment of Relative Risks**  
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The following errors have been detected to date in the first printing. Many but not all of these errors were corrected in the second and later printings. The printing of your copy of the book can be determined by the lowest number on the line at the bottom of the copyright page (iv, not numbered).

I apologize to the reader for this inconvenience. In order to keep the cost down, I agreed to prepare the final camera ready copy, both typing and page layouts. This detracted from carefully proofing the text. All errors are mine. Since publication I and a graduate student have carefully re-read the entire text. Corrections are noted by page and line number, or relative to a referenced equation, example or problem number. Negative line numbers are counted from bottom of the page

Dedication page (missing): To my family.

p. 11, line -10: change "8.1 vs. 9" to "9 vs. 9.9".

p. 18, line 3 after (2.20). Change "Section 2.7.6" to "2.6.6".

p. 22, Example 2.2: Add group numbers 1 and 2 to the column headings in the right 2x2 table.

p. 23, 2 lines above (2.28), change " $\sigma^2$ " to " $\sigma_1^2$ ".

p. 26, 3rd line of Example 2.4: change " $\sigma_1^2$ " to " $\hat{\sigma}_1^2$ ".

p. 26, last line of Example 2.4: change "1.2166" to "1.0217".

p. 26, line 4, remove "\$,".

p. 26, line 3 above (2.43): change " $p =$ " to " $\mathbf{p} =$ ".

p. 26, (2.44): the numerator of the second term should be -1.

p. 27, line after (2.50): change "bounded by -1 to +1" to "contained within  $(0, \infty]$ ".

p. 30, line 1: change " $p =$ " to " $\mathbf{p} =$ ".

p. 31, (2.64): change the second "=" to "= log".

p. 36, (2.78), change "a" to "x" in 3 places.

p. 37, line -3: change "a consistent" to "an efficient".

p. 41, The paragraph following (2.91) should be reworded as follows:

It is also instructive to demonstrate this result as follows. Asymptotically, assume that  $n_1/N \rightarrow \xi$ ,  $n_2/N \rightarrow (1 - \xi)$ ,  $\xi$  being the sample fraction for group 1. Also, since  $m_1/N \xrightarrow{p} \pi$  and  $m_2/N \xrightarrow{p} (1 - \pi)$  under  $H_0$ , then from Slutsky's Convergence Theorem (A.45),  $\hat{E}(a)/n_1 \xrightarrow{p} \pi$  and  $\hat{V}(u)/n_1 \xrightarrow{p} (1 - \xi)\pi(1 - \pi)$ . Since  $a$  is the sum of *i.i.d.* Bernoulli variables, then  $a/n_1$  is asymptotically normally distributed. Then from Slutsky's Theorem (A.43) and (A.44),  $Z_u$  is asymptotically distributed as standard normal.

p. 44, line 1: Interchange  $X_u^2$  and  $X_c^2$ .

p. 51, the elements in the second row of the 2x2 following line 6 should have elements " $\alpha_1(1 - \pi_1)$ " and " $\alpha_2(1 - \pi_2)$ " rather than " $1 - \alpha_1$ " and " $1 - \alpha_2$ ".

