

A Mixture Model with Discrete Variables for Depression Diagnosis in Infertile Couples

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Introduction and motivation

Infertility is a major psychosocial crisis as well as being a medical problem. The factors that predict psychosocial consequences of infertility may vary in different gender, education level, socio-economic status.

- Psychological problems coexisted with infertility were associated with some serious medical conditions and poor treatment outcomes (Cwikel et al., 2004; Domar et al., 1993).
- In the last decade several researches indicated that levels of *depression* and *anxiety* are high in infertile women (Domar et al., 1992; Golombok, 1992; Domar et al., 1990; Wischmann et al., 2001).
- Infertility causes several serious social and psychological consequences such as personal distress, reduced self-esteem and loss of correct partner relationship (Schmidt, 2009).



Aim of the talk

The present study was designed to assess different aspects:

- introduce a statistical model proposed for the analysis of ordinal data that provides insights into the cognitive mechanism leading a person to answer given ratings;
- analyse Italian people who suffer from couple infertility and concentrate the attention on levels of depression and anxiety with investigation of the perception of these aspects in the couple;
- investigate an alternative model to analyse the actor/partner interdependence in case of categorical dyadic data respect to the current used methods (Kenny et al., 2006).



Design and data

Data stem from a survey conducted in medically assisted procreation centers in a period of about two years, from 2014 to 2016.

- The sample concerns 206 infertile couples who attended clinics for treatment of their infertility problems.
- The average age of the couples is 34 years.
- The 31.5% of the sample has a female infertility problem, in 27.7% of cases the lack of a child can be attributed to man. The 24.8% has a mixed diagnosis, however the 16.0% does not know the reason of the infertility.

The questionnaire included, among others, the following scales: Dyadic Adjustment Scale, the Edinburgh Depression Scale and the State-Trait Anxiety Inventory for the evaluation of the perceived levels of psychological disease. For further details, see Zurlo et al. (2017, 2018).



Status of depression

- The measurement of the status of depression has been performed by means of the [Edinburgh Depression Scale](#).
- It consists of 10 item on *Likert scale* to 4 categories (0 to 3).
- The recorded total score, therefore, is in a range between 0 and 30, with higher values that clearly indicate a more severe depressive symptomatology;

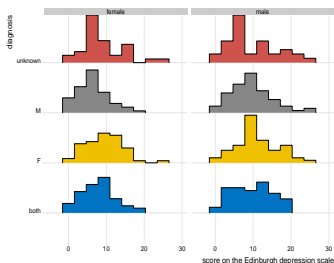


Figure 1 depicts the scores of the couples interviewed: the two columns refer to female (left) and male (right), while the rows correspond to the diagnosis.



Ordinal variables and association structure

The scores have been discretized into 5 equally spaced classes (5 indicates the worst depressive condition).

The assessment referred to dyad scores (Cook, 1998; Kenny et al., 2006) implies that they are nonindependent observations; thus, it is necessary to treat the dyad rather than the individual as the unit of the analysis (Kenny, 1995).

The nonindependence is determined by measuring the association between the scores of the dyad members which has been provided by means of

- The Pearson omnibus test (X^2), the row-means Cochran-Mantel-Haenszel test (Q_1^2), the 2-moment score test (X_2^2), and the 3-moment score test (X_3^2) are reported.

Approach	Test Statistic	Observed Value	df	p-value
Omnibus	X^2	42.019	16	0.000392
Restricted-Alternative	Q_1^2	10.098	4	0.038810
Relaxed-Null	X_2^2	20.945	8	0.007296
	X_3^2	26.660	12	0.008647



Modelling approaches

Background

- Commonly used statistical procedures (e.g., ANOVA and multiple regression), implemented for the analysis of this kind of data, assume independent (uncorrelated) observations in the dependent variable.
 - The scores of two linked individuals would be treated as if they were completely independent observations
 - or analysed as the sum or the average of the the two individual scores and treat it as a dyad score in the analysis.

Both approaches present the complain noted in Christensen and Arrington (1987).



Modelling approaches

Our proposal

- In the present talk we take both individual and dyadic factors into account by using a bidirectional view which would predict as each person influences the other.
- We treat the ordinal score of the partner as predictor variable (explanatory covariate) of the dependent Y of the other member of the couple.
- Actor effects are estimated controlling for partner effects and viceversa in two separate models obtained by means of the implementation of the CUB mixture (Piccolo, 2003).

The model allows to take into account the feeling and the uncertainty expressed by each member of the couple with respect to the depression status.



Modelling approaches

The mixture model

- The proposal is to model the ordinal response (rating) Y_i given by the i -th subject, $i = 1, \dots, n$, with respect to a given item l , on the basis of the two main components
 - The first component (C_1) related to the *feeling* is modelled by means of the shifted Binomial random variable.
 - The second one (C_2), concerning the *uncertainty*, is modelled by means of a discrete Uniform distribution over the support $\{1, \dots, m\}$, where the number of categories $m > 3$ for identification purposes.

Let $\theta = (\beta', \gamma')'$ be the parameter vector characterizing the distribution of (Y_1, \dots, Y_n) ; then, the mixture regression model has the following form:

$$Pr(Y_i = j \mid \mathbf{x}_i, \mathbf{w}_i, \theta) = \pi_i Pr(C_{1i} = j \mid \mathbf{w}_i) + (1 - \pi_i) Pr(C_{2i} = j), \quad (1)$$

for $i = 1, \dots, n$ and $j = 1, \dots, m$, where $\pi_i = \pi(\mathbf{x}_i, \beta) \in (0, 1]$ are introduced to weight the two components and $\mathbf{x}_i \in \mathbf{X}$, $\mathbf{w}_i \in \mathbf{W}$ include the covariates (sociodemographic, behavioural, medical variables) for the i -th subject.



