

## Appendix: Computation and interpretation of odds ratios in multinomial logistic regression

In the familiar context of 2x2 tables, and from a conceptual point of view, the odds ratio can be computed as follows:

$$OR = \frac{a \div b}{c \div d}$$

where  $a$ ,  $b$ ,  $c$ , and  $d$  are cell frequencies as shown below, with 2 levels of a predictor variable in rows 1 and 2, and 2 levels of a dependent variable (or outcome variable) in columns 1 and 2. (We are aware of the more commonly used computational formula,  $OR=(ad)/(bc)$ , but feel that the conceptual formula is more transparent in this context and, therefore, more instructive.)

	Column 1	Column 2
Row 1	$a$	$b$
Row 2	$c$	$d$

When there is only one predictor variable, the odds ratios produced by multinomial logistic regression can be computed in a similar fashion. To see how, let us return to the crosstabulation of Continent and Implant Preference:

Implant Preference in Grade IIIB Open Fractures

Continent	External Fixator	Reamed Nail	Non-reamed Nail
North America	80 $a_1$	50 $a_4$	100 $b_1 b_4$
Europe	40 $a_2$	15 $a_5$	20 $b_2 b_5$
Australia	10 $a_3$	6 $a_6$	3 $b_3 b_6$
Africa	20 $c_{1-3}$	1 $c_{4-6}$	4 $d_{1-6}$

Analysis of this table results in the following odds ratios. We can now compute these same odds ratios by substituting the appropriate frequencies into a modified version of the formula shown above:

$$OR_1 = \frac{a_1 \div b_1}{c_1 \div d_1} = \frac{8 \div 100}{20 \div 5} = 0.02 \quad OR_4 = \frac{a_4 \div b_4}{c_4 \div d_4} = \frac{50 \div 100}{1 \div 4} = 2.00$$

$$OR_2 = \frac{a_2 \div b_2}{c_2 \div d_2} = \frac{40 \div 15}{20 \div 5} = 0.67 \quad OR_5 = \frac{a_5 \div b_5}{c_5 \div d_5} = \frac{15 \div 20}{1 \div 4} = 3.00$$

$$OR_3 = \frac{a_3 \div b_3}{c_3 \div d_3} = \frac{10 \div 6}{20 \div 5} = 0.42 \quad OR_6 = \frac{a_6 \div b_6}{c_6 \div d_6} = \frac{6 \div 3}{1 \div 4} = 8.00$$

From these computations, it is clear that each of these odds ratios is computed relative to the final level of the predictor variable (**Africa** in this case), and relative to the final level of the dependent variable (**Non-reamed nail** in this case).

We then interpret  $OR_1(\text{North America})=0.02$  as North American surgeons are less likely to prefer external fixators over non-reamed nails when compared to surgeons in Africa. Similarly, North American surgeons are twice as likely ( $OR_2=2.00$ ) to prefer reamed over non-reamed nails when compared to surgeons living in Africa.

When there are 2 or more predictors, the odds ratios produced by the multinomial regression cannot be computed this way, because the regression partials out the effects of the other variables in the model. For the odds ratios in Table E-3, for example, the odds ratios for continent are corrected for fellowship training (i.e., the effect of fellowship training is partialled out) and the odds ratios for fellowship training are corrected for continent (i.e., the effect of continent is partialled out).

### Program Code For SPSS ver 10. Contrasts in Multinomial Logistic Regression

\* Comparisons included: Group 1: SA vs AF, Group 2: (AUS vs EUR, AUS vs AS, EUR vs AS) and Group 1 vs Group 2.

Numbering: AUS=1, EUR=2, AS=3, SA=4, AF=5, NA=6, all analyses relative to NA.

