

Chapter 37

Ordinal Scaling for Clinical Scores with Inconsistent Intervals (900 Patients)

General Purpose

Clinical studies often have categories as outcome, like various levels of health or disease. Multinomial regression is suitable for analysis (see Chap. 28). However, if one or two outcome categories in a study are severely underrepresented, multinomial regression is flawed, and ordinal regression including specific link functions may provide a better fit for the data.

Primary Scientific Questions

This chapter is to assess how ordinal regression performs in studies where clinical scores have inconsistent intervals.

Example

In 900 patients the independent predictors for different degrees of feeling healthy were assessed. The predictors included were:

Variable	2	fruit consumption (times per week)
	3	unhealthy snacks (times per week)
	4	fastfood consumption (times per week)
	5	physical activities (times per week)
	6	age (number of years).

This chapter was previously published in “Machine learning in medicine-cookbook 3” as Chap. 4, 2014.

Feeling healthy (Variable 1) was assessed as mutually elusive categories:

- 1 very much so
- 2 much so
- 3 not entirely so
- 4 not so
- 5 not so at all.

Underneath are the first 10 patients of the data file. The entire data file is in extras.springer.com, and is entitled “ordinalsaling”.

Variables					
1	2	3	4	5	6
4	6	9	12	6	34
4	7	24	3	6	35
4	3	5	9	6	30
4	5	14	6	3	36
4	9	9	12	12	62
2	2	3	3	6	31
3	3	26	6	3	57
5	9	38	6	6	36
4	5	8	9	6	28
5	9	25	12	12	28

First, we will perform a multinomial regression analysis using SPSS statistical software. Open the data file in SPSS.

Command:

Analyze....Regression....Multinomial Logistic Regression....Dependent: enter feeling healthy....Covariates: enter fruitt/week, snacks.week, fastfood/week, physicalactivities/week, age in years....click OK.

Parameter estimates								95 % Confidence interval for Exp (B)	
feeling healthy ^a		B	Std. Error	Wald	df	Sig.	Exp(B)	Lower bound	Upper bound
very much so	Intercept	-1,252	,906	1,912	1	,167			
	fruit	,149	,069	4,592	1	,032	1,161	1,013	1,330
	snacks	,020	,017	1,415	1	,234	1,020	,987	1,055
	fastfood	-,079	,057	1,904	1	,168	,924	,827	1,034
	physical	-,013	,056	,059	1	,809	,987	,885	1,100
	age	-,027	,017	2,489	1	,115	,974	,942	1,007

(continued)

Parameter estimates								95 % Confidence interval for Exp (B)	
feeling healthy ^a		B	Std. Error	Wald	df	Sig.	Exp(B)	Lower bound	Upper bound
much so	Intercept	-2,087	,863	5,853	1	,016			
	fruit	,108	,071	2,302	1	,129	1,114	,969	1,280
	snacks	-,001	,019	,004	1	,950	,999	,962	1,037
	fastfood	,026	,057	,212	1	,645	1,026	,919	1,147
	physical	-,005	,051	,009	1	,925	,995	,900	1,101
	age	-,010	,014	,522	1	,470	,990	,962	1,018
not entirely so	Intercept	2,161	,418	26,735	1	,000			
	fruit	,045	,039	1,345	1	,246	1,046	,969	1,130
	snacks	-,012	,011	1,310	1	,252	,988	,968	1,009
	fastfood	-,037	,027	1,863	1	,172	,964	,914	1,016
	physical	-,040	,025	2,518	1	,113	,961	,914	1,010
	age	-,028	,007	14,738	1	,000	,972	,959	,986
no so	Intercept	,781	,529	2,181	1	,140			
	fruit	,100	,046	4,600	1	,032	1,105	1,009	1,210
	snacks	-,001	,012	,006	1	,939	,999	,975	1,024
	fastfood	-,038	,034	1,225	1	,268	,963	,901	1,029
	physical	-,037	,032	1,359	1	,244	,963	,905	1,026
	age	-,028	,010	8,651	1	,003	,972	,954	,991