- p. 55, Problem 2.4.3 should be reworded to read, “assuming  $m_1/N$  is small (close to zero).”
- p. 58, after (2.16) reword to read “Using Taylor’s expansion show that  $Z_g$  is asymptotically equal to the usual  $Z$ -test in (2.80). Hint: evaluate  $g(p_j)$  about the assumed common  $\pi$  under  $H_0$ .
- p. 59, line 6 of 2.12: remove comma.
- p. 59, (2.129): The numbers in the two columns should be interchanged.
- p. 63, line 7: Change “ $N = 1.645\sqrt{(0.3 \times 0.7)}/0.02$ ” to “ $N = (1.645/0.01)^2(0.3 \times 0.7)$ ”
- p. 64, line 1 of text: remove “and”.
- p. 65, line 2 of (3.9): Change “Fail to Reject: +” to “Fail to Reject: -”.
- p. 66, line 4: Change “ $\mu_1 - \mu_0 \neq 0$ ” to “ $\mu_1 - \mu_0 > 0$ ”.
- p. 74, first line after (3.42) replace entire line with "Since the marginal constraints are the same for the  $\eta_{ij}$  and the  $\eta_{0ij}$ , then"
- p. 82, (3.82): change “ $ARE(T, T)$ ” to “ $ARE(T, T)$ ”.
- p. 82, line -1: change “ $ARE(T, T)$ ” to “ $ARE(T, T)$ ”.
- p. 83, line 2 following the table display, change “ $ARE(T, T)$ ” to “ $ARE(T, T)$ ”.
- p. 83. In the table, the entries in the last column should be interchanged between the two rows, 0.34898 in row 1, 0.65102 in row 2.
- p. 84, line 4 of 3.3.3: change “2.0” to “1.5” and change “2.5” to “2.0”.
- p. 84, last line of 3.4.2: change “ $\xi_j$ ” to “ $\xi_i$ ”.
- p. 85, 3.5.2: change “ $Z$ ” to “ $\hat{\lambda}_1 - \hat{\lambda}_2$ ”.
- p. 91. In the last line of the display table in the middle of the page, for stratum 2, change “0.619” to “0.444”.
- p. 93, line 1 after (4.8): change the upper limit of summation from “s” to “K”.
- p. 97. In (4.27): change “S” to “K” and change “ $n_j$ ” to “ $N_j$ ” (5 instances each).
- p. 98. In the last 3 lines relating to the relative risk, change “0.188” to “0.044”; and change “0.68, 2.50” to “0.95, 1.79”.
- p. 99. In (4.29), in the denominator change “ $\varphi^{a_j}$ ” to “ $\varphi^i$ ”.
- p. 99. First line, last paragraph, change “A.5.2” to “A.5.3”.
- p. 101, line 4: change “ $\theta_S$ ” to “ $\theta_K$ ”.
- p. 102, line -4 of Table 4.3: In stratum 3 change “1.000” to “1.001”.
- p. 103, line 11 of program: Change “K=” to “\*K=” at the beginning of the line.
- p. 108, line 5 above (4.42): change “ $p_{xy}$ ” to “ $\rho_{xy}$ ”.
- p. 110, line 1 below first table, change “0.4554” to “0.4455”.
- p. 110, line 5 below first table, change “0.4554” to “0.4455” and change “-0.061” to “-0.059”.
- p. 113, line 5, change 334.706 to 34.706.
- p. 113, last line of first para, change "among females is less" to "among females is greater".
- p. 118, line -4 of Example 4.8: Change “4.8436” to “4.9657”.
- p. 118, line -3 of Example 4.8: Change “0.304” to “0.291”.

