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MODELING INTENTION OF HPV VACCINATION BY MEANS OF A CLASS OF MIXTURE MODELS FOR ORDINAL DATA

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Aim of the paper is to deal by means of a mixture model for the analysis of rating data several psychological factors which influence the decision process of vaccination achieved by mothers for their 12-year-old daughters. The psychological theoretical framework is the Health Action Process Approach (HAPA) model, which allows to investigate goal intention considering risk perception, outcome expectation, and self-efficacy. Specifically, the study intends to explore how these psychological factors plus knowledge, socio-demographic characteristics (job, religion, political orientation, education), and common practices contribute to develop the process of intention expressed on a Likert scale with $m = 5$ categories to the human papillomavirus (HPV) vaccine among mothers. By means of a sampling of 507 mothers, we analyze the level of intention performing a useful framework for data based on a discrete probabilistic model which takes into account both the discrete nature of the observed realizations and the composite nature of the score elicitation mechanism. Conclusion and interpretation are discussed.

Key words: HAPA model; HPV vaccination; Intention; Ordinal data; CUB models; Uncertainty.

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This paper sets out to investigate psychological factors which influence the decisional process of vaccination achieved by mothers for their 12-year-old daughters. Specifically, the study intends to explore how subjective characteristics (job, religion, political orientation, education), health psychological covariates of interest (knowledge, outcome expectations, risk perception, intentions, parental self-efficacy, and family efficacy), and common practices contribute to develop the process of intention to the HPV vaccine among mothers. Human papillomavirus (HPV) is a common infection that is sexually transmitted (Gottlieb et al., 2014). Although its appearance is transient and symptomless, it is a necessary precursor for the development of cervical cancer (Marek et al., 2011; Montgomery & Smith-Glasgow, 2012). Nowadays, cervical cancer is one of the most prevalent gynecological neoplasias (Forman, de Martel, & Lacey, 2012). Furthermore, the global prevalence of HPV is from 11 to 12% among women (Schwarz, 2008). For contrasting this infection, the most successful and primary prevention is vaccination, which should be implemented prior to first sexual intercourse (Garland & Smith, 2010). Specifically, World Health Organization (WHO; 2006) recommended immunizing pre-adolescent girls between 9 and 13 years old. In fact, 57 countries introduced HPV vaccine by 2013 (WHO, 2015). This vaccine has undergone important changes over the recent years, mostly due to the convergence of communication, information, and transformations of attitudes that have taken place both at scientific and socio-institutional level. Specially, in Italy vaccination is recommended but not obligatory and delivered free to girls before 12 years old (Italian Ministry of Health, 2014). The last Italian survey reported by Epicentro (2014), the site of epidemiology to public health, indi-

cated that a large number of girls were vaccinated (70.2%) when the promotion campaign was implemented. Meanwhile, only 54.1% of 12-year-old girls in 2014 completed the vaccine program. This suggests that it is happening a decreasing of vaccination in Italy, supporting a new emergency in considering the socio-demographic and psychological factors which could drive mothers to vaccinate their daughters. Moreover, these Italian levels are lower than female vaccination coverage rates in other countries (such as Australia, Portugal, and Great Britain), in which the vaccination programs are school-based (Kessels et al., 2012). In this respect, the sample analysis, which we report in this contribution, can be considered as the instrument for understanding psychological aspects which underline the process of changing, the level of intention, and the communication gap, inspiring a sense of belonging to information and representing a constitutive vehicle for the further policies. Specifically, in order to support the analysis of aspects which contribute to cover mothers' intention, we propose a study where a class of advanced statistical models (denoted as CUB models, that is, Combination of a discrete Uniform and a shifted Binomial random variable) has been explored. By means of a sampling, we analyze the level of intention performing a useful framework for data based on a discrete probabilistic model which takes into account both the discrete nature of the observed realizations and the composite nature of the score elicitation mechanism. The paper is organized as follows: in the next section, we propose the theoretical background by highlighting both the Health Action Process Approach (HAPA; Schwarzer, 2001) models and the statistical framework for the decision process rendering the mothers' intention on a latent trait into a rating. Then, illustration of data, the analysis, and the main results are presented. Finally, some concluding remarks are given.

THEORETICAL BACKGROUND

HAPA Model

Different researchers (for review, see Etter, Zimet, & Rickert, 2012; Fisher, 2012; Stupiansky, Alexander, & Zimet, 2012) previously found that among the common reasons for receiving or not the HPV vaccine there are risk perception, lack of vaccine awareness, personal consideration about safety and efficacy of the vaccine, lack of provider recommendation, and cost (Bakogianni, Nikolakopoulos, & Nikolakopoulo, 2010; Liddon, Hood, & Leichliter, 2012; Ratanasiripong, 2012). Starting from these considerations, a well-known model that could take into account these reasons for accepting or not HPV vaccine of daughters by their mothers could be HAPA model. This theory showed to be a good predictive framework for explaining several health behaviors, such as breast self-examination (Aikman, Doyle-Portillo, Verhaeghen, & Simmons, 2017; Luszczynska & Schwarzer, 2003), healthy eating behaviors (Godinho & Alves, 2017), food hygiene (Chow & Mullan, 2010) vaccine uptake (Payaprom, Bennett, Alabaster, & Tantipong, 2011), and specifically HPV vaccine (Caso, 2011). HAPA model affirms that the adoption, initiation and maintenance of health behaviors are developed through two phases: motivational and volition phases. The motivational phase is predicted by outcome expectations, risk perception, and perceived self-efficacy. In turn, these three construct influence goal intentions to carry out a determined behavior (Luszczynska & Schwarzer, 2003; Schwarzer, 2001). After the establishment of intention, individuals switch to the volitional phase, in which goal intention could be translated in action, developing planning intentions (Pestwich, Ayres, & Lawton, 2008; Sniehotta, Soares, & Dombrowski, 2011). In the present study we investigated the factors involved in the motivational phases, in order to investigate the roles of outcome expectations, risk perception, and self-efficacy in determining mothers' intention to vaccinate their daughters. Risk perception is considered as an influential but distal construct that is insufficient to produce a goal intention

itself. Outcome expectations play a decisive role in the motivation phase; they can be described as the personal evaluation about a balance of pros and cons of a specific behavioral outcome. Finally, self-efficacy is related to individuals' capability to perform a specific goal behavior. As previously discussed, these factors contribute to develop particular goal intentions. In the current study we selected a specific parental self-efficacy (Caprara, Regalia, & Scabini, 2001) which points at the efficacy perceived by parents (in this case, the mothers) in managing the various aspects of the relationship with their daughters, in depending on the specific task that they have during adolescence. In literature, few studies applied the HAPA model for explaining goal intentions in relation to vaccine uptake. For example, Ernsting, Gellert, Schneider, and Lippke (2013) found that risk perception, self-efficacy, and positive as well as negative outcome expectancies strongly predict intention to vaccination. Caso (2011) found that parental self-efficacy was the strongest predictor of mothers' intentions to vaccinate for HPV their daughter.

However, the large amount of data that can be detected through the use of a questionnaire that includes all the variables provided by the HAPA model has suggested the opportunity to develop and validate a more concise statistical model, which allows to make a selection of the most significant dimensions of the theoretical model applied to the intention to vaccinate, and to identify profiles of mothers based on their intention to vaccinate their daughters. This requirement has led to the implementation of one of the main model introduced for the analysis of ordinal data.

