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Evaluation of health conditions using the POSET approach

Approccio POSET per la valutazione della salute

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Abstract In this contribution we study health status of Italian aging population using an evaluation method based on the theory of partially ordered set. The method allows to create synthetic measures out of a set of ordinal indicators without the need for aggregation. After preliminary definitions, we calculate two indices to evaluate physical and mental health, and by means of regression trees we analyse the role that simple indicators play in discriminating health profiles.
Abstract *In questo contributo si valuta lo stato di salute della popolazione anziana in Italia utilizzando un metodo basato sulla teoria degli insiemi parzialmente ordinali. Il metodo permette, senza bisogno di alcun tipo di aggregazione, di calcolare indicatori sintetici a partire da dati ordinabili. Dopo aver dato alcune definizioni, calcoliamo due indici che misurano la salute fisica e la salute mentale e, utilizzando alberi di regressione, analizziamo quali indicatori semplici contribuiscono a discrimnare fra profili di stato di salute.*

Key words: self-reported health, ordinal data, poset

1 Introduction

Health is a core characteristic in life and it is fundamental for individuals' well-being. Health status is crucial in all dimensions of individual life and bad health conditions dramatically influence it as a whole. Special attention should be paid

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to aging population as it is constantly growing in many countries: measuring and monitoring individual health is hence crucial in aging societies.

Following World Health Organization (WHO) definition health is "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" ([3]). Regardless of the definition adopted, health is a complex phenomenon involving different factors that combined together affect its measurement. There are many methods to measure health leading to different approaches, different purposes and different levels of measurement ([7]). Here we evaluate health at individual level and we consider measures of "subjective" health rather than "objective", which is based on diagnosis by physicians and/or by results of objective examinations. Self-perceived health has been highlighted as a good tool for the measurement of health status ([6]). Moreover, due to its multidimensional nature, we consider a set of indicators. We refer to the SF-12 Questionnaire of Health Survey developed during the 90's in the United States by the Medical Outcomes Trust of Boston ([8]) and based on 12 items widely used in the last decades by international studies for health evaluation. Using aggregative procedures, these items are summarized in 2 synthetic indices one representing the physical health (PCS) and the other the mental health (MCS). Since each item of SF-12 provides ordinal or dichotomous responses, in this contribution we suggest the use of a method based on theory of partially ordered sets (POSET) which allows to build a synthetic indicator out of a set of ordinal variables without the need of any aggregative procedure.

2 Methodology: The Poset approach

Let X be a set and let "$\leq$" be a binary relation on it. This binary relation is a *partial order* if it satisfies the properties of reflexivity, antisymmetry and transitivity (for more details see for instance [4]). The set X is then called a *Partially Ordered Set* (*POSET*). Based on the POSET theory, synthetic measures out of a set of ordinal variables have been proposed to evaluate socio-economic phenomena ([1]). For simplicity, consider a phenomenon that can be measured using three binary indicators X_1, X_2 and X_3. Two *profiles* p_a and p_b, i.e. two combinations of values the three variables, are *comparable* if and only if $p_a \geq p_b$ for all variables, otherwise it is said to be *incomparable*. This means that they could be ordered in different ways, technically speaking there exist different *linear extensions* (see [5] for formalisation). It is possible to set a threshold profile τ so that profiles that are above τ or below τ can be classified in one of two groups, for example having bad/good health (see [2] for considerations on the effects of the choice of the threshold).

Let $\Omega(P)$ be the set of all linear extensions on a POSET P and let $r_l(p)$ be the rank of profile p on a linear extension $l \in \Omega(P)$, measures that evaluate the degree of membership to a group (*identification* function) and the depth of a profile into a group (*wealth* and *severity* functions) can be computed (see [4] for more details). In this work, we evaluate the *Height* of a profile using a synthetic measure proposed in [2] that synthesizes wealth and severity. It is given by the following:

$$H_\tau(\mathbf{p}) = wea(\mathbf{p}) - svr(\mathbf{p}) = \frac{1}{|\Omega(P))|}\sum_{l\in\Omega} wea_l(\mathbf{p}) - \frac{1}{|\Omega(P))|}\sum_{l\in\Omega} svr_l(\mathbf{p}) \qquad (1)$$

Refer to [4] for details on the calculation of $wea_l(\mathbf{p})$ and $svr_l(\mathbf{p})$. Here index H_τ (appropriately normalised) has high values for profiles in good health.