- p. 119, line 3 below (4.55): change “ $\theta \neq \theta_0$ ” to “ $\theta$  possibly unequal to  $\theta_0$ ”.
- p. 121, line 2: Change “1x(K-1)” to “(K-1)x1”.
- p. 122, line 4 of second paragraph: Change “rejection region” to “rejection region boundary”.
- p. 122, line 6 of second paragraph: Change “ $(\hat{\theta}_1 - \hat{\theta}_2)$ ” to “ $|\hat{\theta}_1 - \hat{\theta}_2|$ ”.
- p. 123, Example 4.10, second table: Change “log risk difference” to “risk difference”.
- p. 124, in (4.72), change the term in brackets “[ $n_{2j} - n_{1j} + \dots$ ]” to “[ $n_{2j} - m_{1j} + \dots$ ]”.
- p. 128, in (4.80), change the first “=” to “-”.
- p. 130, (4.94): change the r.h.s. from “ $\mathbf{G}^T \Sigma_0 \mathbf{G}$ ” to “ $\mathbf{G}^T \Sigma_0^{-1} \mathbf{G}$ ”.
- p. 132, in the expression for  $\hat{w}_{(RD)1}$ , change 0.40440 to 0.40449.
- p. 134, line 9: Change “(4.49)” to “(4.48)”.
- p. 136, line 1 below (4.107): change “ $\hat{V}_j$ ” to “ $\hat{V}_{0j}$ ” in two places.
- p. 136, line 1 below (4.109): change “ $\hat{V}_j$ ” to “ $\hat{V}_{0j}$ ”.
- p. 136, (4.111): change “ $w_{sj}$ ” to “ $w_{sj}^2$ ” in the three places in the display.
- p. 136, in (4.112) change “ $E(T_r | \theta_s)$ ” to “ $E(T_r)$ ”
- p. 138, In the numerical computation in Example 4.15, in the numerator change “(0.1×0.53 × 1.733)” to “(0.1×0.58 × 1.733)”.
- p. 142, (4.131): change “or” to “and”.
- p. 146, Section 4.10.1, line 5, change “*i.i.d.* observations” to “independent observations”.
- p. 148, third para beginning “A test of homogeneity”. On line 2 change  $\neq$  to  $>$ .
- p. 152, Table 4.9. In column headings, change “ $\hat{\mu}_\theta$ ” to “ $\hat{\mu}_\theta^{(1)}$ ”.
- p. 152, Table 4.9, change the log Odds Ratio in Stratum 3 from 1.000 to 1.001. Also change the  $\hat{\omega}_j^{(1)}$  in stratum 1 from 0.489 to 0.409.
- p. 156 (4.165), change “ $\tilde{w}_{gj}$ ” to “ $\tilde{w}_j$ ”.
- p. 156 (4.167), change “ $g'(\pi_j)^2$ ” to “ $g'(\pi_j)$ ”.
- p. 156 (4.169), In the last term in brackets on the right, change “ $g'(\pi_j)^2$ ” to “ $g'(\pi_j)$ ”.
- p. 159, in (4.179) denominator change  $\sum_{j=1}^2$  to  $\sum_j$
- p. 160, line 1 of 4.2.4: change “ $\pi_1$ ” to “ $\pi_{1j}$ ” and “ $\pi_2$ ” to “ $\pi_{2j}$ ”.
- p. 160, (4.181). In the denominator (the term in parentheses), change “ $j$ ” to “ $\ell$ ” in two places.
- p. 164, problem 4.8.4, at the end of the sentence, add the phrase “for the log odds ratio.”
- p. 179, line 1 below (5.26), delete “joint”.
- p. 182, Table 5.1: In the program, change “x=f” to “x=g” and vice versa.
- p. 185, (5.50): change the lower limit of summation from “3” to “2”.
- p. 190, line -2: change “[log  $\widehat{OR}$ ]” to “[log  $\widehat{OR}_C$ ]”.
- p. 192, first line of second paragraph, delete “=  $p_f - p_g$ ”. These quantities are defined differently elsewhere, as on p. 193.
- p. 197, in (5.83): change “ $\widehat{RR}_{C(MH)}$ ” to “ $\widehat{RR}_{A(MH)}$ ”.
- p. 199, line 1: change “ $\theta_{j\ell}$ ” to “ $\theta_j$ ”.

- p. 199, line following (5.91): change “ $\pi_{dj} = (\pi_{12j} + \pi_{21j})/2$ ” to “ $\pi_{dj} = \pi_{12j} + \pi_{21j}$ ”.
- p. 205, Problem 5.10.1, all the subscripts should read “ $12|z$ ” and “ $21|z$ ”.
- p. 206, last line, change “four strata” to “three strata”.
- p. 211, second equation from top, change “ $\mathcal{N}[\pi]$ ” to “ $\mathcal{N}[n\pi]$ ”.
- p. 217, lines 2-3: change “ $I(\hat{\alpha}) = 11.489$  and  $I(\hat{\beta}) = 5.3192$ ” to “ $\mathbf{I}(\hat{\theta})_{\hat{\alpha}} = 21.394$  and  $\mathbf{I}(\hat{\theta})_{\hat{\beta}} = \mathbf{I}(\hat{\theta})_{\hat{\alpha}\hat{\beta}} = 9.9048$ ”.
- p. 221, paragraph 2, line 1: Change “Section A.6.2” to “Section A.6.5”.
- p. 223, in (6.75): Change the numerator from “ $\sum_j (|a_{j..})$ ” to “ $(\sum_j |a_{j..})$ ”.
- p. 224, line -1: Change “.” to “= 0.”
- p. 227, there is a minor notation conflict. The  $\pi_{i1}$  on p. 227 has a different meaning from the  $\pi_{11}$  on page 226.
- p. 230, Section 6.6.3, line 6, change “ $L(\beta)$ ” to “ $\log L(\beta)$ ”.
- p. 235, (6.135): change “ $\tilde{\theta}_1$ ” to “ $\hat{\theta}_1$ ”.
- p. 236, paragraph 2 line 3: delete “values”.
- p. 238, Table 6.3: Change the second column heading from “ $\hat{\beta}^{(i)}$ ” to “ $\widehat{OR}^{(i)} = e^{\hat{\beta}^{(i)}}$ ”.
- p. 239. In (6.144), (6.145) and (6.146), change “ $d$ ” to “ $\partial$ ” except for the last term  $d\pi_2/d\alpha$  of the first line of (6.144).
- p. 239, problem 6.2.7 should be changed to read: "Show that these estimates yield the value zero for the score equations presented in problems 6.2.2 and 6.2.3."
- p. 242. Change (6.157) to

