Notes about Pediatrics Hypertension Literacy

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Abstract: Pediatric hypertension (PH) is an important public health problem with multiple problems on the health of children and adults. It is an important issue that health professionals and family members have awareness of PH existence, the negative consequences associated with it, the risk factors and it prevention. Its expected the knowledge about this pathology increases with the level of education of the family members. To investigate the caregivers knowledge degree about PH and to check if the assessment of PA in health regular consultations is an usual practice, an experimental questionnaire was built with the aim of easy and quick answers. The statistical analysis and modeling of such questionnaire by Generalized Linear Model (GLM), took into account the presence of dichotomous data, discrete models which are usually estimated by logistic or probit regression. This approach can be found in [19, 20] where each statistical significant question was modeled separately. Continuing such approach and exploring the idea of simplicity and reduced dimensionality, a factor analysis was applied and a multivariate analysis of variance was performed considering as dependent variables the obtained factors by exploratory factor analysis (EFA) as dependent variables. The results are consistent with the ones presented in [19, 20].

Key–Words: Pediatric hypertension, Caregiver, Knowledge, Factor Analysis, Analysis of Variance

1 Introduction

In medical, behavioral and social sciences it is usual to get a binary outcome. For example, in the present work is collected information related with the perception of pediatric patients caregivers about high blood pressure (HBP) in childhood where some of the outcomes are binary variables (1='yes'/ 0='no').

The hypertension is a serious public health problem present since childhood [4], silent in most cases and whose only form of early diagnosis is the regular blood pressure (BP) measurement in health monitoring consultations. It is a condition that interferes negatively with numerous functions in the body of the children still in development. Like all chronic diseases, not only interferes with the child but also with his family. For this reason, a clinical and therapeutic approach to the family, instead of a targeted intervention only for the patient, it is usually more effective [15].

The diagnosis of pediatric hypertension (PH) should be based on multiple measurements of BP in medical office environment and at different times [11]. The current recommendation of the European Society of Hypertension (ESH) [11] is the inclusion of the practice assessment arterial blood pressure (ABP) in all children above three years of age, in all health surveillance pediatric attendees, and below this age, if there exist risk factors. The publication of these and other guidance standards enabled the detection of cases of secondary asymptomatic hypertension, which otherwise would be hidden. On the other hand, moderate elevations in BP during childhood are more common than it was thought, especially in teenage years. In [1] Ahern evidences PH as a growing problem in health care, which is underdiagnosed [9]. This pattern is also presented in [8], where the trends and future challenges of this disease are explored.

The study [15] standardized the wide variety of published data and prepared reference tables of ABP

Table 1: Classification of pediatric hypertension (adapted from [15])

Class	SBP and/or DBP Percentile
normal	< 90
normal-high	≥ 90 until $< 95\ mmHg$
	Teenagers: AP $> 120/80\ mmHg$, including percentile < 90
HBP- class 1	$95 \leq$ Class $1 \leq 99 + 5\ mmHg$
HBP - class 2	$> 99 + 5\ mmHg$

values considered normal for each gender depending on the child's age and his height [11]. Regardless the limitations, such work is seen as a reference study and, according to its recommendations, the ABP in children is considered normal (see Table 1) when the systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) are below than 90th percentile for gender, age and height of the child in question, while hypertension is defined as SBP and/or DBP persistently higher or equal to the 95th percentile, measured at least on 3 different occasions by auscultation [11]. The middle class, SBP and / or DBP greater or equal than 90^{th} percentile but less than 95^{th} percentile is classified as high normal BP [11]. Also teenagers with BP equal or greater than $120/80\ mmHg$, regardless the correction of percentile for height, are considered to have HBP. In cases where the measured values are very different from each other, the child should be classified based on the highest one [15].

PH, although considered an adult disease appear very often in infancy, tending to increase with age and with body mass [11]. The same author establishes a strong correlation between body mass and BP levels. The diagnostic criteria for PH have as their main reference the distribution of blood pressure in healthy children [3]. These criteria are based on the concept that the pediatric BP increases with age and with body mass. In [14, 17] is highlighted that childhood obesity is a great risk for developing HP.

