MEASURING THE CAPABILITY OF LIVING A HEALTHY LIFE WITH FUZZY LOGIC IN A GENDER PERSPECTIVE

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Abstract: The capability of living a healthy life may be considered a key dimension in the construction of individual well-being. It is itself the outcome of a complex set of indicators also including subjective indicators. This paper measures health at an individual level by using fuzzy logic to maintain the complexity of its definition while providing a crisp indicator of the level of health which may be disaggregated in relevant intermediate variables. The system has been implemented on the basis of the Italian National Statistical Institute (ISTAT) survey on health conditions, the results of which show a higher level of gender inequality in health than ,may be obtained by the traditional techniques used to measure health. We do find that when controlling for age, women are still characterized by poorer health conditions. Data disaggregated by regional area show a degree of variability in the outcome which may be connected to the varying policies implemented in different regions of Italy.

1 INTRODUCTION

This paper presents the initial results of a wider research project supported by the Italian Ministry of Health on gender and health[1]. It is made up of six projects, each dealing with different aspects from a gender perspective. One of these projects, that developed by the research unit of the University of Modena & Reggio Emilia, is concerned with the socio-economic determinants of health from a gender perspective. We thank the expert group on health (Sivana Borsari, Maria Cristina Florini and Erica Villa) for their comments on the construction of the model used to measure health; Anna Maccagnan for her elaborations of the microdata and the other participants in the project for their comments on a previous version of this paper.

This idea is supported by the increasing attention given in recent years to gender differences and inequalities, which no longer come down to mere biological factors also seen within a wider perspective that includes the concept of women's capability of living a healthy life. Nonetheless, in Italy we observe a systematic lack of appreciation of "gender-oriented health", fundamental to guaranteeing equity and planning efficient health and social services. In our group's project, the evaluation of the gender factor will refer to four dimensions: access to services, objective and subjective health, life styles and states of well-being. The classical definition of a country's well-being is usually connected with GDP measurements. The need to take the health dimension into account in the evaluation of well-being in order to go beyond GDP and towards an extended measurement of human development has been widely recognized in the literature (Fleurbaey, 2009), (Stiglitz et al., 2009) leading to the proposal of indicators that measure human development and explicitly include measures of the health dimension such as the Human Development Index (United Nations Development Programmes, 1990). Here we follow Sen's capability approach (Sen, 1993) by measuring well-being in its multidimensional setting devoting special attention to one dimension: the capability of living a healthy life.

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In defining this capability we are aware of its complexity stemming from various dimensions (physical vs mental health; subjective vs objective) and bound up in the social environment that affects its development. In order not to lose its complexity while measuring it, we adopt fuzzy logic. Fuzzy logic is ideal, in our opinion, since it allows us to get to the heart of the development process of the capability without losing the various dimensions that interact to define it.