$$\hat{\beta} = \sum_j \left( a_j - \frac{m_{1j}n_{1j}}{N_j} \right) \left( \sum_l \frac{m_{1l}m_{2l}n_{1l}n_{2l}}{N_l^2(N_l - 1)} \right)^{-1} \quad ((6.157))$$

and change (6.158) to

$$V(\hat{\beta}) = \left( \sum_j \frac{m_{1j}m_{2j}n_{1j}n_{2j}}{N_j^2(N_j - 1)} \right)^{-1}. \quad ((6.158))$$

- p. 243, in 6.8.2 change “stratum specific” to “pair specific”.
- p. 255. line 1: Change “among females” to “among those with high SBP”.
- p. 258, line 6 (two places), line after (7.29) and in (7.30) change “ $\pi$ ” to “ $\pi_i$ ”.
- p. 261. Line -3, replace “exp” with “int”.
- p. 262, line -6, change “since it the” to “since it is the”.
- p. 262, line -10: change “-0.0895” to “-0.8905”.
- p. 266, line 2 of paragraph 2, change “ $\mathbf{x}$ ” to “ $\mathbf{X}$ ” in three places.
- p. 272, line 4 of 7.3.1.2: change “ $(p \leq q + r)$ ” to “ $(p = q + r)$ ”
- p. 274, (7.60): change “ $\mathbf{x}$ ” to “ $\mathbf{X}$ ” in two places.
- p. 274, line -1: change “ $\mathbf{x}$ ” to “ $\mathbf{X}$ ”.
- p. 275, (7.61): change “ $\mathbf{x}$ ” to “ $\mathbf{X}$ ” in two places.
- p. 281, (7.69) and (7.70): change “ $\overline{\pi}$ ” to “ $\widehat{\pi}$ ”