Despite the wide variety of percentages estimated by different authors, a recently published study obtained high-normal BP prevalence values in order 16% and HT 3.2% [13], which is consistent with other studies showing that 25% of all pediatric patients have BP levels that meet the criteria for diagnosis of pediatric BP [9]. However, the same study, elaborated by Hansen et al in [9], have also shown that despite the high estimated prevalence, this disease remains under diagnosed.

An experimental questionnaire was built and applied to evaluate the caregivers perception of Portuguese pediatric attendees of the Hospital of Santa Maria (HSM) so we could get their perception about PH and possibles risks. We can found in [19] a preliminary analysis of such questionnaire. The collected information was statistically analyzed, where a descriptive analysis and a predictive model were performed using logit models. In [20] was completed such approach. In [19, 20] the authors checked the fulfillment about regular measurement of pediatric BP.

This article is the continuation of such work. We complete the results presented in [19, 20] so we get simpler interpretations. It is performed a statistical approach estimating a reduced number of factors relatively to questions 1-5. Considering the selected factors was also applied a multivariate analysis of variance (MANOVA), which can also be considered a particular case of GLM approach.

The summary of this work is divided as it follows. Section 2 introduces questionnaire issues. Some theoretical details about the statistical procedure are in Sect. 3. The results of such approach are displayed in Sect. 4. Discussion and conclusions can be found in Sect. 5.

2 Questionnaire

An experimental questionnaire was applied to caregivers of children aged between 3 and 18 years. It is intended to get the perception of children and young people caregivers about HBP in children.

The questionnaire is an attempt to design a "minimal" scheme to be finished quickly. It required the information described bellow.

- Some socio-demographic characteristics such as age, gender, race, residence area, level of education, profession;

- Five dichotomous questions in order to be answered (Yes/No) quickly:

    1. May the hypertension arise during the pediatric age?
    2. Is hypertension a silent disease?

3. Should a BP measurement be made in health routine visits from 3 years age?
4. Are there risk factors such as obesity, lack of practice physical activity or overeating that may be associated with hypertension?
5. Is it usual to measure your child's blood pressure in health surveillance visits?

3 Methodology

3.1 GML

In the classical linear model, a vector X with p explanatory variables $X = (X_1, X_2, \ldots, X_p)$ can explain the variability of the variable of interest Y (response variable), where $Y = Z\beta + \epsilon$. Z is a specification matrix with size $n \times p$ (sometimes $Z = X$, considering an unitary vector in first column), β a parameter vector and ϵ a vector of random errors ϵ_i, independent and identical distributed to a reduced Gaussian.

In the univariate case, data are in the form (y_i, x_i), $i = 1, \ldots, n$, as result of observation of (Y, X) n times. The response variable Y has expected value $E[Y|Z] = \mu$.

In GLM, where the model is an extension of classical model, the response variable, following an exponential family distribution [21], does not need to be Gaussian, and a transformation of expected value of response variable is related with explanatory variables. A detailed description of GLM ca be found in [21, 16].

Another extension from the classical model is the fact that the function which relates the expected value and the explanatory variables can be any differentiable function. Each Y_i has expected value $E[Y_i|x_i] = \mu_i = b'(\theta_i)$, $i = 1, \ldots, n$.

Also, it is defined a differentiable and monotone link function g that relates the random component with the systematic component of the response variable. The expected value μ_i is related with the linear predictor $\eta_i = z_i^T \beta_i$ through the relation

$$\mu_i = h(\eta_i) = h(z_i^T \beta_i), \qquad \eta_i = g(\mu_i) \tag{1}$$

where h is a differentiable function, $g = h^{-1}$ is the link function, β is a vector of parameters with size p (the same size of the number of explanatory variables) and Z is a specification vector with size p.

We can found different link functions in GLM. When the random component of response variable has a Poisson distribution, the link function is logarithmic and the model is log-linear. In particular, when the linear predictor $\eta_i = z_i^T \beta_i$ coincides with the canonical parameter θ_i, $\theta_i = \eta_i$, which implies $\theta_i = z_i^T \beta_i$, the link function is denominated canonical link function.

Usually, in presence of dichotomous data, discrete models are usually estimated by logistic or probit regression [21]. This was the approach followed in [19, 20]. In present work, we have also another approach, we perform a multivariate analysis of variance.