Statistical Model: Background, Notation, and Assumptions

From statistical point of view, our analysis deals with a class of models aimed at analyzing the behavior of respondents when faced to multiple assessments of *self-perception* (qualitative scores deriving from subjective scales). Motivations for these models stem by the awareness that two latent components move mood, cognition, and performance measure of the psychological process of selection among discrete ordered alternatives: attractiveness/repulsion towards the item and uncertainty/fuzziness in the process of response.

Both of them generate a stochastic mechanism in term of feeling which is an internal/personal movement of the subject (self-reported evaluation or perceived intention) towards the item and uncertainty pertaining to the final score. In other way, we may interpret the first as a true latent variable modified by measurement error and the second as a component of human decisions. Specifically, this second component includes absent-mindedness, short term memory, "satisficing" behavior (Simon, 1957), lack of interest towards the question and/or complexity of survey/questionnaire, the difficulty of the task, the ability of the respondent, his/her motivation, and so on.

The framework, denoted as CUB models and introduced by Piccolo (2003) and D'Elia and Piccolo (2005), subsumes a wide range of models proposed in the psychometric, econometric, (bio)statistical, and marketing literatures. It is also used to analyze how subjects' (individual) covariates affect self-perception to generate the assessment of intention in a context of health psychology (Zurlo, Iannario, & Piccolo, 2017).

Let Y_i be the response given by the i-th subject, $i = 1, 2, \ldots, n$, on the item I. Denoting the Uniform and shifted Binomial random variable distributions defined on the support $1, 2, \ldots, m$, for given m categories of response ($m > 3$), as U_j and $b_j(\xi_i)$, respectively, the probability mass distribution of the CUB mixture is:

$$Pr(Y_i = \boldsymbol{j} \mid x_i, w_i, \theta) = \pi_i\, b_j(\xi_i) + (1-\pi_i)\, Pr(U_j = \boldsymbol{j}),$$

for $i = 1, 2, \ldots, n$ and $j = 1, 2, \ldots, m$. Here, the first component concerns the distribution — a shifted Binomial random variable — which represents the feeling component (Iannario & Piccolo, 2012) and it is the discrete version over the support $1, 2, \ldots, m$ of a latent unimodal continuous variable. Instead, the second component — a discrete Uniform random variable — represents the probability distribution which allows to support the uncertainty concept because it is the extreme solution for a totally indifferent choice. Moreover, $\theta = (\beta', \gamma')'$ is the parameter vector characterizing the distribution of $(Y_1, Y_2, \ldots, Y_n)$, with β' and γ' denoting the parameter vectors for the uncertainty and feeling components, respectively.

Thus, we interpret opinions expressed by means of ratings (expressed evaluations) $(y_1, y_2, \ldots, y_n)$ as realizations of a weighted combination of a personal feeling and some intrinsic uncertainty. Specifically, $\pi_i = \pi(x_i, \beta) \in (0, 1]$ are introduced to weight the two components and $x_i \in X$, $w_i \in W$ include the selected covariates for the i-th subject. By introducing mother's characteristics, we relate parameters to subjects' covariates by means of the logit links:

$$logit(1 - \pi_i) = -\beta' x_i; \quad logit(1 - \xi_i) = -\gamma' w_i,$$

where x_i and w_i are the covariates of the i-th mother, suitable to explain π_i and ξ_i, respectively. If we don't have information concerning the covariates of the i-th subject, the parameters ($\pi_i = \pi$, $\xi_i = \xi$) specify the probability distribution of the response $Y_i = Y$ of the i-th subject. Thus, Y is a random variable defined over the support $1, 2, \ldots, m$, for a given m, whose probability mass distribution is:

$$Pr(Y = j \mid \theta) = \pi\, br(\xi) + (1 - \pi)1/m \qquad j = 1, 2, \ldots, m.$$

Since the model is well defined when $\pi \in (0, 1]$ and $\xi \in [0, 1]$, the parameter space is the (left open) unit square $\Omega(\theta) = \Omega(\pi, \xi) = \{(\pi, \xi): 0 < \pi \leq 1;\ 0 \leq \xi \leq 1\}$. Thus, it is immediate to relate parameters (π, ξ) to uncertainty and feeling components, respectively. Indeed, each respondent acts with a propensity to adhere to a thoughtful and to a completely uncertain question/issue, measured by π and $1 - \pi$, respectively. Specifically, we observe that $\pi \to 0$ implies a model with an almost totally uncertain selection of a category (a sort of random selection), whereas $\pi \to 1$ implies a severe reduction of this component; then, $1 - \pi$ expresses the weight of the uncertainty in the process of selection.

Instead, $1 - \xi$ may be interpreted as a measure of adhesion to the proposed item. The exact meaning of ξ changes with specific empirical contexts since ξ is related to the predominance of "unfavorable" responses (that is, lower than the midrange). High values of the responses usually imply high consideration/evaluation towards the item. Then, the quantity $1 - \xi$ increases with agreement towards the item. Similarly, assuming a positively worded item, when $\xi \to 0$ high values of the support are more likely whereas for $\xi \to 1$ the preferred selection of responses are on the low values of the support (see Iannario & Piccolo, 2012).

Furthermore, given that a CUB model is univocally defined by (π, ξ), each model may be depicted in the unit square by means of a point with coordinates $(1 - \pi; 1 - \xi)$, related to uncertainty and feeling, respectively, with a one-to-one correspondence between CUB models and those points. The graphical representation of each estimated model improves the interpretation of similarity, clusters, modification of patterns, atypical behaviors, and so on. For estimation purposes, given a sample of response $(y_1, y_2, \ldots, y_n)$ and the subjects' covariates x_i and w_i, for $i = 1, 2, \ldots, n$, asymptotically efficient estimates of the parameters may be obtained by maximum likelihood (ML) methods and a specific expectation-maximization (EM) algorithm (McLachlan & Krishnan, 1997; McLachlan & Peel, 2000) whose details can be found in Piccolo (2006).

Diagnostics and fitting of CUB models have been investigated by Iannario (2009). Specifically a test of deviance is generally implemented for selecting the best (nested) model as we present in this contribution. Another aspect which we have to consider concerns the determination of disparities among fitted and observed models merely caused by a *shelter* effect (concentration of answers/scores in a specific category). For the analysis of this aspect we propose an extension of standard CUB models (Iannario, 2012a) which includes a degenerate distribution and it may be implemented even with subjects' covariates.

CUB models have been further extended and generalized in several directions: to include objects' covariates (Piccolo & D'Elia, 2008), for instance, which measure the impact of the physical, chemical, and organoleptic characteristics of the item on uncertainty and feeling components. They are usually obtained by a samples of qualified assessors and/or technical instruments (blood pressure for classifying heart health status or in sensory analysis chemical compounds expressed by quantitative variables as sugar content, citric acid, total amount of poliphenols, and so on). Among others generalizations extensions to take hierarchical effects (Iannario, 2012b) and varying uncertainty into account (Gottard, Iannario, & Piccolo, 2016), to consider overdispersion (Iannario, 2014; Piccolo, 2015), to examine non-linear transition probabilities (Manisera & Zuccolotto, 2014a), don't know responses (Manisera & Zuccolotto, 2014b), and zero inflated categories (Iannario & Simone, 2017) have been introduced, among others. All the main functions concerning the implementation of CUB models are available in the R environment on the Comprehensive R Archive Network (CRAN) in the R package CUB (Iannario, Piccolo, & Simone, 2018).