3 Data and Results

In this paragraph, we use the described method to evaluate physical and mental health conditions of aging population in Italy. We use data from the 2013 Multipurpose Survey on Health Conditions carried out by the Italian National Institute of Statistics and we focus on people aged ≥ 65 years. We build two indicators, one for physical health and one for mental health, using the variables in the SF12 ([8]). The threshold was chosen based on external information.

In order to better understand which elementary variables characterise low and high values of the health indicators, we implemented a regression tree where the two synthetic indicators are included as output variables and the simple indicators as regressors. Synthetic results are given in Table 1. The table shows the size of groups obtained, along with the average value of $H_\tau(.)$ for physical and mental health (calculated using variables $X_1 - X_6$ and $X_7 - X_{12}$ [1] respectively), and the values of the elementary indicators at each splitting node. With regards to physical health, note for instance that physical limitation (X_2) discriminates well for groups of people with very bad health, while X_6 discriminates well for nealry all groups. Similar considarations can be made on mental health.

4 Final remarks

In this paper we evaluated health of aging population in Italy using two composite indicators built using a poset-based approach. This approach has the advantage of preserving the ordinal nature of the involved variables without the need to make any aggregation while allowing for evaluation. We investigated which simple indicators play a role in discriminating "health groups" and found that indicators are not equally important in discriminating groups of healthy people.

[1] X_1: Perceived health; X_2: Limited activities; X_3: Difficulties in climbing several fights of stairs; X_4: Accomplished less due to phyisical condition; X_5: Limited work due to physical condition; X_6 Pain interferes with everyday activities; X_7: Accomplished less because of emotional status; X_8: Less concentrated because of emotional status; X_9: Felt calm; X_{10}: Felt full of energy; X_{11}: Felt sad; X_{12}: Emotional status compromised social life

Table 1 Groups as identified by the regression tree

	group	n	$\bar{H}_\tau(.)$	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
Physical Health	1	3918	0.038	-	1	-	-	-	1-2	-	-	-	-	-	-
	2	2589	0.230	-	2-3	-	-	1	1-2	-	-	-	-	-	-
	3	941	0.318	1-2	-	-	-	1	3-4-5	-	-	-	-	-	-
	4	647	0.598	-	2-3	-	-	2-3	1-2	-	-	-	-	-	-
	5	3595	0.624	3-4-5	-	-	-	1	3-4-5	-	-	-	-	-	-
	6	2603	0.782	-	-	-	-	2-3	3	-	-	-	-	-	-
	7	12710	0.964	-	-	-	-	2-3	4-5	-	-	-	-	-	-
Mental Health	1	3834	0.037	-	-	-	-	-	-	-	-	1-2	-	1-2	1-2
	2	4426	0.225	-	-	-	-	-	-	-	-	1-2	-	3-4	1-2
	3	2164	0.349	-	-	-	-	-	-	-	-	1-2	-	1-2-3	3-4-5
	4	2085	0.403	-	-	-	-	-	-	-	-	3-4	1-2	-	1-2
	5	1695	0.6	-	-	-	-	-	-	-	-	1-2	-	4	3-4-5
	6	847	0.726	-	-	-	-	-	-	-	-	3-4	3-4	-	1-2
	7	3935	0.793	-	-	-	-	-	-	-	-	3-4	1-2	-	3-4-5
	8	8017	0.98	-	-	-	-	-	-	-	-	3-4	3-4	-	3-4-5
Range				1-5	1-2	1-2	1-3	1-3	1-5	1-2	1-2	1-4	1-4	1-4	1-3

As the approach we consider is based on a threshold that we set externally, we would like to further investigating the choice of such threshold in order to make our evaluation more robust.

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