- p. 290, table in middle of page, on the line with " $X_1X_3$ " change "Group" to "Intensive Rx"
- p. 290, table at bottom of page: In the last column, the odds ratios for the intensive group are incorrect. Change "0.06213" to "0.15899" and change "0.05984" to "0.16999".
- p. 291, lines 3-4, change " $\widehat{OR}_{I:C|D=9} = (0.06213/0.91147) = 0.0682$ " to " $\widehat{OR}_{I:C|D=9} = (0.15899/0.91147) = 0.1744$ ".
- p. 291, lines 4-5, change " $\widehat{OR}_{I:C|D=10} = 0.0663$ " to " $\widehat{OR}_{I:C|D=10} = 0.1884$ ".
- p. 291, line 7: change " $\widehat{\beta}_{13}$  and  $\widehat{OR}_{D+1|I}$ " to " $\widehat{\beta}_{13}$ ; and in the conventional group  $\widehat{OR}_{D+1|C}$ ".
- p. 291, line 7, change " $\widehat{OR}_{D+1|I} = (0.05984/0.06213) = 0.963$ " to " $\widehat{OR}_{D+1|I} = (0.16999/0.15899) = 1.06919$ ".
- p. 303, line 15: Change "54 (69%)" to "54 (31%)".
- p. 305, 7.1.5: Change "with elements in" to "has elements as in".
- p. 307, 7.6.4. Add "Assume  $X_1$  is also a binary variable."
- p. 311, Problem 7.14.4, change A.193 to A.195.
- p. 314, 7.16, line 1: change "Section 7.5" to "Section 7.6".
- p. 319, (8.7): Change " $\partial$ " to " $d$ ".
- p. 326, line 2 after (8.38): change " $\widehat{r}$ " to " $r$ ".
- p. 331, line 4 above Example 8.4: Change "(8.26)" to "(8.25)".
- p. 341, line below (8.55): Change " $x$ " to " $X$ ".
- p. 344, line 2 below (8.57): Change "covariate" to "coefficient".
- p. 345, in Problem 8.2, replace A.8 with A.9.
- p. 350, 8.8.3: Change "(8.26)" to "(8.25)".
- p. 359, 2 lines above (9.26): change " $j$ th event is" to " $j$ th event time is".
- p. 363, line 3: change " $[t_{(j)}, t_{(j+1)}]$ " to " $(t_{(j)}, t_{(j+1)})$ ".
- p. 364, line -7: change "continuation probabilities ( $p_j$ )" to "continuation probabilities ( $q_j$ )".
- p. 365, line -1: change "proportions, is" to "proportions, such as".
- p. 366, the group labels in the table should be reversed.
- p. 368, line -6: change "follow-up at  $\tau_j$ ," to "follow-up at  $\tau_{j-1}$ ,".
- p. 369, 4 lines after (9.42): change "through the  $i$ th interval" to "through the  $j$ th interval".
- p. 372. In (9.46) replace the product with a summation.
- p. 394, line 5 of section 9.4.6.1, change " $[\tau_{j-1}, \tau_j]$ " to " $(\tau_{j-1}, \tau_j]$ ".

A point of clarification is necessary. For an event time, the interval should be closed right, so that on line 5 of Section 9.4.6.1, change  $A_j = [\tau_{j-1}, \tau_j)$  to  $A_j = (\tau_{j-1}, \tau_j]$ . Thus an observation at  $t_i = \tau_j$  has the associated value  $a_i = j$ . The problem then arises as to the appropriate interval for a censored observation. The convention is that a censored observation tied with the time of an event is considered to be at risk at that time, and then censored thereafter. Thus if an observation is censored at  $t_i = \tau_j$ , then that observation should have the associated value  $a_i = j + 1$ . This implies that the intervals for censored observations should be closed left  $A_j = [\tau_{j-1}, \tau_j)$ , so that the expression at

the bottom of the page for  $A_{K+1}$  applies. Then the likelihood in (9.98) results. Note that the distinction is irrelevant if no censored observations occur at the boundary of any intervals.

p. 395. In (9.98) the indicator functions should appear in the exponent, not as multipliers. The first expression should read

$$L(\boldsymbol{\theta}) = \prod_{i=1}^N \prod_{j=1}^{K+1} \left[ \left( 1 - \varphi_{0j}^{\exp(\mathbf{x}'_i \boldsymbol{\beta})} \right)^{\delta_i I_{\{a_i=j\}}} \right] \left[ \left( \varphi_{0j}^{\exp(\mathbf{x}'_i \boldsymbol{\beta})} \right)^{I_{\{a_i < j\}}} \right]$$

p. 417, line above (9.131): change “hazard” to “intensity”.  
p. 419, line 5: change “ $\pm b/2$ ” to “ $\pm b$ ”.  
p. 421, 2 lines above Example 9.11: change “hazard” to “intensity”.  
p. 425, line -9: change “37.9% reduction” to “55.5% increase”.  
p. 425, line -8: change “23.6% reduction” to “29.2% increase”.  
p. 442, line 1 after (9.212) replace “where  $\pi_{0j} = \lambda_0(t)dt$  and  $\pi_{j|\mathbf{x}} = \pi_{0j}^{\exp(\mathbf{x}'\boldsymbol{\beta})}$ ” with the following:

”where  $\pi_{0j} = \pi_{j|\mathbf{x}=\mathbf{0}} = 1 - \int_{\tau_{j-1}}^{\tau_j} \lambda_0(t)dt$  and  $\pi_{j|\mathbf{x}} = 1 - \int_{\tau_{j-1}}^{\tau_j} \lambda(t|\mathbf{x})dt$ ”.