METHODOLOGY

Participants

The participants are 507 mothers with at least one 12-year-old daughter (118 of them have already accepted to vaccinate their daughters) who have been contacted in a specific geographical area (Campania region, South Italy). Their socio-demographic characteristics are summarized in Table 1. Supplementary materials, available from the Authors under request, specify the missing values corresponding to the items and covariates analyzed in the paper.

Measures

A self-report questionnaire built specifically for this study has been analyzed. It includes several sections. Below we will present only those tools that are functional to the specific objectives of this study.

The *information and knowledge* possessed by the mothers were analyzed through a series of questions with the aim of detecting: if the interviewed mothers already knew the HPV virus, the new vaccine and the current vaccination campaign, and which were the sources of their knowledge (modality of dichotomous answer: *yes*, *no*); the satisfaction of the information received (mode of response from 1 = *none* to 5 = *very much*). Further questions on what was the right age to administer this type of vaccination (open answer modality), on the possibility of extending it also to males, and if it was fair to give information to adolescents before giving the vaccine (modality of dichotomous answer: *yes*, *no*).

TABLE 1
Socio-demographic data

Socio-demographic data	
Age	Between 28 and 56 years (M = 41)
Marital status	
Married	86.89%
Separated / Divorced	7.97%
Widow	0.51%
Cohabiting	3.86%
Single mother	0.77%
Religious orientation	
Practising Catholic	55.27%
Non-practising Catholic	36.25%
Atheist	4.11%
Other	4.37%
Political orientation	
Right	34.96%
Centre	17.73%
Left	24.16%
Apolitical	23.13%
Profession	
Businesswoman, freelancer	14.65%
Self-employed	8.42%
Employee, teacher	24.42%
Official, manager, doctor	3.08%
Blue-collar worker	16.71%
Housewife	11.31%
Unemployed	21.34%
Study title	
Elementary license (Primary)	4.63%
Middle	25.45%
Secondary-3: Professional school (two or three years after middle school)	10.80%
Secondary-5: High school diploma	45.50%
Degree	13.64%

The *intention* to have your daughter vaccinate or not have been measured with only one item. Mothers were asked to express their intention to have their daughters vaccinated against HPV in their near future (5-point scale, from l = *none* to 5 = *very much*).

The expectations regarding the outcomes deriving from the behavior under investigation were measured with the *outcome expectancies* scale relative to the HPV vaccine (Caso, 2011) consisting of six items with a 5-point response range (from 1 = *nothing* to 5 = *very much*). The items refer to the possible

positive and negative consequences of the practice of the anti-HPV vaccine. It consists of two dimensions that both show a good internal coherence (positive expectations: Cronbach's α .87; negative expectations: Cronbach's α .72).

The *perception of risk* in the sphere of sexual behaviors, referring to their adolescent daughters, has been measured through the scale for the perception of risk in the sphere of sexuality (Caso, 2011) consisting of four items (α = .92) that investigate the mother's perception of her daughter's exposure to sexually transmitted diseases (STD) risk, unwanted pregnancies, AIDS, and non-malignant lesions (5-point scale, from l = *none* to 5 = *very much*).

The *parental self-efficacy* of mothers was measured with the Parental Efficacy Scale perceived in the relationship with the children (Caprara et al., 2001) composed of 15 items (5-point scale, from l = *none* to 5 = *very much*. This scale measures the effectiveness perceived by mothers in managing the different aspects of the relationship with their daughter, according to the specific task that they have in the adolescent phase (α = .92).

At the end of the questionnaire a sheet was also attached to the socio-demographic data such as age, number and age of the children, marital status, religious and political orientation, the profession carried out, and the degree of study. The mothers who participated in the research were contacted through the school channel, after authorizing the manager of the school, inviting them through a letter to participation in the research. Only the mothers who gave their consent to the research were involved in the survey. The questionnaire, filled in anonymous form, was returned in a sealed envelope to guarantee privacy. The average compilation time was 30 minutes.

In the analysis, for the implementation of the main model based on HAPA variables, we decided to focus our attention only on some specific items (see Table 2) which have been selected because they are the most statistically significant.

TABLE 2
Selected items for the HAPA models

Positive outcome expectancies "I expect the HPV vaccine to be a primary prevention tool" *(Disease prevention)*
Negative outcome expectancies "I expect the HPV vaccine to be harmful to one's health" *(Contraindication)*
Risk perception "I think my daughter is exposed to the risk of papillomas, condylomata, and warts (non-malignant lesions)" (*Papilloma risk)*
Parental self-efficacy "How capable do you feel in talking to your child about your relationship and your mutual feelings?" *(Feelings/relationship)*

Analysis

In this section we first report some aspects concerning mother's covariates and then we concentrate the analysis on the statistical model performed on the HAPA issues. The first consideration concerns the study of the ordinal variable (to have the intention to do the vaccine to their daughters) which presents a

concentration of answers in the third category. Thus, we report both a plot of standard model and an implementation of the extension with *shelter* effect at 3 (Figure 1). Here, the observed relative frequencies (dots) and fitted probabilities (circles) are reported.

Indeed, we usually define as a shelter choice the category that receives an upward bias of preference with respect to the expected response of the maintained model. In this case, the structure of the scale shows higher concentration on intermediate level of response ($s = 3$) with respect to the values predicted from the model. It could be caused by high level of indecision expressed by the sample of respondents or alternatively to the absence of a *don't know* choice. A remarkable feature is that indecisive respondents choice the intermediate category (in our case, $Y = 3$) as a safe solution so that we have to consider the proportion induced by the estimated model, that is the probability $Pr(Y = 3|\Theta)$ as the result of two components: *structural indecision* derived by the estimated CUB distribution, and *shelter indecision* derived by *shelter* effect. We may also analyze the intention by considering some covariates. First, we report a description of respondents by implementing CUB models with varying age, education, and profession. For each cluster we fit separate CUB models and evaluate the increasing or decreasing level of mothers' intention (measured by the value of ξ parameter, specifically by $1 - \xi$). For the age variable (Figure 2) we perform two CUB models for mothers older than the middle age 41 years old (they present higher level of intention with a low level of uncertainty) and mothers younger than 41 (they show a lower level of intention by confirming low uncertainty in the choice). The analysis concerning education (left panel of Figure 3) shows a higher level of intention for mothers with a degree or high school leaving qualification.

