Chapter 11
Predictions from Ordinal Clinical Data (450 Patients)

General Purpose

In Chap. 9 the typology of medical data was reviewed. Ordinal data are, like nominal data (Chap. 10), discrete data, however, with a stepping pattern, like severity scores, intelligence levels, physical strength scores. They are usually assessed with frequency tables and bar charts. Unlike scale data, that also have a stepping pattern, they do not necessarily have to have steps with equal intervals. Statistical testing is not of much interest. Statistical testing becomes, however, interesting, if we want to know whether two ordinal variables like levels of satisfaction with treatment and treatment outcome are differently distributed between one another. An interaction matrix of these two ordinal variables could then be used to test whether one treatment level performs better than the other. We should add that sometimes an ordinal variable can very well be analyzed as a nominal one (e.g., treatment outcome in the current Chap. and in Chap. 10).

Primary Scientific Question

This chapter assesses the relationship between five levels of satisfaction with the treating doctor, and, as outcome, five levels of quality of life (qol). Can an interaction matrix, otherwise called contingency table or crosstab, be used to assess whether some "satisfaction-with-treating-doctor" levels are associated with a better qol score than others, and to assess the directions of the differences in distribution of the variables.

T.J. Cleophas, A.H. Zwinderman, *Machine Learning in Medicine - a Complete Overview*, DOI 10.1007/978-3-319-15195-3_11

Example

In 450 patients with coronary artery disease the satisfaction level of patients with their doctor was assumed to be an important predictor of patient qol (quality of life).

treatment	counseling	qol	sat doctor
3	1	4	4
4	0	2	1
2	1	5	4
3	0	4	4
2	1	2	1
2	0	1	4
4	0	4	1
3	0	4	1
4	1	4	4
2	1	3	4

Treatment = treatment modality (1 = cardiac fitness, 2 = physiotherapy, 3 = wellness, 4 = hydrotherapy, 5 = nothing)
counseling = counseling given (0 = no, 1 = yes)
qol = quality of life score (1 = very low, 5 = vey high)
sat doctor = satisfaction with doctor (1 = very low, 5 = very high)

The above table gives the first 10 patients of a 450 patients study of the effects of doctors' satisfaction level and qol. The data are also used in the Chap. 16. The entire data file is in extras.springer.com and is entitled "qol.sav".

SPSS is used for analysis.

Command

Analyze….Descriptive Statistics….Crosstabs….Rows: enter "sat doctor"….Columns: enter "qol score"….click Statistics….mark Gamma, Somer's d, Kendall's tau-b, Kendall's tau-c….click Continue….click OK.

Sat with doctor * qol score crosstabulation							
Count							
		Qol score					Total
		Very low	Low	Medium	High	Very high	
Sat with doctor	Very low	11	12	12	11	4	50
	Low	24	16	23	28	15	106
	Medium	21	23	17	22	27	110
	High	18	16	15	32	36	117
	Very high	12	6	4	16	29	67
Total		86	73	71	109	111	450

The above matrix of observed counts is shown in the output sheets. Very high qol was frequently observed in patients who were very satisfied with their doctor, while

few patients with very high qol (only 4) had a very low satisfaction with their doctor. We wish to assess whether this association is chance or statistically significant.

"Ordinal x ordinal crosstabs" work differently from "nominal x nominal crosstabs" (Chap. 16). The latter compares the magnitude of the cells, the former compares the magnitude of the concordant and those of the discordant cells, whereby the concordant cells are, e.g., "very low versus very low", "low versus low", etc.

Directional measures

			Value	Asymp. Std. Error[a]	Approx T[b]	Approx Sig.
Ordinal by ordinal	Somers' d	Symmetric	,178	,037	4,817	,000
		Sat with doctor dependent	,177	,037	4,817	,000
		Qol score dependent	,179	,037	4,817	,000

[a]Not assuming the null hypothesis
[b]Using the asymptotic standard error assuming the null hypothesis

Symmetric measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx Sig.
Ordinal by ordinal	Kendall's tau-b	,178	,037	4,817	,000
	Kendall's tau-c	,175	,036	4,817	,000
	Gamma	,225	,046	4,817	,000
N of valid cases		450			

[a]Not assuming the null hypothesis
[b]Using the asymptotic standard error assuming the null hypothesis

The above tables are also in the output. The gamma value equals $\text{probability}_{\text{concordance}} - \text{probability}_{\text{discordance}}$, whereby the tied cells are excluded (the cells that have the same order of both variables). Somer's d measures the same but includes the ties. The measures demonstrate that the association of the two variables is closer than could happen by chance. A positive value means a positive correlation, the higher the order in one variable, the higher it will be in the other one. Tau b and c have similar meanings, but are more appropriate for data where numbers of categories between the two variables are different. Both directional and symmetry measures are statistically very significant. This means that high satisfaction levels with the treating doctors are strongly associated with high qol levels, and that low satisfaction levels are strongly associated with low qol levels.

Conclusion

We can conclude from this analysis that there is a statistically significant positive association between the qol score levels and the levels of satisfaction with the patients' doctors, can make predictions from the levels of satisfaction with the doctor about the expected quality of life in future patients, and could consider to recommend doctors to try and perform better to that aim. An interaction matrix, otherwise called contingency table or crosstab, can be used to assess whether treatment levels are associated with a better outcome score than others, and to assess the directions of the differences in distribution of the variables.

Note

More background, theoretical and mathematical information of crosstabs is given in Statistics applied to clinical studies 5th edition, Chap. 3, The analysis of safety data, pp 41–59, Edited by Springer Heidelberg Germany, 2012, from the same authors.