p. 451, line 3 of A.1.3: Change “ $\sum_i y_i = \sum_i z_i = n\bar{y}$ ” to “ $\sum_i a_i y_i = \sum_i a_i z_i$ ”.

p. 456, (A.35): Change “ $\mathbf{G}(\mathbf{T})$ ” to “ $\mathbf{G}(\boldsymbol{\mu})$ ”.

p. 458. lines 3-4, change to read “Let  $t_n$  be a sequence of statistics such that as  $n \rightarrow \infty$

Change (A.43) to read

$$\sqrt{n}[(r_n + t_n) - (\rho + \mu)] \xrightarrow{d} \mathcal{N}(0, \sigma^2) \quad ((A.43))$$

Change (A.44) to read

$$\sqrt{n}(r_n t_n - \rho\mu) \xrightarrow{d} \mathcal{N}(0, \rho^2 \sigma^2). \quad ((A.44))$$

p. 458, last line: change “mean  $\mu$ ” to “mean 0”.  
p. 461. In (A.58), change  $\theta$  to  $\hat{\theta}$ .  
p. 465, 4 lines above (A.77): change “values  $\theta_0$ ” to “value  $\theta_0$ ”.  
p. 466, (A.80), change “ $\partial\ell(\theta)/\partial\theta$ ” to “ $d\ell(\theta)/d\theta$ ”.  
p. 466, in (A.82) change  $\mathbf{U}_i(\theta)$  to  $\mathbf{U}_i(\boldsymbol{\theta})$ .  
p. 467 in (A.85) change  $dy$  to  $dy_i$  in three places.  
p. 468, (A.94), line 2, change “ $E[U'(\theta)]$ ” to “ $E[-U'(\theta)]$ ”.  
p. 469, 1 line after (A.97), change “A.96” to “A.95”.  
p. 470, (A.108): change “ $= E\{[T - \mu_T(\theta)]U(\theta)\}$ ” to “ $= (E\{[T - \mu_T(\theta)]U(\theta)\})^2$ ”.  
p. 471, line -2 above (A.111): change “ $\partial$ ” to “ $d$ ” in two places.  
p. 474, (A.129), change “ $= -E$ ” to “ $= E$ ”.  
p. 478: The expression in (A.150) is repeated in the preceding text. Delete the expression from text.  
p. 479, line -2 above A.7.3: change “test.” to “tests.”.  
p. 481, paragraph 2, line 2: change “ $\boldsymbol{\theta}$ ” to “ $\theta$ ” in 4 places.

p. 482, line 4 above Example A.12: change “also be shown” to “also been shown”.

p. 485, (A.184): change “ $y|\mathbf{x}$ ” to “ $y_i|\mathbf{x}_i$ ” in 3 places in the right two expressions.

p. 486, line -1 above A.8.2: change “for observations” to “for all observations”.

p. 490, line -2 above A.9.1.2: change “information sandwich  $\widehat{\Sigma}_R(\widehat{\boldsymbol{\theta}})$ ” to “inverse information sandwich  $\widehat{\Sigma}_R(\widehat{\boldsymbol{\theta}})^{-1}$ ”.

p. 491, line -3 above (A.218): change “defined as” to “defined by”.

p. 493, line -8: change “ $C(\alpha)$  test subset” to “ $C(\alpha)$  test for a subset”.

p. 494, lines 2 and 4 of A.10.1: change “ $\mu$ ” to “ $\mu(\mathbf{x})$ ” in three places.

p. 498, in the second row of the table, second column, change the denominator for “ $1 - e^\varphi$ ” to “ $1 + e^\varphi$ ”.

p. 500, line -3 above A.10.4: change “ $N = 100$ ” to “ $df = 100$ ”.

p. 501, line -3: change “Section 6.5” to “Section A.6.5”.

Web Supplement: Chapter 9 Programs. Some programs, such as `nepha1c` use arrays within PROC PHREG. Older versions of SAS used expressions like “Array mhba (9) “ and statements like “`lmhba=log(mhba(j))`”. In later versions of SAS the (9) and (j) must be changed to {9} and {j}.