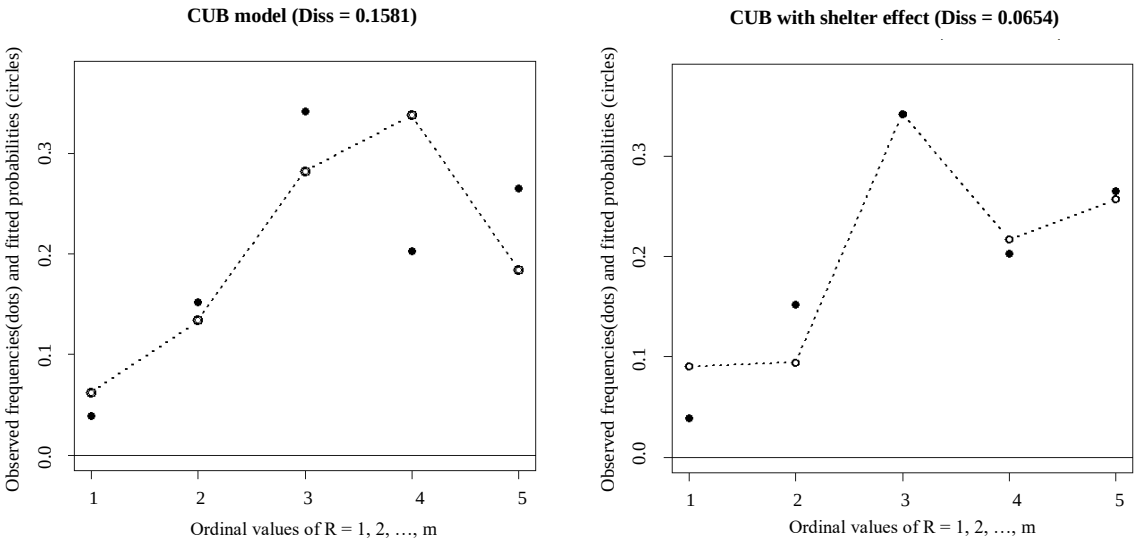

FIGURE 1
CUB without (left panel) and with *shelter* effect $s = 3$ (right panel) on *intention of vaccination*.

A different profile turns out to be for mothers with primary, secondary (five or three years) which express a lower level of intention. An interesting aspect concerns the level of uncertainty which is very low for mothers with degree and mother with only the primary license. Generally, the global level of intention is higher than the midrange (when $\xi = 0.5$). Same profile is confirmed if we analyze the occupation of women (right panel of Figure 3). By remembering that 33% of the sample do not get salary, we observe a higher intention for managers, teachers, and businesswomen, followed by unemployed, housewives, and

blue collars. The lowest intention for self-employed requests a higher information for the analysis of such modality. If we concentrate the attention on the religion (clustered in fourth groups: practicing catholic, not practicing, atheist, other) the implementation of CUB models (left panel of Figure 4) shows a higher level of intention to the vaccine for other and atheist (their responses present a low level of uncertainty, especially for atheist). The other two groups, the Catholics who usually follow religion practices and no practicing, answer a lower level of intention with a general low uncertain in the response.

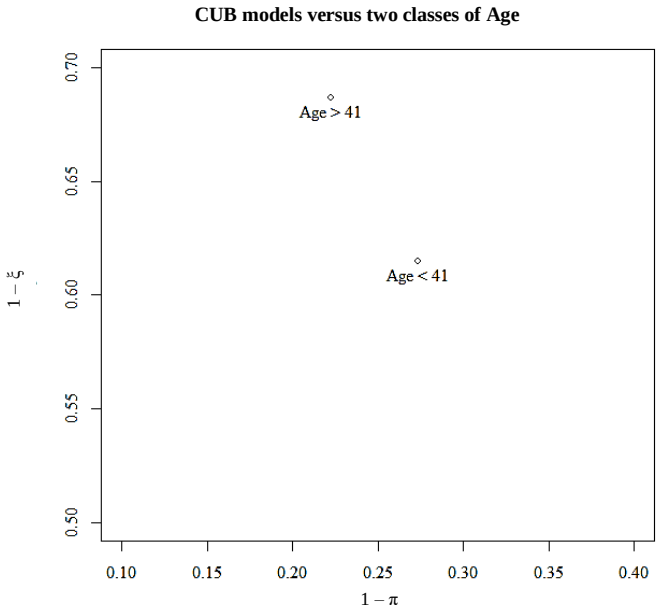

FIGURE 2
Representation of the estimated CUB models versus two classes of age
in a subset of the parameter space.

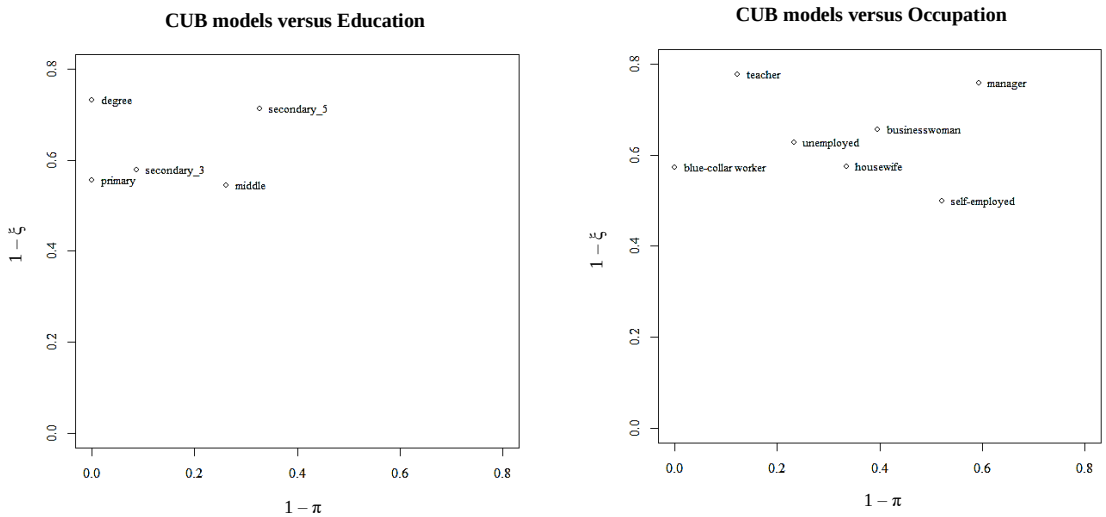

FIGURE 3
CUB models by *education* (left panel) and *occupation* (right panel) on *intention of vaccination*
in a subset of the parameter space.

Finally, when we consider the political orientation (right panel of Figure 4) we observe a higher level of intention for the mothers who denote a left orientation; they also give this answer with a low level of uncertainty. They are followed by woman of a right political orientation and of the center. Their feeling value is very close whereas a dissimilar level of intention is expressed for mothers who do not express their orientation and who also respond with higher level of uncertainty ($1 - \pi = 0.571$).