An attempt to exploit fuzzy logic to measure healthy living has previously been undertaken by Pirotti (2006) using Italian microdata (yet with a limited number of variables to define health) and by Addabbo et al. (2010a) to measure the capability of living a healthy life in the Modena district. However, this is the first attempt to implement a fuzzy inference system on the definition of living a healthy life with a large number of dimensions at national level in Italy. Due to the different methodology adopted, this work differs in methodological terms, from other previously published papers, dealing with the issue of health from a capability perspective (Kuklys, 2003). The fuzzy technique in fact allows us to preserve the complexity of the measuring issue and, at the same time through a system of rules,to make explicit the relationships between the variables that help to assess the degree of capability development. The presence in the project of experts in health problems has helped us in fuzzy inference building, in the fuzzification of inputs and in the rule construction. But our purpose is also to compare our "non main stream" approach with a classical method to look at differences, faults and values. So we have looked at the SF12 questionnaire, which is an instrument adoptedto measure the "health level" widely used (in over 40 countries) and validated by the international scientific community. It has been in use since 1992, when the Medical Outcomes Study (MOS) developed a standardized survey form made up of 115 items synthesized in 12 steps. The MOS was a two year study of patients with chronic conditions that set up to measure the quality of life, including physical, mental and general health. The SF-12 requires only two minutes to be filled in, and it can be self-reported. It can be added to larger surveys or printed on a single sheet and easily faxed away. Due to its handiness, yet still being of great meaningfulness as stated before, during the last decade the use of SF-12 has spread throughout the world. Even the Italian National Institute of Statistics (ISTAT) decided to add an SF-12 section to its 2005 national health survey. So we carried out our analysis using the Italian Statistical National Institute survey on health conditions in 2004-2005, which provides a set of variables well-suited to the information needs for the treatment of the topic in question. Particularly relevant for the purposes of this work is the information on the measurement of health-related elements of quality of life, such as obesity, certain diseases, disabilities, on specialist visits and visits to the ER. Moreover, the survey contains information on factors that may affect the capability of living a healthy life and/or its conversion in functionings. Amongst them, we may identify in the light of Sen's capability approach: *Socio/Institutional factors*. These refer to the presence of social services in the region where the individual lives. In a further extension, we will also include data on the health structure available. In this specification of the model, we do take into account these factors by including regional dummies (given the uneven presence of health services in the Italian regions). *The individual factors:*age, gender, educational level and employment conditions. We expect to find a negative correlation between age and health status due to the worsening of health conditions experienced by the elderly. As regards the level of education, it is now documented extensively in the international literature that higher education is usually associated to a better health. This is due to a greater awareness of the importance of lifestyles on health and also to improved access to health services(Mackenbach et al., 2003). Furthermore a higher education level allows for a wider choice about of jobs that individuals may take and access to posts characterized by healthier conditions as well as a higher income, which may improve access to health services. Individuals employment status may be considered a crucial individual conversion factor: some contractual arrangements, like temporary work contracts, given their high level of instability, may have a negative effect on health, mainly due to the stress induced by the uncertainty linked to the job security (Addabbo and Favaro, 2011). Individual health status, as experienced in literature, is also influenced by *familiar conversion factors* such as parents' education level, marital status, parents' level of health, family income and housing conditions. These factors can affect lifestyles, for example, or access to health services.The fuzzy approach we propose provides all the values of the knowledge-based systems. Everything is transparent; the rule blocks, which translate the weights proposed by the experts, are readable and always justified and may be changed if necessary. SF12 applied to the ISTAT 2005 national survey on health is not able to produce this effect as its results are based on a weighted average. Moreover, the weights used to compute the weighted average were evaluated in 1994 using data based on the 1992 MOS survey for the USA (Ware Jr et al., 1998); thus, one may question the validity of the same weights years later and in a

different country. On the other hand, though affected by the reliability of experts and the need to use a more complex methodology, fuzzy logic with its tree structure of the inference system, allows us to understand the inputs that produce the final result and to improve the final outcome by devising policies in those areas that appear to be less developed.

2 THE USE OF A FUZZY INFERENCE SYSTEM WITHIN A CAPABILITY APPROACH FRAMEWORK

Fuzzy logic has been previously used to measure poverty and well-being by Cheli & Lemmi (1995) and, by following the capability approach, by Chiappero Martinetti (2000). However the method they follow is different from the one adopted in our contribution. In fact they use a mix of probability theory and fuzzy logic and data are used to build variables distributions similar to aleatory distributions, while the aggregation functions are similar to weighted averages, explained on the basis of weights that are determined ex-ante. In this method the creation of the membership functions relies on the distribution of every single variable in the population of reference. In our contribution, we use fuzzy logic following more heuristic methods, which, in our opinion, are more effective and able to reflect the multidimensionality of the issue of measuring capabilities without depending on current data. The system is constructed by following experts' judgments and rules based on their experience and/or on the literature. The experts start by choosing the 'input' variables, they then propose their aggregation with 'intermediate' variables and then to an output variable. The latter is interpreted as the final evaluation of the development of the functionings of the capability under analysis. Experts are also responsible for identifying the membership functions of the initial variables; therefore, unlike the method followed by Chiappero Martinetti (2000) the latter do not depend on the current available data, but are set by the experts on the basis of their experience. Experts suggest how to aggregate input variables by using only linguistic rules and attributes without seing the data in advance. The experts' linguistic rules are translated formally by mathematicians. The proposed system of rules is then explicitly described 'rule by rule', allowing us to understand to what extent the results depend on the ratings determined by the experts. The method we apply here to measure of the capability of living a healthy life has already been used on an experimental basis for the measurement of well-being within the capability approach, (Addabbo et al., 2004; Addabbo et al., 2006; Addabbo and Di Tommaso, 2008; Addabbo et al., 2010b) and specifically for the measurement of the capability of living a healthy life by Pirotti (2006) and by Addabbo, Chiarolanza, Fuscaldo and Pirotti (2010).