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cfracle BY continen
/CRITERIA = CIN(95) DELTA(0) MXITER(100) MXSTEP(5) LCONVERGE(0)
PCONVERGE(1.0E-6) SINGULAR(1.0E-8)
/MODEL
/test
    continen 0 0 0 1/2 -1/2 0;
    continen 1/2 -1/2 0 0 0 0;
    continen 1/2 0 -1/2 0 0 0;
    continen 0 1/2 -1/2 0 0 0;
    continen 1/3 1/3 1/3 -1/2 -1/2 0;

/INTERCEPT = INCLUDE
/PRINT = PARAMETER SUMMARY LRT .
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**Table E-1: Characteristics of the Respondents (N=444)**

Characteristic	No.	Percent
Age		
≤40 years	130	29.4
41-50 years	192	43.3
≥51 years	122	27.3
Gender		
Male	436	98.2
Female	8	1.8
Type of Practice		
Academic	266	60.0
Community	178	40.0
Supervise Residents	373	84.0
Trauma Fellowship	289	65.1
Volume of Tibial Shaft Fractures at Center		
<100/year	300	67.6
≥100/year	144	32.4
Proportion of Tibial Shaft Fractures Requiring Surgery		
<50%	85	19.1
≥50%	359	80.9
Continent of Practice		
North America	230	51.7
South America	65	14.7
Europe	56	12.7
Asia	20	4.5
Africa	34	7.7
Australia	39	8.7

**Table E-2: Predictors of Implant Preference in Closed Tibial Shaft Fractures, Using Non-reamed Nail as the Standard for Each Comparison**

Variable	External Fixator vs NRN OR	Plate vs NRN OR	IM Nail (Reamed) vs NRN OR
Closed Fracture (Low Energy)			
Continent	ID		
AUS/EUR/AS vs NA		0.85	0.18**
SA/AF vs NA		0.45*	0.31**
Closed Fracture (High Energy)			
Age			
<50 vs ≥50	ID	2.19*	2.24*
Continent			
AUS/EUR vs NA	ID	0.15*	0.20**
AS/AF/SA vs NA#	ID	6.43**	0.47*
Closed Fracture (Compartment Syndrome)			
Academic Practice	1.3*	0.27**	0.72*
Continent			
AUS/EUR vs NA	0.88	0.23**	0.33*
AS/SA/AF vs NA	4.74**	8.53**	0.77*

**Results from 3 different regression analyses.** ID=Insufficient Data (option was not chosen by respondents), OR=odds ratio, NRN=Non-reamed nail, AS=Asia, EUR=Europe, SA=South America, AUS=Australia, AF=Africa, NA=North America. \*P<0.01, \*\*P<0.001. All comparisons were made against non-reamed nails (OR=1.0). #The odds of a surgeon from Asia, Africa, or South America preferring a plate over a non-reamed IM nail is 6.43 times that of a North American surgeon. The null hypothesis is that there is no difference in preference between plates and non-reamed IM nails among surgeons from Asia, Africa, or South America compared to North American surgeons.

**Table E-3: Predictors of Implant Preference in Open Tibial Shaft Fractures, Using Non-Reamed IM Nails as the Standard of Comparison**

Variable	External Fixator vs NRN OR	IM Nail (Reamed) vs NRN OR
Grade I Open Fractures		
AUS/EUR vs NA#	0.10**	0.21**
AS/SA/AF vs NA	12.44**	0.21**
Fellowship Training	0.34*	2.04**
Grade II Open Fractures		
AUS/AS vs NA	8.33**	0.08**
SA/AF vs NA	3.21**	0.45*
EUR	0.45*	0.39*
Fellowship Training	0.31*	1.69*
Grade IIIA Open Fractures		
AUS/EUR vs NA	2.51**	0.22**
AF/SA vs NA	7.22**	0.39*
AS vs NA	10.53**	2.01**
Fellowship Training	0.32*	1.82*
Grade IIIB Open Fractures		
AUS vs NA	4.51**	1.42*
EUR vs NA	2.29**	0.62*
AS/SA/AF vs NA	15.03**	0.01**
Fellowship Training	0.42*	0.73*

**Results from 4 different regression analyses.** OR=odds ratio, NRN=Non-reamed nail, AS=Asia, EUR=Europe, SA=South America, AUS=Australia, AF=Africa, NA=North America. All comparisons were made against non-reamed nails (OR=1.0). \*P<0.01, \*\*P<0.001. #The odds of a surgeon from Australia or Europe preferring an external fixator over a non-reamed IM nail is 0.1 times that of a North American surgeon. The null hypothesis is that there is no difference in preference between external fixators and non-reamed IM nails among surgeons from Australia and Europe compared to North American surgeons.