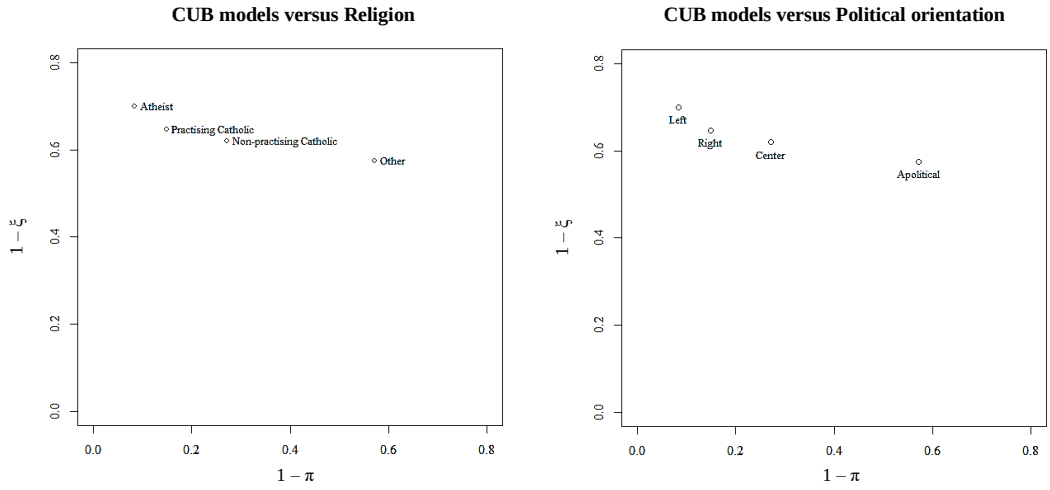

FIGURE 4
CUB models by *religion* (left panel) and *political orientation* (right panel) on *intention of vaccination* in a subset of the parameter space.

Modeling HAPA Issues by means of CUB Models

After several implementations of CUB models concerning knowledge about HPV, and variable of HAPA model (outcome expectations, risk perception, intentions, parental self-efficacy, and family efficacy), we present in this section the best CUB model (in terms of fitting results) obtained by including disease prevention, contraindication, papilloma risk for explaining feeling, and feeling/relationship for explaining the level of uncertainty (see Table 2). These covariates derive from outcome expectancies, risk perception, and self-efficacy blocks, respectively. More specifically, among positive outcome expectancies we selected the disease prevention item (vaccine is a primary instrument for prevention, ordinal ranging from 1 to 5) because it improves — in term of log-likelihood — the fitting of models when compared with the other two items of the same block included in questionnaire (see Figure 5 left panel for the estimated CUB models for each item). Generally, the level of uncertainty of this cluster is high ($0.65 < 1 - \pi < 0.78$). Among negative expectancies the outcome contraindication (vaccine could have contraindication on health, ordinal ranging from 1 to 5) is the selected one (see Figure 5 right panel for the estimated CUB models for the items concerning negative expectancies). In this case the level of ξ parameter for the item expressed in this block range in (0.84-0.91) with an intermediate level of uncertainty ($0.35 < 1 - \pi < 0.46$). For the block of health care risk we have chosen the item concerning the perception of papilloma risk whereas for self-efficacy the selected item is feeling/relationship (to talk with her daughter of your relationship and your feeling, ordinal from 1 to 5). As mentioned both of them have been selected according to the analysis of deviance. See Figure 6 for details on the other estimated models concerning risk perception and self-efficacy (left and right panel, respectively).

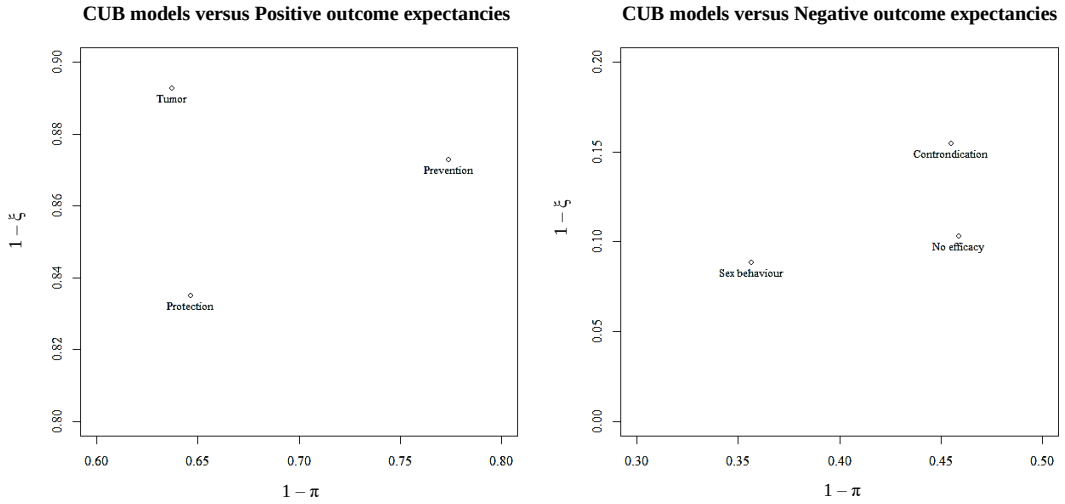

FIGURE 5
CUB models by *positive outcome expectancies* (left panel) and *negative* (right panel) on *intention of vaccination* in a subset of the parameter space.

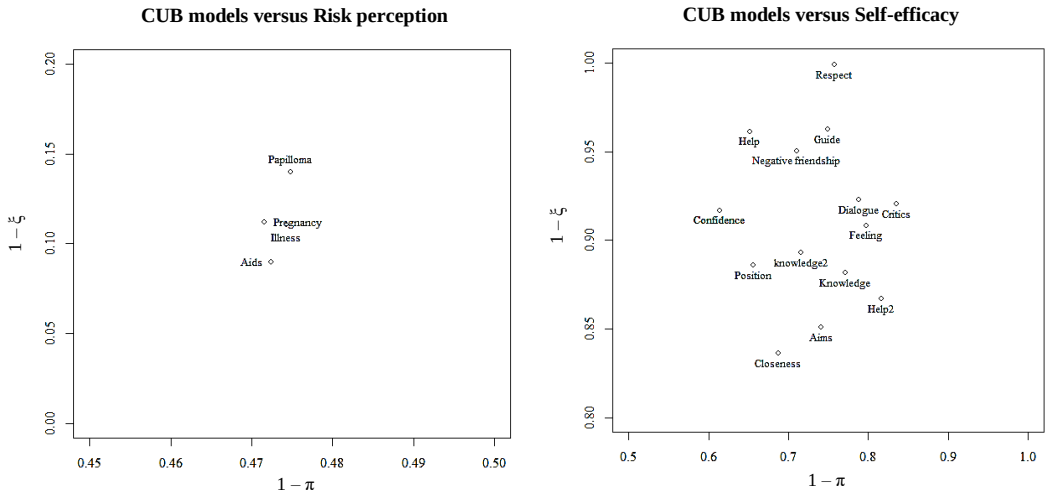

FIGURE 6
CUB models by *risk perception* (left panel) and *self-efficacy* (right panel) on *intention of vaccination* in a subset of the parameter space.

A summary of selected covariates which affect the feeling and uncertainty component of the CUB model may be observed in Table 3. The direction of the arrow is related to a negative/positive estimate which induces ceteris paribus an increasing (↑)/decreasing (↓) effect on the parameters of the mixture distribution. CUB models estimation results are in Table 4. More specifically, the selected CUB model (Table 3) has been obtained after a stepwise procedure which implies a sequence of estimated models, stopping when all the covariates previously mentioned are significant.