3.2 Factor analysis

Factor analysis (FA) is technique often used to reduce data. The purpose is to get a reduced number of variables from an initial larger set of variables and get easier interpretations [10]. The FA computes indexes with variables that measures similar things. There are two types of factor analysis: exploratory factorial analysis (EFA) and confirmatory factorial analysis (CFA) [22]. It is called EFA when there is no idea about the structure or the dimension of the set of variables. When we test some specific structure or dimension number of certain data set we name this technique the CFA. There are various extraction algorithms such as principal axis factors, principal components analysis or maximum likelihood (see [5] for example). There are numerous criteria to decide about the number of factors and theirs significance. For example, the Kaiser criterion proposes to keep the factors that correspond to eigenvalues greater or equal to one. In the classical model, the original set contains p variables $(X_1, X_2, \ldots, X_p)$ and m factors $(F_1, F_2, \ldots, F_m)$ are obtained. Each observable variable X_j, $j = 1, \ldots, p$ is a linear combination of these factors:

$$X_j = \alpha_{j1}F_1 + \alpha_{j2}F_2 + \cdots + \alpha_{jm}F_m + e_j, \; j = 1, \ldots, p, \tag{2}$$

where e_j is the residual. The factor loading α_{jk} provides an idea of the contribution of the variable X_j, $j = 1, \ldots, p$, contributes to the factor F_k, $k = 1, \ldots, m$. The factor loadings represents the measure of association between the variable and the factor [10, 22].

FA uses variances to get the communalities between variables. Mainly, the extraction issue is to remove the largest possible amount of variance in the first factor. The variance in observed variables X_j which contribute to a common factor is defined by communality h_j^2 and is given by

$$h_j^2 = {\alpha_{j1}}^2 + {\alpha_{j2}}^2 + \cdots + {\alpha_{jm}}^2, \qquad j = 1, \ldots, p. \tag{3}$$

According with the author of [12], the observable variables with low communalities are often dropped off once the basic idea of FA is to explain the variance by the common factors. The theoretical common factor model assumes that observables depend on the common factors and the unique factors being mandatory to determine the correlation patterns. With such objective the factors/components are successively extracted until a large quantity of variance is explained. After the extraction technique be applied, it is needed to proceed with the rotation of factors/components maximizing the number of high loadings on each observable variable and minimizing the number of factors. In this way, there is a higher probability of a simple interpretation of factors 'meaning'.

4 Application

In [6] was developed an observational and prospective study where all participants were attendees of external regular pediatric consultation of HSM, during May-December 2014, with pediatric department director consent. A random sample of 128 individuals was collected, all of them first-degree relatives or legal representatives of children and/or teenagers, users of the National Health System (NHS), which resorted to external consultation (general pediatrics and/or subspecialties) for reasons not related to changes in the BP. Only 107 questionnaires were considered correctly filled.

About 66.6% of participants know that the pediatric hypertension may arise during the pediatric age, 82% take into account that, frequently, hypertension is a silent disease, 61.3% know that a BP measurement should be made from 3 years age in health surveillance visits and 91.9% are aware about some risk factors that may be associated with hypertension. The question 5 was implemented to verify if regular measurement of the pediatric BP was fulfilled according to current recommendations. This issue is not fulfilled by 40.5% the participants. Initially, in [19, 20] the questionnaire statistical inference took into consideration the questions 1, 2, 3 and 4.

Firstly, the data was classified using descriptive statistic techniques (for example see [18]). Taking into account the specific nature of the variables in the study, some association measures were computed, nonparametric Spearmann correlation coefficient, nonparametric test of Friedman for paired samples, etc. The codification of selected variables can be found in Table 2.

We have measured the homogeneity and internal consistence of questionnaire and respective validation. The alpha-Cronbach coefficient was lower than expected, giving the indication of sufficient, bad not good internal consistency. We also performed several tests to compare the answers of questions 1, 2, 3 ad 4: the paired T-test, McNemar's test for frequencies comparison, Crochan's Q test for binary variables comparison. For details see [19].