3 THE SHORT FORM 12 (SF-12)

This questionnaire is a set of 12 questions relating to the condition perceived over the four weeks prior to the interview, allowing us to compile two indexes: the Physical Component Summary (PCS) (index of physical health) and Mental Component Summary (MCS) (index of mental health), with values from 0 to 100. Because of its brevity and simplicity, it is widely used in more than 40 countries and has been validated by the international scientific community(Gandek et al., 1998). SF-12 is based upon a 12 questions tool of analysis that has its roots in the instruments used since 1992, when the Medical Outcomes Study (MOS) developed a standardized survey form consisting of 115 items synthesized in 12 steps. MOS was a two-year study of patients with chronic illnesses which aimed to measure the quality of life, including physical, mental and general health. As part of the MOS, RAND, (acronym of Research and Development) developed the 36-Item Short Form Health Survey (SF-36): a set of generic, coherent and easily administered quality-of-life indicators. These measurements rely upon patient's self-reporting; thus the administration of the survey is very handy, yet a wide range of literature has backed up the quality of the results assessed by this survey. Through the analysis of case studies collected during the MOS project, RAND selected eight groups of questions, or health concepts, from the original 40 (Ware Jr et al., 1996). Those chosen represent the most frequently measured concepts in widely-used health surveys and those most affected by disease and treatment (Ware Jr et al., 1993). The questionnaire items selected also represent multiple operational indicators of health, including: behavioural function and dysfunction, distress and well-being, objective reports and subjective ratings, and both favourable and unfavourable self-evaluations of general health status (Ware Jr et al., 1993). This psychometric survey was first developed in the US and then developed internationally over the last 10 years. The SF-36 idea is based on a three-level tree scheme, starting from the single 36 items, aggregating them in eight scales and defining the summary measures of physical and mental health on the third level (respec-

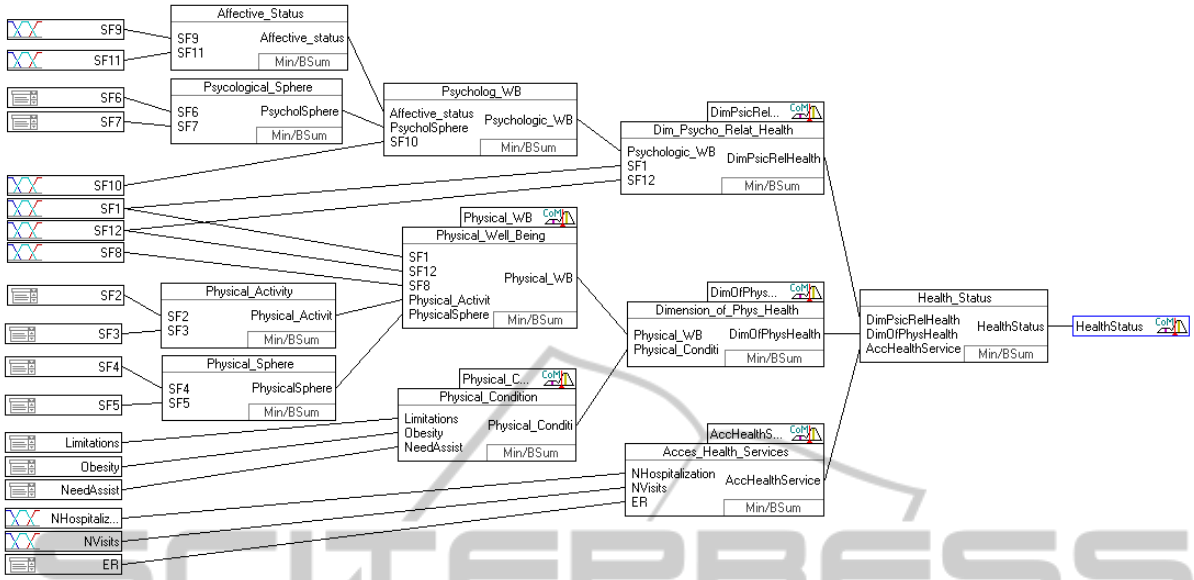

Figure 1: The chosen fuzzy inference system tree.