TABLE 3
Significant covariates for the HAPA model

CUB Component	HAPA structure	Significant covariates
Uncertainty	Self-efficacy	Feeling/relationship ↑
Feeling	Positive outcome expectancies	Disease prevention ↑
	Negative outcome expectancies	Contraindication ↓
	Risk perception	Papilloma risk ↑

TABLE 4
Estimation results for a CUB model with HAPA covariates

Component	Covariates	ML-estimates	Standard errors	Wald-test
Uncertainty	Constant	8.166	3.694	2.210
	Feeling/ relationship	−1.604	0.798	−2.010
Feeling	Constant	0.616	0.343	1.795
	Disease prevention	−0.379	0.073	−5.188
	Contraindication	0.277	0.068	4.040
	Papilloma risk	−0.174	0.065	−2.676
$\ell(\theta)$	−554.3513			
BIC	1.144.484			

On the basis of estimated results we can observe that when parents talk with their children (i.e., daughters) about their feeling and their life, the level of uncertainty to do vaccine increases (thus, we can confirm that the efficacy in the relationship between parents and their sons influence the uncertainty); moreover, when the consideration of vaccine as instrument of prevention becomes important, the intention of vaccination increases; on the contrary when mothers consider vaccine a dangerous issue for health the intention reduces.

Then, more the mothers think that their daughters could be exposed to the risk, higher intention to do vaccine they express. Furthermore, we define different profiles concerning A = low, B = medium, C = high level of intention (in A we include mothers no confident in vaccine and related effect, on the contrary for mothers in C), for fixed level of uncertainty (median) expressed as undecided, and we calculate the probability of answering (intention) from 1 to 5, for covariates equals to the different levels of the rating scale as reported in Table 5.

TABLE 5
Some selected profiles for respondents

Profile	Feeling/relationship	Disease prevention	Contraindication	Papilloma risk
A	Undecided	Extremely disagreement	Extremely agreement	Extremely disagreement
B	Undecided	Undecided	Undecided	Undecided
C	Undecided	Extremely agreement	Extremely disagreement	Extremely agreement

In details, the three profiles (Figure 7) may be identified as follows. Profile A: mothers who express the lowest value of Likert scale when interviewed on the vaccine as primary instrument for prevention, and highest of the scale when is requested if the vaccine could have contraindication on health. They present a low-risk perception with respect to the risk exposure on papilloma virus by expressing the lowest score on the scale. Profile B: mothers undecided respect all the item requested. They represent the case of extreme uncertainty in the process of responses. Profile C: mothers who express the highest value of Likert scale when interviewed on the vaccine as primary instrument for prevention, and lowest of the scale when is requested if the vaccine could have contraindication on health. They present a high-risk perception with respect to the risk exposure on papilloma virus by expressing the maximum score on the scale.

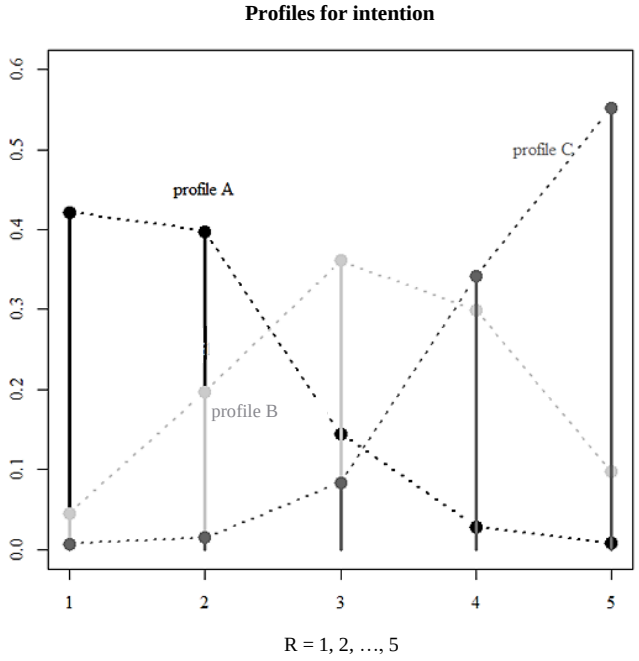

FIGURE 7
Representation of the estimated CUB models by profiles A, B, and C.

CONCLUDING REMARKS

The results so far discussed should convince of the adequacy and flexibility of the selected modeling framework based on CUB models as an alternative paradigm for the analysis of ordinal data respect to the standard framework (McCullagh, 1980; McCullagh & Nelder,1989; Agresti, 2010) in the context of psychology.

The advantages of using this method in psychology derive from the possibility of defining profiles or clusters of respondents and use them for predictions. In this regard, several studies have shown how the CUB methodology allows a significant improvement of the overall adaptation in describing a set of data, obtaining a better interpretation of results and a better statistical performance. A remarkable added value of the proposed approach is the possibility to represent these models in a parameter space and to see how they are modified with respect to covariates. The obtained interpretation is always consistent with the expected

one and the findings support the relevance of the HAPA determinants (risk perception, outcome expectation, and self-efficacy) to predict the intention to do the HPV vaccine in line with the literature that has stretched the HAPA model on flu vaccines (Ernsting et al., 2013; Payaprom et al., 2011). Thus, empirical evidence shows that the intention of vaccination increases in case of mothers older than 41 years old, with higher education level (Gilkey et al., 2016), generally managers, teachers, and businesswomen, atheist or who do not report indication about religion, with left political orientation. These results show the existence of different profiles of the respondents according to their choice referring to the HPV vaccine. This could have useful implications in prevention campaigns in favor to screening vaccine, suggesting to adopt different strategies based on the mothers characteristics. In line with a recent meta-analysis on educational interventions to increase HPV vaccination acceptance (Fu, Bonhomme, Cooper, Joseph, & Zimet, 2014), future studies are required to determine the effectiveness of culturally competent interventions reaching diverse populations. Starting from the scientific evidence that messaging intervention (Carfora, Caso, & Conner, 2017a, 2017b; Caso & Carfora, 2017) and Internet domain (Callea, Cacioppo, Lucchetti, & Caretti, 2016; Caso, 2015) are key instruments for increasing health behaviors, future researches could implement a new program for promoting the adherence to HPV vaccine using these types of persuasive communication. Moreover, in future it may be relevant to deepen the role of additional factors, such as self-identity as healthy person (Carfora, Caso, Sparks, & Conner, 2017; Caso, Carfora, & Conner, 2016), the emotions in decision-making process in pediatric primary care (Dicè, Maiello, Dolce, & Freda, 2017) and many important issue as health locus of control (Donizzetti & Petrillo, 2015), paranormal health beliefs (Petrillo & Donizzetti, 2012), and well-being aspects (Joshanloo, Capone, Petrillo, & Caso, 2017), which could contribute to better understand the parents' intention to vaccinate their sons.

References

Agresti, A. (2010). *Analysis of ordinal categorical data* (2nd ed.). Hoboken, NY: John Wiley & Sons.

Aikman, S. N., Doyle-Portillo, S., Verhaeghen, P., & Simmons, N. (2017). The effect of instruction point of view on self-efficacy for performing breast self-exams. *American Journal of Health Education*, *48*, 1-10. doi:10.1080/19325037.2016.1250687

Bakogianni, G. D., Nikolakopoulos, K. M., & Nikolakopoulou, N. M. (2010). HPV vaccine acceptance among female Greek students. *International Journal of Adolescent Medicine and Health*, *22*, 271-273. doi:10.1515/IJAMH.2010.22.2.271

Callea, A., Cacioppo, M., Lucchetti, F., & Caretti, V. (2016). Internet use and psychosocial well-being in an Italian adult sample. *Clinical Neuropsychiatry*, *13*(1), 3-6.