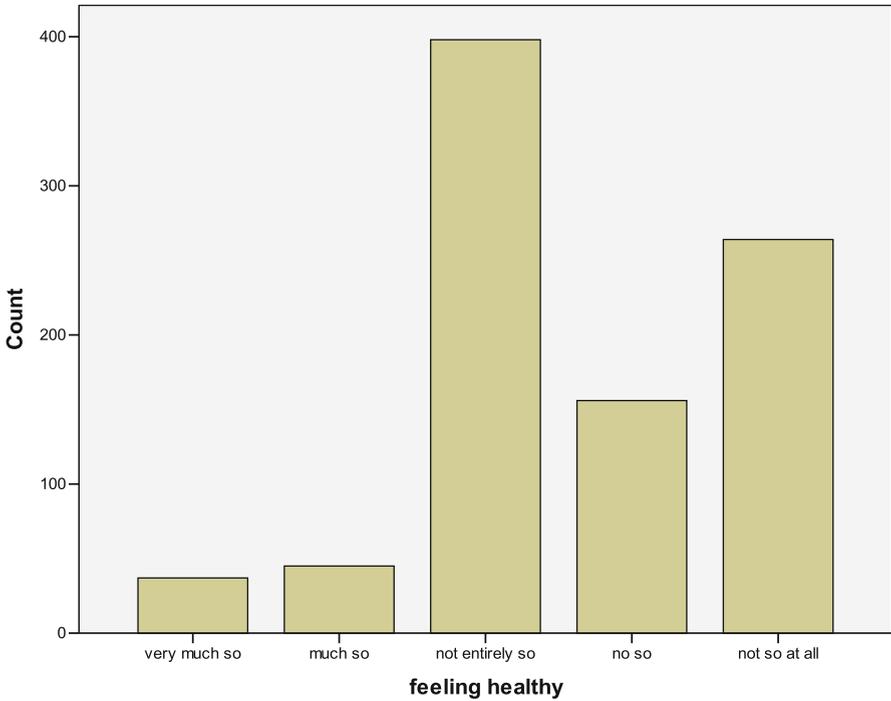
^aThe reference category is: not so at all

The above table gives the analysis results. Twenty-four p-values are produced, and a few of them are statistically significant at $p < 0.05$. For example, per fruit unit you may have 1.161 times more chance of feeling very healthy versus not healthy at all at $p = 0.032$. And per year of age you may have 0.972 times less chance of feeling not entirely healthy versus not healthy at all at $p = 0.0001$. We should add that the few significant p-values among the many insignificant ones could easily be due to type I errors (due to multiple testing). Also a flawed analysis due to inconsistent intervals has not yet been excluded. To assess this point a graph will be drawn.

Command:

Graphs....Legacy Dialogs....Bar....click Simple....mark Summary for groups of cases....click Define....Category Axis: enter "feeling healthy"....click OK.

The underneath graph is in the output sheet. It shows that, particularly the categories 1 and 2 are severely underrepresented. Ordinal regression analysis with a complimentary log-log function gives little weight to small counts, and more weight to large counts, and may, therefore, better fit these data.



Command:

Analyze....Regression....Ordinal Regression....Dependent: enter feeling healthy.... Covariates: enter fruit/week, snacks.week, fastfood/week, physicalactivities/week, age in years....click Options....Link: click Complementary Log-log....click Continue....click OK.

Model fitting information				
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	2349,631			
Final	2321,863	27,768	5	,000

Link function: Complementary Log-log

In the output sheets the model fitting table shows that the ordinal model provides an excellent fit for the data.

Parameter estimates								
		Estimate	Std. Error	Wald	df	Sig.	95 % Confidence interval	
							Lower bound	Upper bound
Threshold	[feelinghealthy = 1]	-2,427	,259	87,865	1	,000	-2,935	-1,920
	[feelinghealthy = 2]	-1,605	,229	49,229	1	,000	-2,053	-1,156
	[feelinghealthy = 3]	,483	,208	5,414	1	,020	,076	,890
	[feelinghealthy = 4]	,971	,208	21,821	1	,000	,564	1,379
Location	fruit	-,036	,018	3,907	1	,048	-,072	,000
	snacks	,004	,005	,494	1	,482	-,006	,013
	fastfood	,017	,013	1,576	1	,209	-,009	,042
	physical	,017	,012	1,772	1	,183	-,008	,041
	age	,015	,004	15,393	1	,000	,008	,023

Link function: Complementary Log-log

The above table is also shown, and indicates that fruit and age are significant predictors of levels of feeling healthy. The less fruit/week, the more chance of feeling healthy versus not health at all ($p=0.048$), the higher the age the more chance of feeling healthy versus not healthy at all ($p=0.0001$).

Conclusion

Clinical studies often have categories as outcome, like various levels of health or disease. Multinomial regression is suitable for analysis, but, if one or two outcome categories in a study are severely underrepresented, ordinal regression including specific link functions may better fit the data. The current chapter also shows that, unlike multinomial regression, ordinal regression tests the outcome categories as an overall function.

Note

More background, theoretical and mathematical information of multinomial regression is given in the Chap. 28.