tively PCS and MCS). The discovery that SF-36 physical and mental component summary scales (referred to as PCS-36 and MCS-36 respectively) capture about 85% of the reliable variance in the eight-scale SF-36 health profile provided a new strategy for meeting this challenge. While two outcome measures are satisfactory for many purposes, a survey with fewer questionnaire items could be constructed to estimate these outcomes. Predictive studies supported this strategy. 12 SF-36 items and improved scoring algorithms reproduced at least 90% of the variance in PCS-36 and MCS-36 in both general and patient populations, and reproduced the profile of eight SF-36 health concepts sufficiently for large sample studies. The reproductions of PCS-36 and MCS-36 proved to be accurate enough to warrant the use of published norms for SF-36 summary measures in interpreting SF-12 summary measures. The SF-12 Survey represents an efficient synthesis of SF-36. Several empirical studies also conducted in European populations showed that the synthetic indices of the SF-12 correlated with the corresponding indices of the SF-36 with a range of values between 0.93 and 0.97 (Gandek et al., 1998). SF-12 requires only two minutes to be filled in, and it may be self-reported. It can be added to larger surveys or printed on a single sheet and easily faxed away. Due to its handiness, yet still being of great meaningfulness as stated before, over the last decade the use of SF-12 has spread all over the world. Even the Italian National Institute of Statistics (ISTAT) decided to add an SF-12 section to its 2005 national survey on health. We will use variables collected in the ISTAT Survey by using SF-12s to construct our fuzzy inference system (FIS) on the capability of living a healthy life and compare the results obtained through FIS to the original SF-12 outputs.

4 A FUZZY INFERENCE SYSTEM TO MEASURE THE HEALTH OF THE ITALIAN POPULATION

A fuzzy inference system (FIS) (Figure 1) may be graphically represented as a tree. Starting from the right hand side we see the output of the system: the health status. Moving to the left, the tree grows and presents various nodes, representing the intermediate variables describing the macro-indicators, through to the smallest branches which show the initial inputs. The basic input variables that appear on the left side of the tree conceptually pertain to three different areas: the first, concerning perceived physical and mental health; the second, whicj attains to more objective indicators of physical health, and the third, which regards access to health services. Lifestyles were not taken into account because they represent risk factors in the medium and long term but they are not “manifestations” of the immediate state of health of individuals. What we aim to do here is instead to understand the health status over a relatively short period, such as the last four weeks. Instead of directly using SF-12 outcomes, available as a ready to use variable, we decided to build a “fuzzy SF-12”, the results of which (Physical Well-being and Dimen-

Table 1: The system variables: abbreviations and relative questions.

ER	Did you need assistance from the ER during the last 12 months?
Limitations	Did you experience limitations during at least the last six months?
NeedAssist	Do you think that you need house care assistance?
NHospitalizations	Number of Hospitalizations in the last 3 months
NVisits	Number of visits during the last 4 weeks
Obesity	Are you obese?
SF1	In general, would you say your health is: excellent, very good, good, fair or poor?
SF10	How much of the time during the past 4 weeks did you have a lot of energy?
SF11	How much of the time during the past 4 weeks have you felt downhearted and blue?
SF12	During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?
SF2	Does your health now limit you in moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf
SF3	Does your health now limit you in climbing several flights of stairs?
SF4	During the past 4 weeks (relatively to your work or other regular daily activities as a result of any physical problems) did you accomplished less than you would like?
SF5	During the past 4 weeks, as a result of any physical problems, were you limited in the kind of work or other regular daily activities?
SF6	During the past 4 weeks (relatively to your work or other regular daily activities as a result of any emotional problems such as feeling depressed or anxious) did you accomplished less than you would like?
SF7	During the past 4 weeks, as a result of any emotional problems such as feeling depressed or anxious, didn't you do work or other regular daily activities as carefully as usual?
SF8	During the past 4 weeks, how much did pain interfere with your normal work (including both paid work and housework)?
SF9	How much of the time during the past 4 weeks have you felt calm and peaceful?
AccHealthService	Access to the Health Services
DimOfPhysHealth	Dimension of Physical Health
DimPsicRelHealth	Dimension of Psycho-Relational Health
HealthStatus	Health Status
Physical_Conditi	Physical Condition
Physical_WB	Physical Well-being
Affective_status	Affective Status
Physical_Activit	Physical Activity
PhysicalSphere	Physical Sphere
PsycholSphere	Psychological Sphere