This preliminary analysis suggested the exclusion of question 3 from our work, all tests show evidence that question 1 - question 3 are not significantly different. Also the non-parametric Spearmann coefficient of association is significant for the pair question 1 - question 3. The Cochran's Q tests rejects that the distributions of question 1, question 2, question 3 and question 4 are the same. Initially, we compute the association of the questionnaire answers with sociodemographic characteristics of participants.

The Spearmann coefficient was significant for question 1 and question 3, question 2 and age, question 2 and profession, the Kruskal-Wallis test was significant between question 4 and age ($\eta - coefficient = 0.561$) and question 4 and level of education ($\eta - coefficient = 0.224$).

4.1 Model Estimation

On [19, 20] was performed an univariate approach on each question separately. Noe, we apply an EFA to all questions so we get new dependents variables which are modeled simultaneously. The last stage of statistical inference process consists in estimation, validation and selection of the models by MANOVA (which is considered a particular case of GLM). These three steps are summarized as follows: 1- Models formulation: identify response variable distribution, select the preliminaries explanatory variables and specification matrix; 2- Models adjustment: estimation of model parameters, application of suitability measures of estimates; 3- Selection and validation of models: selection of variables, diagnostics, residual analysis and interpretation.

To formulate such models, we need to select the dependent variables. To do such selection, we apply an EFA to reduce the initial five questions to fewer explained variables; we consider the factors that explain the majority of the data variance.

For such purpose we estimate the communality for the factors, analyzed the significance of R-matrix, test the multicollinearity or singularity. The Bartlett's sphericity test conduced a significant level p, so we confirmed the existence of patterned relationships. Also, the Kaiser-Meyer-Olkin measure (KMO) of sampling adequacy indicated the data is appropriate to apply an EFA.

In Table 3 are displayed the eigenvalues and total variance accounted by each factor by descendent order. The i^{th}line presents the cumulative variance percentage explained by the first i factors. Notice that Table 3 contains information, after extraction and after rotation.

Table 2: Codification of variables.

Variables	**Description**	**Codification**	**Variables**	**Description**	**Codification**
Y_1	Question 1	1=Yes	x_2	Profession	11=Other
		0=No			10=Without qualification
Y_2	Question 2	1=Yes			$\cdots$
		0=No			$\cdots$
Y_3	Question 3	1=Yes			1=High qualification
		0=No	x_3	age	$'1' = ([18, 29])$
Y_4	Question 4	1=Yes			$'2' = ([30, 49])$
		0=No			$'3' = (\geq 50)$
x_1	Education level	1=primary	x_4	Gender	0=Female
		2=High School			1=Male
		3=University			

Table 3: Total variance accounted for each factor. Raw data (top); scaled data (bottom).

Component	Extraction Sum of Squares Loadings			Rotation Sum of Squares Loadings		
	total	% of Variance	Cumulative %	total	% of Variance	Cumulative %
raw						
1	$0,377$	$40,534$	$40,534$	$0,351$	$37,693$	$37,693$
2	$0,209$	$22,464$	$62,998$	$0,236$	$25,305$	$62,998$
3	$0,159$	$17,051$	$80,049$			
scaled						
1	$1,676$	$32,330$	$40,534$	1.465	$29,294$	$29,294$
2	$0,209$	$22,343$	$62,998$	1.269	$25,379$	$54,672$
3	$0,159$	$17,051$	$80,049$			

Also contains the information when we consider raw data and scaled data respectively. If we select raw data, the first 2 factors explain 33% of total variance; considering the scaled data case, 2 factors explain 56% of total variance.

We can conclude that, by Kaiser criterion for simplicity, we retain the first 2 factors (eigenvalues great or equal to one) for raw data case. Other criteria may be applied, for example using the scree plot or using the average of extracted communalities to determine the eigenvalue cutt-off. The varimax algorithm which produces orthogonal factors was applied after the extraction process. This technique is adequate when we want to identify variables to create indexes or new variables without inter-correlated components. Once the objective of an EFA is to select the smallest number of factors that explain the most variance, we choose to work with raw data (at top of Table 3).

In Table 4, we can find the rotated component matrix for each factor; we also have displayed in Table 4 the measures of adequacy for each variable (taken from correlation matrix anti-image diagonal). We consider the questions whose values are greater than 0.5. The reliability for each component is also available at bottom of Table 4.