Model based results

The 'best' estimated models are reported in Table. Here, the direction of the arrows indicates the effects (positive or negative) that the covariates exert on feeling component, in relation to depression.

Notice that that there are no significant covariates in estimating the component of uncertainty.

Response variable	Significant covariates	BIC index
Male depression [1]	Male anxiety ↑, Male diagnosis ↑, Female depression ↑	435.78
Male depression [2]	Male anxiety ↑, Female diagnosis ↓, Female depression ↑	439.03
Female depression [1]	Female anxiety ↑, Female education ↓, Male depression ↑, Male dyadic satisfaction ↑	512.82
Female depression [2]	Female anxiety ↑, Female work ↓, Male depression ↑, Male dyadic satisfaction ↑	521.10

Among the selected models for male and female depression, the Bayesian Information Criterion (BIC) suggests the choice of models marked with [1] for both the male and female ordinal variables.



Model based results

Male depression

It is appropriate to define risk profiles for infertile couples. They were defined, taking the significant covariates into account, as the odds of depressive risk for various kinds of partners.

- In the light of Male depression model [1] and [2], for an **anxious husband** (with a level of anxiety that takes the highest value of the *State-Trait Anxiety Inventory*) and who is married to a woman who has a **serious depressive disorder** (the value of the *Edinburgh Depression Scale* is maximum), the values of the parameter ξ_i in the case of male (*M_diag*) or female (*F_diag*) **diagnosis** are presented below:

$$\log(1 - \xi_{i[1]}) = \underset{(0.421)}{-4.448} + \underset{(0.142)}{1.256} \text{Anx}(max) + \underset{(0.194)}{0.559} M_diag + \underset{(0.079)}{0.192} F_dep(max) = 0.111$$

$$\log(1 - \xi_{i[2]}) = \underset{(0.419)}{-4.086} + \underset{(0.142)}{1.218} \text{Anx}(max) - \underset{(0.216)}{0.461} F_diag + \underset{(0.079)}{0.198} F_dep(max) = 0.212$$

- It is clear that, *ceteris paribus*, infertile men with the characteristics just described, have a higher probability of maximum depressive risk of 62.3% compared to those who do not have this problem.



Model based results

Female depression [1]

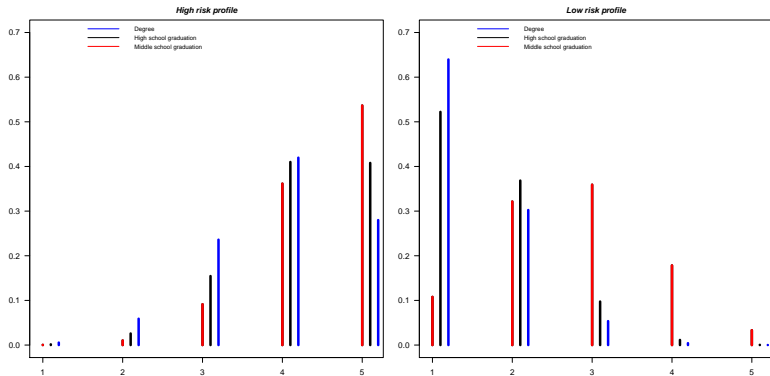
Component	Covariates	ML-estimates	Stand.errors	Wald-test
Feeling	Constant	3.760	0.738	5.098
	<i>Female anxiety</i>	-1.041	0.132	-7.866
	<i>Female education</i>	0.399	0.112	2.900
	<i>Male depression</i>	-0.221	0.084	-2.622
	<i>Male dyadic satisfaction</i>	-0.045	0.018	-2.506

- Starting from this model we have analysed some risks profiles.
- We calculated, as an instance, the probability that a woman with a slight level of anxiety, married to a man who has depression levels lower than national standards (validated by Edinburgh Depression Scale) and high level of satisfaction perceived into the couple, takes different modal value, when her degree of study changes.
- Other different profiles may be of course observed by varying the levels of covariates.



Model based results

Female depression [1] - profiles



It is clear the protective role deriving from cultural training. *As the level of education is high and, ceteris paribus, the less likely are the odds for an infertile woman to suffer from depressive disorders.* This aspect is also underlined for high risks profile (right panel of Figure).

General discussion and concluding remarks

- This article has presented and illustrated the implementation of a mixture model introduced for the analysis of rating as a means of conceptualising and measuring **interdependence** in close relationships, with a special focus on the assessment of bidirectional effects.
- **Interdependence** is measured by the partner effect, the extent to which one person's thoughts, feelings, or behaviour influence the thoughts, feelings, or behaviour of another person.
- These effects are present when the partner covariates for both members of a dyad are present and statistically significant.



General discussion and concluding remarks

There are other models of dyadic relationships that correspond to other forms of dyadic nonindependence.

- We presented some results which encourage the use of this approach. Specifically we measure the interdependence in the couple and weigh for the level of depressive symptoms associated also with other subjective characteristics.
- Data revealed that perceived levels of depression in each partner of infertile couples is significantly correlated to the development of depressive symptoms in the other member of the couple.
- The findings concerning a reciprocal influence in the development of depressive symptoms needs to be addressed as a significant risk factor in predicting infertile couples psychological health conditions, to define adequate intervention promoting well-being and psychological health in practices of reproductive medicine.



Open issues


Finally, studying other models of dyadic relationships that correspond to other forms of dyadic non-independence, among of the *open issue* we found:

- a possible comparison of the mainly used approaches
- the introduction of a new model based on the presented experience.

Thank you



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