sion of Psychological and Relational Health) could be used as intermediate variables for the final "status of health index" and at the same time, be compared to the original Physical Component Summary (PCS) SF-12 index of physical health and the Mental Component Summary (MCS) SF-12 index of mental health. The reason for this choice is that, as already stated, even though the SF-36 idea relies on a tree scheme basis, SF-12 outcomes are obtained as a reduction of the variables based on a statistical basis that makes impossible to reconnect the final SF-12 analysis scheme to the original logic that guided the researchers in first place. According to the SF-12 operative manual, MCS and PCS are built through the use of weighted means, using regressive coefficients coming from analysis based on the American population. However, the coefficients are given and derived from SF-36 coefficients that, in turn, come from the original 115 questions of the MOS survey; therefore, it is hard to trace back the path that led to the construction of the coefficients. Moreover, we believe that the assumption that the coefficients estimated using a sample representative of the American population in the mid '90s remains valid even when applied to the analysis of other countries and almost ten years later is rather strained. There is no guarantee of the validity of results. As a last consideration, we must notice that MCS and PCS are two indica-

tors that have been designed to be two well separated indexes, not to be bundled toghether in a single synthetic health indicator. Instead in our opinion, supported by our health experts' opinions and by the literature, it is possible to proceed with the construction of a third synthetic index that takes into account elements of both dimensions. For this reason, even if we assume that SF-12 results are proven to be reliable, we wanted to produce indexes whose results could arise from immediately understandable choices and that could also produce a unified health index. Our "fuzzy SF-12" is hence an expert system, driven by experts' judgments, so that the survey outcomes are the direct reflection of a precise will, connected to the analysis of the specific Italian framework. Moreover in our evaluation system, following Wagstaff et alt. (1991) we have decided to propose not just the PCS and MCS scheme, but three macro-indicators (physical and mental health, physical condition and access to the health services). The "health" of the fuzzy system's final output (Health Status) investigated from a physical point of view (physical health dimension) and a mental or psychological point of view (mental health dimension) use the items in the SF-12 survey; however, it is not just the result of the use of these items: firstly we have a third dimension, bound up in the actual use of services and structures connected to the healthcare service. Thus in our vision there are not just two dimensions but three. We have noticed that SF-12 items are far too connected to a subjective evaluation of health. This third leg of the tree helps to connect subjective to objective information. In addition to this the physical health dimension is not just the result of the elaboration of the SF-12 items, but, for the same reason, we have added physical objective data. Looking at the PCS items, it becomes clear that the items attain to "Physical Well-being". For a comprehensive evaluation of health, its perception represents an important reference as it helps to capture the multidimensionality of the concept itself, defined according to the World Health Organization as a state of "complete physical, mental and social wellbeing" (Di Martino, 2008). Adding information about people's physical conditions greatly helps to better evaluate the dimension of physical health. In this way functional indicators define health in relation to the loss of skills in performing 'normal' daily activities. Medical indicators identify the presence of specific diseases or disabling conditions diagnosed by physicians. Subjective ones,on the other hand, define health according to the perception of the individual. In a fuzzy system, the same variable can be used several times. The complexity of relationships between different determinants of individual health is indicated by the presence of some input variables, in keeping with the literature in more than one dimension of the state of individual health. The "access to health care services" dimension comprises information (or basic variables) as the number of hospitalizations (excluding childbirth hospitalizations), over the past three months, the number of accesses to the Emergency Room (ER) over the past 12 months, not counting the so called white codes, meaning wrong or unnecessary accesses to the ER, and the number of doctors's visits, excluding dental visits. As may be easily understood, the effect of these variables (and of the intermediate index) on the final variable, "individual health status" is negative because a high number of accesses to health services is likely to be connected to a poor health status. In order to fuzzify the inputs, the experts have decided to identify three linguistic membership functions per each variable, respectively named "none", "some" and "many". These are applied to "number of visits", for which 0 is connected to the spike of none, 2 to the spike of some and 4 to the spike of many.

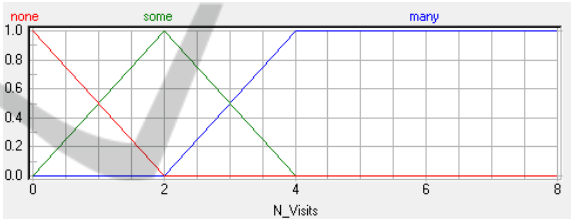

Figure 2: Fuzzyfication scheme and membership functions of N_Visits.

