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

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1. Introduction and motivation

Infertility is a major psycho–social crisis as well as being a medical problem. The factors that predict psycho–social consequences of infertility may vary in different gender, education level, socio-economic status. The primary purpose of this study was to investigate the relationship between socio-demographic characteristics and levels of depression and anxiety in infertile couples by exploring the role of each partner and of the related perceived levels of depression and of quality of dyadic adjustment.

The perception of depression and/or anxiety are typically evaluated through latent components. This paper analyses these components by means of a mixture model for ordinal rating responses, allowing for uncertainty in answering. In responding to rating questions, indeed, an individual may give answers either according to her/his feeling or to her/his level of indecision, typically motivated by a response style. Since ignoring the uncertainty may entail misleading results, we define the distribution of the ordinal responses via a mixture model which weights both components in answering. The study allows also to model the actor/partner interdependence in case of categorical dyadic data (Kenny et al., 2006) by presenting an alternative approach with respect to the current used methods.

The effectiveness of the model is attested through the analysis of a cross-sectional study of infertile couples. The research aims to test and to evaluate the effects that some aspects linked to the couple's relationship in infertile dyads have on depressive experience for both partners. It points out the role played by marital adjustment perceived by the wives in the definition of depressive symptoms of husbands, and vice versa. Specifically, the study is designed to measure *interdependence within interpersonal relationship*, that is when one person's emotion, cognition, or behaviour affects the emotion, cognition, or behaviour of the partner (see Kelley and Thibaut (1978), among others). One of the consequences is that observations of the two individuals are linked or correlated such that knowledge of one person's score provides information about the other individual's score.

2. The survey: 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 baby 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). The measurement of the status of depression has been performed by means of the second scale. 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. In particular *both*

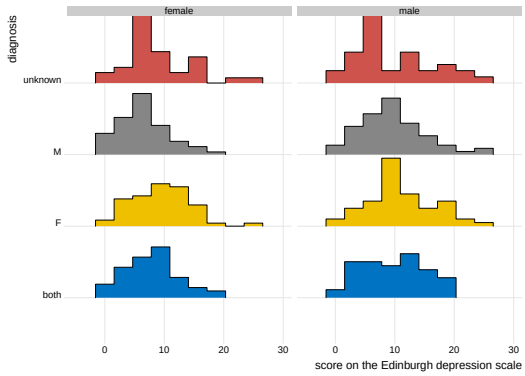

Figure 1: Score on the depression scale.

refers to the cases of mixed diagnosis, *unknown* to the case in which the reasons of the infertility are unknown, while *F* and *M* to the cases of female and male infertility, respectively. The scores have been discretized into 5 equally spaced classes (5 indicates *the worst* depressive condition) for the proposed mixture model. 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 presence of nonindependence is determinated by measuring the association between the scores of the dyad members which in this paper, has been provided by means of the tests in Table 1 referred to Lang and Iannario (2013). Here, 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.

Table 1: Tests of Independence for depressive condition in dyads

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

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. Consequently, 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 by presenting the complain noted in Christensen and Arrington (1987).

In the present paper 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. Thus, 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 uncertianty expressed by each member of the couple with respect to the depression status. The order of these two analyses does not matter. Couple is the unit of analysis, so the independence assumption is not violated. The interests are the magnitude of actor and partner effects in each analysis and their statistical significance. Notice that a partner effect for each partner must be statistically significant to support the hypothesis that influence is bidirectional. It may be tested by means of the common local tests of validation. Additionally, the model also includes other contextual variables or other factors that are not personal characteristics of either partner.

3. Model based results

The 'best' estimated models are reported in Table 2. 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. The latter can be considered as the result of a number of converging factors that summarize the interest/disinterest of respondents to the items considered. It is believed that the interviewed couples have replied with pleasure to the questionnaire, mainly with the objective to help future patients to understand and consciously address the difficulties related to a possible cycle of medically assisted procreation. Moreover, the presence of a specialized interviewer minimized the errors from lack of understanding of questions.

Table 2: Significant covariates for the feeling component

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 ↓,	*512.82*
	Male depression ↑, Male dyadic satisfaction ↑	
Female depression [2]	Female anxiety ↑, Female work ↓,	521.10
	Male depression ↑, Male dyadic satisfaction ↑	

The model for male depression [1] (in Table 2) explains male depression as a direct function of personnel anxiety, level of female depression and the situational variable (a dummy) concerning "male diagnosis" (male responsible for infertility). According to the latter variable, it is interesting to note that the estimated coefficient has a negative sign ($\gamma_2 = -0.559$), that is, the risk of depression in infertile men tends to increase when he finds out to be the cause of the lack of a son. Notice that the feeling is measured by $log(1 - \xi_i) = -\boldsymbol{x}_i\boldsymbol{\gamma}$ in the CUB model where $\boldsymbol{x}_i$ represents the information set extracted from the matrix $\boldsymbol{X}$ and $\boldsymbol{\gamma}$ is the parameter vector.

The second model for male depression [2] differs from the first one because of the presence of the situational variable (dummy) concerning "female diagnosis". The signs and the values of the estimated coefficients are almost the same, except for the dichotomous variable "diagnosis of infertility" ($\gamma_2 = 0.461$). The positive sign indicates, in fact, that the husband tends to be less depressed when he knows he is not the cause of infertility.

According to the estimated female model [1], the risk of female depression tends to increase if accompanied by a personnel anxiety component and a depressive situation in the partner. Furthermore, the perception of satisfaction for the latter directly influence the level of female depression, the less the husband is satisfied, the more the emotional life of the woman weakens. Model [1] emphasizes also the role of education for women: depression reduces with high qualified female; whereas model [2] indicates the significant role of job which reduces the perceived levels of depression.

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.

By further inspecting the female depression model [1] (estimation results for the feeling component are in Table 3), 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 (left panel of Figure 2; the opposite profile in the right panel). Other different profiles may be of course observed by varying the levels of covariates. In the selected profiles, it is

Table 3: Estimation results for the Female depression CUB model [1]

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

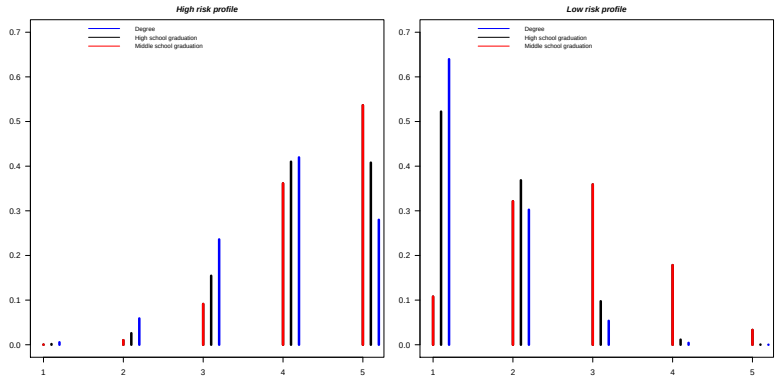

Figure 2: Risk profiles for female depression.

clear the protective role deriving from cultural training. For infertile women, *ceteris paribus*, a higher level of education corresponds lower suffering from depressive disorder. This aspect is also underlined for high risks profile (right panel of Figure 2). Finally, there are other models of dyadic relationships that correspond to other forms of dyadic non-independence. One of the aim for future researches is the comparison of the mainly used approaches and the the introduction of a new model based on the development of the presented experience.

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