Caprara, G. V., Regalia, C., & Scabini, E. (2001). Autoefficacia familiare [Family self-efficacy]. In G. V. Caprara (Ed.), *La valutazione dell'autoefficacia: Costrutti e strumenti* [Self-efficacy evaluation: Constructs and tools]. Trento, Italy: Erikson.

Carfora, V., Caso, D., & Conner, M. (2017a). Randomised controlled trial of a text messaging intervention for reducing processed meat consumption: The mediating roles of anticipated regret and intention. *Appetite*, *117*, 152-160. doi:10.1016/j.appet.2017.06.025

Carfora, V., Caso, D., & Conner, M. (2017b). Correlational study and randomised controlled trial for understanding and changing red meat consumption: The role of eating identities. *Social Science and Medicine*, *175*, 244-252. doi:10.1016/j.socscimed.2017.01.005

Carfora, V., Caso, D., Sparks, P., & Conner, M. (2017). Moderating effects of pro-environmental self-identity on pro-environmental intentions and behaviour: A multi-behaviour study. *Journal of Environmental Psychology*, 53, 92-99. doi:10.1016/j.jenvp.2017.07.001

Caso, D. (2011). L'accettabilità del vaccino contro il Papilloma Virus (HPV): fattori psicosociali che incidono sulla scelta delle madri [The acceptability of the vaccine against the Human Papilloma Virus (HPV): Psychosocial factors influencing the choice of mothers]. *Psicologia della Salute, 1*, 83-99. doi:10.3280/PDS2011-001007

Caso, D. (2015). L'uso di Internet e il benessere psicosociale in adolescenza: Uno studio correlazionale. [Internet use and psychosocial well-being in adolescence: A correlational study]. *Psicologia della Salute, 2*, 141-155. doi:10.3280/PDS2015-002008

Caso, D., & Carfora, V. (2017). Un intervento di messaggistica istantanea per la promozione del monitoraggio del consumo di frutta e verdura. [Messaging intervention for promoting self-monitoring of fruit and vegetable consumption]. *Psicologia della Salute, 1*, 97-111. doi:10.3280/PDS2017-001005

Caso, D., Carfora, V., & Conner, M. (2016). Predicting intentions and consumption of fruit and vegetables in Italian adolescents: Effects of anticipated regret and self-identity. *Psicologia Sociale, 3*, 319-326. doi:10.1482/84668

Chow, S., & Mullan, B. (2010). Predicting food hygiene. An investigation of social factors and past behaviour in an extended model of the health action process approach. *Appetite, 54*, 126-133. doi:10.1016/j.appet.2009.09.018

D'Elia, A., & Piccolo, D. (2005). A mixture model for preference data analysis. *Computational Statistics & Data analysis, 49*, 917-934. doi:10.1016/j.csda.2004.06.012

Dicè, F., Maiello A., Dolce, P., & Freda, M. F. (2017). Le trasformazioni dialogiche delle preoccupazioni in Pediatria di Famiglia: Un'indagine empirica [Dialogic transformations of preoccupations in pediatric primary care: An empirical inquiry]. *Psicologia della Salute, 3*, 74-96. doi:10.3280/PDS2017-003004

Donizzetti, A. R., & Petrillo, G. (2015). Validazione della versione per adulti della Health Locus of Control Scale (HLCS) [Health Locus of Control Scale for adults: A validation study]. *Psicologia della Salute, 3*, 126-142. doi:10.3280/PDS2015-003007

Epicentro. (2014). *L'andamento della copertura vaccinale anti-Hpv nelle Regioni italiane* [The trend of the anti-Hpv vaccination coverage in the Italian regions]. Retrieved from http://www.epicentro.iss.it/problemi/hpv/CopertureVaccinali.asp

Ernsting, A., Gellert, P., Schneider, M., & Lippke, S. (2013). A mediator model to predict workplace influenza vaccination behavior – an application of the health action process approach. *Psychology & Health, 28*, 579-592. doi:10.1080/08870446.2012.753072

Etter, D. J., Zimet, G. D., & Rickert, V. I. (2012). Human papillomavirus vaccine in adolescent women: A 2012 update. *Current Opinion in Obstetrics and Gynecology, 24*, 305-310. doi:10.1097/GCO.0b013e3283567005

Fisher, W. A. (2012). Understanding human papillomavirus vaccine uptake. *Vaccine, 30S*, F149-F156. doi:10.1016/j.vaccine.2012.04.107

Forman, D., de Martel, C., & Lacey, C. (2012). Global burden of human papillomavirus and related diseases. *Vaccine, 30*, F12-23. doi:10.1016/j.vaccine.2012.07.055

Fu, L. Y., Bonhomme, L. A., Cooper, S. C., Joseph, J. G., & Zimet, G. D. (2014). Educational interventions to increase HPV vaccination acceptance: A systematic review. *Vaccine, 32*, 1901-1920. doi:10.1016/j.vaccine.2014.01.091

Garland, S. M., & Smith, J. S. (2010). Human papillomavirus vaccines: Current status and future prospects. *Drugs, 70*, 1079-1098. doi:10.2165/10898580-000000000-00000

Gilkey, M. B., Calo, W. A., Moss, J. L., Shah, P. D., Marciniak, M. W., & Brewer, N. T. (2016). Provider communication and HPV vaccination: The impact of recommendation quality. *Vaccine, 34*, 1187-1192. doi:10.1016/j.vaccine.2016.01.023

Godinho, J. R. S., & Alves, H. M. B. (2017). Behavioural factors in young people's fruit consumption. *International Journal of Consumer Studies*, *41*, 104-119. doi:10.1111/ijcs.12319

Gottard, A., Iannario, M., & Piccolo, D. (2016). Varying uncertainty in CUB models. *Advances in Data Analysis and Classification*, *10*(2), 225-244.

Gottlieb, S. L., Low, N., Newman, L. M., Bolan, G., Kamb, M., & Broutet, N. (2014). Toward global prevention of sexually transmitted infections (STIs): The need for STI vaccines. *Vaccine*, *32*, 1527-1535. doi:10.1016/j.vaccine.2013.07.087

Iannario, M. (2009). Fitting measures for ordinal data models. *Quaderni di Statistica*, *11*, 39-72.

Iannario, M. (2012a). Modelling shelter choices in a class of mixture models for ordinal responses. *Statistical Methods and Applications*, *21*, 1-22. doi:10.1007/s10260-011-0176-x

Iannario, M. (2012b). Hierarchical CUB models for ordinal variables. Communications in Statistics. *Theory and Methods*, *41*, 3110-3125. doi:10.1080/03610926.2011.645987

Iannario, M. (2014). Modelling uncertainty and overdispersion in ordinal data. Communications in Statistics. *Theory and Methods*, *43*, 771-786. doi:10.1080/03610926.2013.813044

Iannario, M., & Piccolo, D. (2012). CUB models: Statistical methods and empirical evidence. In R. S. Kenett and S. Salini (Eds.), *Modern analysis of customer surveys with applications using* R (pp. 231-258). Chichester, UK: Wiley & Sons.

Iannario, M., & Simone, R. (2017). Zero inflated CUB models for the evaluation of leisure time activities. In F. Greselin, F. Mola, & M. Zenga (Eds.), *Cladag 2017. Book of Short Papers*. Mantova, Italy: Universitas Studiorum Srl.