The same membership functions (MBFs) were applied to the number of hospitalizations, so that 0 is associated to none, some to 3 and many to 5. The access to the ER instead is just a dummy and it tells us whether an individual had to ask for assistance over the previous 12 months.

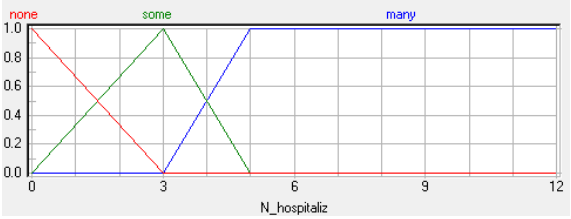

Figure 3: Fuzzyfication scheme and membership functions of N_Hospitaliz.

The aggregation method amongst fuzzified variables is not an explicit function, but it is expressed in the form of the explicit rule block, where every possible interaction between the fuzzy sets (for instance none, some and many(is represented by a block line

in the "IF" part, while the effect on the variable on which they insist is represented by a synthetic lexical effect in the "THEN" part. Since more than one rule may be activated at the same time, every rule is activated with the MIN aggregating rule, which stands for the minimum level of activation between the sets (always between 0 and 1), acting in the "IF" part. If a term is activated with a level of 0, it means that it is absolutely not activated (the data do not belong to that fuzzy set). On the other hand if the level is 1 it means that the term is fully activated, meaning that the data belongs entirely to that specific term and just to that one. Every number in between stands for a partial belonging between different fuzzy sets. The way the membership degree to a particular fuzzy set is decided depends on the specific membership function of every fuzzy set. On the THEN side, there may be many lines that lead to the same lexical effect. If there are more activated lines in the same rule block with the same effect, the chosen aggregation rule is the bounded sum (BSUM): all the effect activation levels get summed up tol the level of 1. Any effect added to that level produces no result. The described aggregating process, through the use of rule blocks, is iterated from the left to the right of the system tree. At the end of the process, to make the results intelligible to human beings it is necessary to de-fuzzify them. This is done with a system called "Center of Maximum" or, in short, CoM: if more effect are active at the same time in the final rule block, only the highest will be considered and the result will be equivalent to the peak of its membership function.

The variable named "Dimension of Physical Health" was designed to be an aggregation between the "Physical condition" and the "Physical Well-being". The "Physical condition" identifies health conditions caused by chronic or incapacitating diseases through objective indicators such as the presence of limitations for at least six months, need for home care, and finally the presence of obesity, discriminated by body mass index values over 30 among over 18s, while in the population below 18 years of age, the corrections suggested in the literature were adopted (Cole et al., 2000). While the first of the three basic indicators may be seen as a categorical variable on three levels, the other two are dummy variables. "Physical well-being", contributing to the definition of the "Dimension of physical health", uses some of the 12 items that make up the SF-12 questionnaire. The reason was to identify the most significant scales underlying the conceptual model, which lead to the creation of the PCS of the SF-12 survey (Apolone et al., 2005; Gandek et al., 1998). Therefore, in detail the input variables are conceptually related to the following scales: general health, bodily pain, physical functioning play their role into the definition of the "Physical well-being" intermediate factor. This intermediate variable therefore contains the subjective evaluation of individual general health conditions, given by the interviewee, his perception of physical limitation due to pain at work and during usual social activities with family. The other intermediate variable taken into account is the "Dimension of Psychological and Relational Health", whose purpose is to evaluate individual health from a psychological-well being point of view. The dimension of Psychological and Relational Health is deliberately made up of many variables relying on the scales that are the main components of PCS in the SF-12 analysis: vitality, social functioning, emotional role and mental health. The aggregating process described, through the use of rule blocks, is iterated from the left to the right of the system tree. At the end of the process, to make the results intelligible to human beings it is necessary to de-fuzzify the results. This is done by using the Center of Maximum method described above.

Table 2: A rule-block example:the access to health services.