Table 4: Rotate Component Matrix.

		Factors	
	MSA	1	2
Q_5	0.820	0.413	
Q_3	0.852	0.391	
Q_1	0.832	0.163	0.400
Q_2	0.896		0.261
Q_4	0.945		0.085
% of Variance		37.693	25.305
Cronbach		0.664	0.634

In Fig. 1 are displayed the questions in the plan defined by the factors F_1 and F_2.

We can see that questions Q5, Q3 and Q1 respectivelly Is it usual to measure your child's blood pressure in health surveillance visits?", "Should a BP measurement be made in health routine visits from 3 years age?" and May the hypertension arise during the pediatric age?", are the major (positive) contributions for F_1. The main (positive) contributors for F_2 are questions Q1, Q2 and Q4, May the hypertension arise during the pediatric age?", "Is hypertension a silent disease?" and "Are there risk factors such as obesity, lack of practice physical activity or overeating that may be associated with hypertension" respectively.

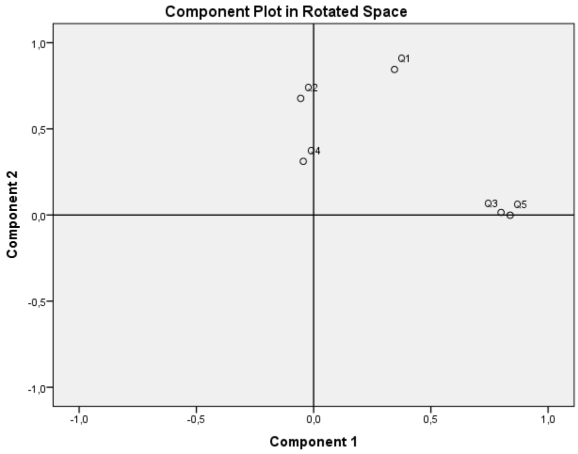

Figure 1: Component plot in rotated space.

In the present case, we could get the 'meaning' of each factor. Namely each factor is related with: F_1-Literacy about existence and prevention of HBP; F_2-Risks about HBT.

Now, we can apply a multivariate analysis of variance to estimate the models which explain F_1 and F_2 using the individual socio-demographic explanatory variables.

Below, we present a MANOVA analysis. We look for the effects of independent variables (IVs) on the dependents variables (F_1 and F_2) at the same time. Each dependent variable has available the information about the socio-demographic characteristics. Some levels of residential area and/or race had few individuals. We didn't consider these particular individual characteristics as explanatory variables or effects.

Initially, we treat simultaneously both factors. We Therefore, we will treat each of factor separately. The out put has two parts: the simultaneous analysis and individual analysis. We have selected a model where considered effects are gender and education level. The multivariate F-tests, namely Pillai's rank, Wilks trace, Hotelling rank and Roy's largest root, conduced to $p-values \approx 1,2\%$, so we conclude that there is a significant influence of IVs on both factors as group. We can establish that the chosen socio-demographic information has a significant effect on both factors globally. Also the Box's test statistically does not reject equal covariance matrices null hypothesis. We also can analyze separately the effect gender and the effect education level. The multivariate tests (Table 5) reveal that gender is statistically significant as IV in model; on the other hand, the education level is not statistically significant as IV, by the interaction *gender* education* level is already significant in model.

The second part of output provide us from the in-

Table 5: Multivariate Tests *p-value*. Design: Intercept + Gender + Ed.Level+ Gender * Ed.Level

	Effects		
	Gender	*E.level*	*Gen.* E.level*
Pillai	0.012	0.746	0.056
Wilks	0.012	0.747	0.053
Hotteling	0.012	0.749	0.051
Roy	0.012	0.378	0.010

fluence of IV's on each separate EV (F_1 and F_2). The Levene's Test does not reject the null hypothesis that the error variance of the dependent variable is equal across groups ($p - value = 0.213$ and 0.762) relatively to F_1 and F_2. The univariate F to test the effect of gender and education level relatively to F_1 and F_2 separately, can be found in Table6. Notice that gender and education level are not significant effects to F_2; but for F_1, gender and gender*education level are significant effects. The pairwise comparison using the estimated marginal means, concludes that F_1 for woman has a mean greater than man ($p-value = 0.003$). When we consider the model with interaction, the same is verified, for women the F_1 mean is greater than for men, when both have similar education.