Iannario, M., Piccolo, D., & Simone, R. (2018). *CUB: A Class of mixture models for ordinal data* (*R package version 1.1.2).* Retrieved from http://CRAN.R-project.org/package=CUB

Italian Ministry of Health. (2014). Updating the anti-papillomavirus vaccination schedule and recognition methods of vaccine coverage Retrieved from: http://www.trovanorme.salute.gov.it/norme/renderNormsanPdf;jsessionid=sacY8orqWaJnl1nQynnH0A__sgc

Joshanloo, M., Capone, V., Petrillo, G., & Caso, D. (2017). Discriminant validity of hedonic, social, and psychological well-being in two Italian samples. *Personality and Individual Differences*, *109*, 23-27. doi:10.1016/j.paid.2016.12.036

Kessels, S. J. M., Marshall, H. S., Watson, M., Braunack-Mayer, A. J., Reuzel, R., & Tooher, R. L. (2012). Factors associated with HPV vaccine uptake in teenage girls: A systematic review. *Vaccine*, *30*, 3546-3556. doi:10.1016/j.vaccine.2012.03.063

Liddon N. C., Hood, J. E. & Leichliter, J. S. (2012). Intent to receive HPV vaccine and reasons for not vaccinating among unvaccinated adolescent and young women: Findings from the 2006-2008 National Survey of Family Growth. *Vaccine*, *30*, 2676-2682. doi:10.1016/j.vaccine.2012.02.007

Luszczynska, A., & Schwarzer, R. (2003). Planning and self-efficacy in the adoption and maintenance of breast self-examination: A longitudinal study on self-regulatory cognitions. *Psychology & Health*, *18*, 93-108. doi:10.1080/0887044021000019358

Manisera, M. & Zuccolotto, P. (2014a). Modeling "Don't know" responses in rating scales. *Pattern Recognition Letters*, *45*, 226-234. doi:10.1016/j.patrec.2014.04.012

Manisera, M., & Zuccolotto, P. (2014b). Modeling rating data with Nonlinear CUB models. *Computational Statistics and Data Analysis*, *78*, 100-118. doi:10.1016/j.csda.2014.04.001

Marek, E., Dergez, T., Kricskovics, A., Kovacs, K., Rebek-Nagy, G., Gocze, K., . . . Gocze, P. (2011). Difficulties in the prevention of cervical cancer: Adults' attitudes towards HPV vaccination 3 years after introducing the vaccine in Hungary. *Vaccine*, *29*, 5122-5129. doi:10.1016/j.vaccine.2011.05.048

McCullagh, P. (1980). Regression models for ordinal data. *Journal of the Royal Statistical Society*, *42*(2), 109-142.

McCullagh, P., & Nelder, J. A. (1989). *Generalized Linear Models* (2nd ed.). London, UK: Chapman & Hall.

McLachlan, G., & Krishnan, T. (1997). *The EM algorithm and extensions*. New York, NY: Wiley & Sons.

McLachlan, G., & Peel, G. J. (2000). *Finite mixture models*. New York, NY: Wiley & Sons.

Montgomery, K., & Smith-Glasgow, M. E. (2012). Human papillomavirus and cervical cancer knowledge, health beliefs, and preventive practices in 2 age cohorts: A comparison study. *Gender Medicine*, *9*, 55-66. doi:10.1016/j.genm.2011.11.002

Payaprom, Y., Bennett, P., Alabaster, E., & Tantipong, H. (2011). Using the Health Action Process Approach and implementation intentions to increase flu vaccine uptake in high risk Thai individuals: A controlled before-after trial. *Health Psychology*, *30*, 492-500. doi:10.1037/a0023580

Pestwich, A., Ayres, K., & Lawton, R. (2008). Crossing two types of implementation intentions with a protection motivation intervention of the reduction of saturated fat intake: A randomized trial. *Social Science and Medicine*, *67*, 1550-1558. doi:10.1016/j.socscimed.2008.07.019

Petrillo, G., & Donizzetti, A. R. (2012). Credenze illusorie sulla salute in adolescenza: Validazione di uno strumento di rilevazione [Paranormal health beliefs in adolescence: Validation of an instrument of measure]. *Giornale Italiano di Psicologia*, *39*, 407-434. doi:10.1421/37808

Piccolo, D. (2003). On the moments of a mixture of Uniform and shifted Binomial random variables. *Quaderni di Statistica*, *5*, 85-104.

Piccolo, D. (2006). Observed information matrix for MUB models. *Quaderni di Statistica*, *8*, 33-78.

Piccolo, D. (2015). Inferential issues on CUBE models with covariates. Communications in Statistics. *Theory and Methods*, *44*, 771-786. doi:10.1080/03610926.2013.821487

Piccolo, D., & D'Elia, A. (2008). A new approach for modelling consumers' preferences. *Food Quality and Preference*, *19*, 247-259. doi:10.1016/j.foodqual.2007.07.002

Ratanasiripong, N. T. (2012). A review of human papillomavirus (HPV) infection and HPV vaccine-related attitudes and sexual behaviors among college-aged women in the United States. *Journal of American College Health*, *60*, 461-470. doi:10.1080/07448481.2012.684365

Schwarz, T. F. (2008). AS04-adjuvanted human papillomavirus-16/18 vaccination: Recent advances in cervical cancer prevention. *Expert Review of Vaccines*, *7*, 1465-1473. doi:10.1586/14760584.7.10.1465

Schwarzer, R. (2001). Social-cognitive factors in changing health-related behaviours. *Current Directions in Psychology Science*, *10*, 47-51. doi:10.1111/1467-8721.00112

Simon, H. A. (1957). *Models of Man.* New York, NY: John Wiley & Sons.

Smith, J. S., Gilbert, P. A., Melendy, A., Rana, R. K., & Pimenta, J. M. (2011). Age-specific prevalence of human papillomavirus infection in males: A global review. *Journal of Adolescent Health*, *48*, 540-552. doi:10.1016/j.jadohealth.2011.03.010

Sniehotta, F. F., Soares, V. A., & Dombrowski, S. U. (2007). Randomized controlled trial of a one-minute intervention changing oral self-care behaviour. *Journal of Dental Research*, *86*, 641-645. doi:10.1177/154405910708600711

Stupiansky, N. W., Alexander, A. B., & Zimet, G. D. (2012). Human papillomavirus vaccine and men: what are the obstacles and challenges? *Current Opinion in Infectious Diseases*, *25*, 86-91. doi:10.1097/QCO.0b013e32834ed5be

World Health Organization (WHO). (2006). Preparing for the introduction of HPV vaccines: Policy and program guidance for countries.
Retrieved from http://www.rho.org/files/WHO_HPV_vac_intro_2006.pdf

World Health Organization (WHO). (2015). Global vaccine action plan. Retrieved from http://www.who.int/immunization/global_vaccine_action_plan/gvap_secretariat_report_2014.pdf?ua=1

Zurlo, M., Iannario, M., & Piccolo, D. (2017). Stress dimensions and psychological health conditions of schoolteachers: Validation of a risk model using CUB models for the analysis of ordinal data. *Psicologia della salute*, *1*, 5-25.
doi:10.3280/PDS2017-001001