If			Then
Hospitalizations	**Visits**	**E.R.**	**Health Service**
none	none	No	very low
none	none	Yes	low
none	some	No	low
none	some	Yes	low
none	many	No	low
some	none	No	low
none	many	Yes	medium
some	none	Yes	medium
some	some	No	medium
some	some	Yes	medium
some	many	No	medium
many	none	No	medium
some	many	Yes	high
many	none	Yes	high
many	some	No	high
many	some	Yes	high
many	many	No	high
many	many	Yes	very high

5 THE INDIVIDUAL HEALTH STATUS IN ITALY AND THE ROLE OF OBSERVABLE CONVERSION FACTORS

In this paragraph we will analyze the results of the FIS applied to health, trying to place some personal

or social factors in relationship with the development of the capability of living a healthy life. The degree of development will be approximated using the final output of the FIS presented in the previous paragraph. The sample for this analysis, as already stated, comes from the Italian National Institute of Statistics survey on health for 2004-2005. In particular, the object of our investigation is the subset of people over 14 who did not present any missing values on the variables chosen to run the FIS. In fact, one of the main prerequisites of an FIS is that the data matrix has to be dense. Since our dataset contains a relatively high number of observations, this prerequisite can be easily satisfied: the final sample is made up of 111,151 individuals, weighted to be significant both at a national and at a regional level. In Table 3 we compare the results on the measurement of the two Phsycological Health indicators: the fuzzy DPRH and the SF-12 MCS, while in Table 4 we compare the results obtained for the two Physical Health indicators the fuzzy PWB and the SF-12 PCS. Table 5 contains the results of the Fuzzy final output value on Health by gender and age.

Table 3: A comparison between the two Psychological Health indicators: DPRH and MCS.

Age Classes	DPRH		MCS	
	Men	Women	Men	Women
15-24	88.64	84.34	53.70	51.36
25-34	85.56	81.05	52.58	50.52
35-44	82.14	78.34	51.59	49.88
45-54	78.50	72.89	50.81	48.60
55-64	74.21	67.73	50.43	48.03
65-74	68.20	59.99	49.67	46.43
75+	56.21	47.84	47.16	44.09

Standardizing both the outputs of the evaluation system on a 0-100 range, we discovered that the fuzzy indexes are generally higher than MCS and PCS with respect to all the age classes, for both genders, but it is also pretty clear that the variability of the fuzzy indexes is much higher; hence the fuzzy outcomes are more sensitive to the changes caused by age. Furthermore, even though the results are generally higher, the trends are the same: women's health is worse than men's at every age, with a strong and constant decrease over time.

This result is also confirmed by the trend in the main index (Health Status), which is higher, on average, among the youngest individuals, a little better for men than for women, decreasing with age. All the indexes obtained and analyzed present a similar trend.

If we consider people's health status and we compare it now with their employment status, we see that the results are fairly consistent with what we might

Table 4: A comparison between the two Physical Health indicators: PWB and PCS.

Age Classes	PWB		PCS	
	Men	Women	Men	Women
15-24	92.35	90.60	55.28	55.31
25-34	90.45	87.71	54.52	53.95
35-44	88.19	85.98	53.59	53.12
45-54	85.49	80.93	52.43	51.13
55-64	80.99	74.22	50.38	48.27
65-74	72.97	63.55	46.96	44.10
75+	55.46	44.23	40.39	36.87

Table 5: The average Health Status index by gender and age class.

Age Classes	Men	Women
15-24	87.19	85.13
25-34	88.46	85.87
35-44	85.91	84.02
45-54	83.20	80.02
55-64	79.83	75.79
65-74	74.87	69.48
75+	65.50	59.61

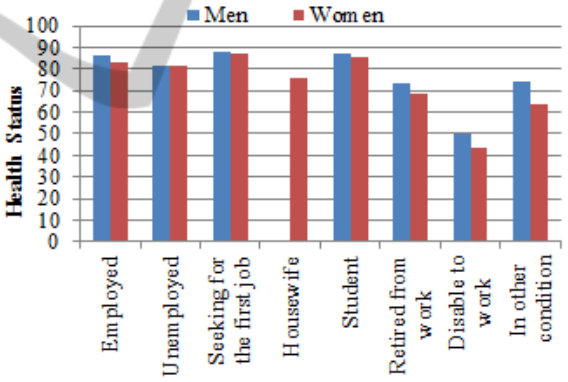

Figure 4: The average Health Status by gender and employment status.

expect: students and people seeking their first job are expected to be younger and they actually receive the highest marks. On the other hand, we find people who are retired from work whose health status is worse given their average higher age.