Table 6: Univariate F Tests *p-value*. Design: Intercept + Gender + Ed.Level+ Gender * Ed.Level.

	Effects		
	Gender	*E.level*	*Gender * Ed.Level*
F_1	0.003	0.760	0.003
F_2	0.618	0.505	0.618

The residual analysis evaluation of all models was done. All validation and selection techniques were completed. The deviance residuals are represented in Fig. 2.

Literacy about pediatric HBP and its relation with socio-demographic characteristics of participants was established. It was concluded that the factor associated to literacy is lower for a man than for women, when they have similar education. The profession and age were not statistically significant as explanatory variables. The factor associated to risks couldnt get any strong significance social-demographic variable.

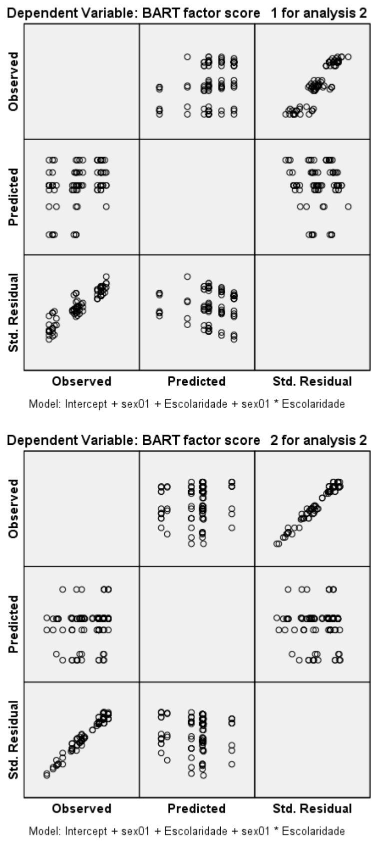

Figure 2: Deviance residuals versus fitted values. Design: Intercept + Gender + Ed.Level+ Gender * Ed.Level.

5 Final remarks

Pediatric arterial hypertension is a highly prevalent, silent, and perhaps because of this, under-diagnosed in most cases, with multiple repercussions on the health of children and adults. It is imperative that health professionals and family members be aware of HBP existence, the negative consequences associated with it, the risk factors and it prevention. Its expected the knowledge about this pathology increases with the level of education of the family members.

A simple questionnaire was built with the aim of easy and quick answers. We can establish that, despite not rejecting the questionnaire in terms of internal consistency, there is some evidence that it needs some improvement, for example, reformulation of some questions. Exploring the binary outcome issue, the estimated probit/logit models described in [19, 20] got reasonable explication of the data. Here, we extend this approach using MANOVA, specifically, exploring some socio-demographic variables. The process was not totally successful, we have expected that some of the significant explanatory variables used in [19, 20] could be selected as independent variables in our model. Only the gender and education level were considered as significant effects.

The present work needs of another detailed analysis, using a more complete data set.

Accordingly with the questionnaire, caregivers literacy depends on positively of the educational level and the gender. Higher levels of education are associated with greater knowledge about the existence of hypertension risk factors. With such objective, was applied recently a new questionnaire with a different target population, structure and questions: Fifteen theoretical questions about pediatric hypertension, on which the evaluation of the object of the study is based: Characterization of the knowledge of parents and / or caregivers on Pediatric Hypertension; One final question regarding the periodicity of evaluation of BP in periodic health surveillance visits of the pediatric relatives of the participants.

The questionnaire was sent to 182 participants via e-mail (containing the link to the online form), previously sent by the respective class directors of the ten schools of the Group.

For improved survival and quality of life of hypertensive patients is mandatory an early diagnosis and an early and appropriate therapeutic intervention . Prevention is possible by controlling known risk factors and modifiable.

We also intend to continue this study in a different scale, identifying the risks of the disease and its relationship with inherited and acquired changes in the state of potential patients. Following the objective to get a picture of pediatric hypertension in Portugal, under the aim of a project proposed by Portuguese Pediatric association, we are collecting data at national level (simple size=5500).

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