But if we consider employed and unemployed people (Figure 4) we see that these two groups, which apparently should not differ so much as regards their average age, present quite different marks: 85.95 for the employed males against 81.62 for the unemployed and 83.48 for the employed women, compared to 81.48 of the unemployed women. This is in line with the health costs linked to unemployment status as outlined in Sen (1997). Turning to education (Figure 5),

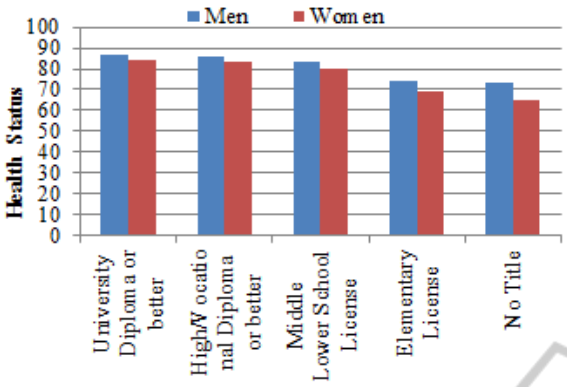

Figure 5: The average Health Status by gender and educational level.

the data confirm what the literature claims as common ground: a higher educational level is positively related to individual health. We then completed our analysis by estimating a multivariate OLS regression model that allows us to take into account the weight of the different conversion factors on the index of living a healthy life resulting from the implementation of our FIS model (Table 6) to the data.The results obtained confirm a negative effect of ageing on the fuzzy measure of health and, having controlled for age, one can see that women are still characterized by worse health than men. Health improves when the education level is higher. Turning to employment conditions, we may see that controlling for age and education levels, if one holds a temporary work position, his/her health status deteriorates (the control variable being employed on a permanent basis). Joblessness is also consistent with Sen's analysis (1997) leading to lower health. Those living in the South of Italy show a lower level of health achievement, and this is probably connected to worse health infrastructures in the South of Italy. Deeper analyses on regional variability will be performed in further research by matching our population data with health infrastructures administrative data.

Table 6: Health Status: a multivariate analyses (standard errors in parenthesis).

Variables	**Health**
Age	-0.184*** (0.00186)
Woman	-0.0401*** (0.00142)
Married/Cohabiting	0.0516*** (0.00143)
Diploma	0.0487*** (0.00151)
Degree and more	0.0712*** (0.00237)
Temporary	-0.00978*** (0.00330)
Retired	-0.0772*** (0.00212)
Disable to work	-0.539*** (0.00551)
Other empl. condition	-0.0563*** (0.00178)
Unemployed	-0.0282*** (0.00302)
South	-0.0125*** (0.00139)
Constant	5.060*** (0.00671)
Observations	111.151
R-squared	0.187

6 CONCLUSIONS

In the analysis of individual well-being, health status is a central dimension. In this paper we have analyzed the individual health status by considering its multidimensional nature. In order not to lose its complexity we have proposed a modular approach (the fuzzy tree diagram) which allows us to obtain an index on health without losing single macro-index information. The choice, interaction and the effects of the various available indicators were chosen by the authors on the basis of health experts' opinions, expressed through linguistic rules. This methodology reduces the debated problem of the numerical attribution of weights. The health status (the final output of our fuzzy inference system) is determined by the interaction in the FIS of access to health services, the dimension of mental health and that of physical health. The first innovative product is thus precisely the use of a fuzzy inference system on the health status since it shows the individual settlement through the combination of the observable variables in the survey on the health status of the Italian population. We then analyzed the crisp value produced in relation to individual and family variables which may interact with the very fundation of a healthy condition. During the construction of the intermediate variables and of the whole system, the method that we applied maintains the complexity of the definition of health status, while at the same time, is able to produce a synthetic and numeric index. On average, the health status index of the Italian population is found to be lower for women than for men and for people holding unstable working positions, without work or living in the South. Further developments are at two different levels. The first, follow-

ing Addabbo et alt.(2010a) will be in a local direction, the analysis will be replicated to a more homogeneous area (the province of Modena). At national level we aim to match the survey data on the population with regional administrative data on the health infrastructures to allow for a deeper analysis of the impact of health services on individual health outcomes.The results of our research on the construction of a new index of the capability of living a healthy life can then be transferred - by a researcher from our research unit - to the Italian Commission on the Definition of the Quality of Life created in April 2011 by the Italian National Institute of Statistics (ISTAT) and the National Centre of Economics and Labour (Cnel) both because health is a relevant dimension in the construction of the quality of life, and because of the innovative methodology used for its measurement.

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