

AIQUAV 2019

VI Convegno Nazionale dell'Associazione Italiana
per gli Studi sulla Qualità della Vita

Benessere Collettivo e Scelte Individuali

Fiesole (FI), 12-14 Dicembre 2019

Libro dei Contributi Brevi

a cura di

Leonardo Salvatore Alaimo, Alberto Arcagni, Enrico di Bella,
Filomena Maggino e Marco Trapani



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è il marchio editoriale dell'Università di Genova



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Eligibility to Long-Term Care in Italy: a novel fuzzy approach and its implications on coverage

Ludovico Carrino¹ and Silvio Giove²

Abstract *We propose a fuzzy approach for allocating home-care allowances to older people affected by functional or cognitive limitations. Population ageing makes access to care a crucial challenge for Western economies. Public programmes of care in Europe determine access to care-benefits using rule-based approaches which aggregate basic health-outcomes into eligibility categories. Focusing on the Italian Toscana region, we show how such legislations violate basic properties of monotonicity and continuity, thus potentially increasing inequity in care access. By using micro-data from SHARE, we show how a fuzzy approach to the eligibility determination would increase care-coverage to sick individuals previously left uncovered, lower the average benefit among receivers, and increase total spending.*

Parole chiave: Home-Care, Ageing, Eligibility, Inequality, Membership functions.

Gruppi tematici: 3. Lavoro e politiche sociali; 23. Qualità della vita e disabilità.

1 Introduction

While both longevity and health conditions have largely improved in the last century in many developed countries, disease-free life-expectancy indicators have increased at a much lower pace and a significant degree of health inequality is emerging among different socioeconomic groups [1]. Due to a higher prevalence of disability conditions and to a higher number of disorders limiting the autonomy of individuals, there has been a substantial increase in the rate of older people in need of Long-Term Care (LTC), defined as services required by persons with limitations in basic Activities of Daily Living (ADL) and instrumental Activities of Daily Living (iADL).[2-4] In order to postpone the onset of severe disability and reduce social exclusion in older age, policy makers have focused on implementing proactive and inclusive programs of formal home-care [3, 5].³

Crucially, the literature has highlighted that a crucial determinant of inequality in care-access and coverage is played by eligibility rules, which are policy tools defining the

¹ King's College London; e-mail: ludovico.carrino@kcl.ac.uk

² Ca' Foscari University Venezia; e-mail: sgiove@unive.it

³ *Formal home-care* includes all care services that are provided in the context of formal regulations (acknowledged by the Social or Health departments). *Informal-care* refers to the unpaid assistance provided by partners, adult children and other relatives, friends or neighbors of the dependent older person.

target population in ‘need-of-care’: they represent a compulsory gateway to receive home-care benefits, either in-kind or in-cash [2, 6, 7]. However, there is limited evidence on how eligibility algorithms affect horizontal equity in care-access (people with similar needs should receive similar benefits) and vertical equity in care-access (people with different needs should receive different benefits).

This paper investigates how a rule-based approach which determines eligibility for LTC schemes may impact care-coverage and costs. We implement a Fuzzy Inference System (FIS) as an eligibility Decision System for LTC, and discuss the benefits of this approach. We select Italy’s Toscana region as a case study, due to its comprehensive design (it accounts for several dimensions of loss-of-autonomy such as cognitive, functional and mental health): its eligibility algorithm, which is similar to other systems in France and Germany,[7] is particularly suitable for a FIS application. We show that the existing legislation introduces sharp discontinuities in the relationship between the cash-allowance and the individual health status, which can in turn result in a failure of both horizontal and vertical equity. While some specific marginal change in health conditions may result in large and unjustified changes in the allowance, other large changes in health may not result in an increased care-allowance.

Using microdata from a large European survey on older people, we show that implementing a FIS decision system characterised by an increased granularity and smoothness in the eligibility algorithm, increases the programme’s coverage rate while reducing the average benefit allowed to the eligible population, yet increasing overall costs.

Our contribution is relevant under several perspectives. First, we are among the first who explicitly investigate how eligibility algorithms affect care coverage. This is particularly important given the ongoing policy debate on the trade-off between public budget sustainability and adequate care-provision [8]. Second, we introduce a novel strategy adopting a flexible fuzzy system in the field of Long-Term Care. Third, although our analysis is necessarily restricted to a specific European region, we pave the way for future research on how the care-coverage in Europe might be enhanced by the adoption of a FIS approach.

2 Care eligibility: the Italian case study

In European countries, eligibility for LTC is determined based on the evaluation of functional (ADL and iADL), cognitive and mental health limitations: legislations define an eligibility algorithm which summarizes single health outcomes into an eligibility (for a review, see Brugiavini et al [7]). The Italian public LTC is based on in-kind or in-cash programs which are mostly region-based and whose eligibility rules are not harmonised [7].⁴ In 2006, the Italian government established a National Fund to be allocated to regions in order to provide in-cash or in-kind LTC support (FNNA, *Fondo Nazionale Non Autosufficienza*), while several Regions established a similar Regional Fund (FRNA).

⁴ A nation-wide cash benefit, the *Indennità di Accompagnamento* (IA), is available to individuals classified as *invalid*. Yet, there is no nationwide guideline as to how to assess and evaluate such outcome.

2.1 A case study: Italy's Toscana

Toscana's main regional Long-term Care programme PAC (*Progetto per l'assistenza continua alla persona non autosufficiente*) was introduced in 2010 (regional law n.370/03). The PAC, which is financed by the FRNA, includes benefits in-cash (aimed at compensating professional caregivers) for older adults. The programme is means-tested.[7]

Need of care is assessed through a multi-dimensional approach by a Multi-disciplinary Evaluation Unit (*Unità di Valutazione Multidisciplinare*, UVM) in three main domains: Functional limitations, Cognition, Behavior/depression disorders. Within each domain, the loss-of-autonomy is categorized as either Light, Medium or Severe.

Functional autonomy is evaluated through the Basic Activities of Daily Living scale (BADL), a Katz-adapted list of activities-of-daily-living with seven items. The scale ranges between 0 (no limitation) to 24 (highly limited), according to the need of care required in the last seven days.[9] Cognitive impairment is measured through Pfeiffer's Short Portable Mental Status Questionnaire, which includes questions such as time orientation and working memory (numeric exercises).[10] Its score ranges from 0 (non impaired) to 10 (highly impaired). Depression/behavioural issues are assessed through the MDS-HC guidelines, resulting in a score ranging from 0 (low behavioral/depression risk) to 12 (high risk).

Table 1 summarises the three measures involved and their measurement (further details available elsewhere [7]).

Eligibility rules

By combining the scores obtained in the functional, cognitive and the behavioral/depression dimensions, individuals are categorized in 5 ISO-groups, representing five levels of need-of-care.[11] Group 5 corresponds to the most severe profiles, while group 1 gathers individuals who have at most a light deficit in the three domains (**Table 2**), and a specific benefit allowance is assigned to each of the five ISO groups. The eligibility conditions are as follows:

- Age should be at least 65 years
- Yearly household income should be lower than € 25000⁵
- ISO-group should be 3 or higher⁶

Dependency	BADL scale	Short Portable Mental Score	MDS-HC score
Light	8-14	0-4	0-3
Moderate	15-20	5-7	4-7
Severe	21-24	8-10	8-12

Table 1. Functional, cognitive and behavioral scales, Toscana's PAC

⁵ See, e.g., the regulation of the Casentino district, at: <http://www.uc.casentino.toscana.it/regolamenti/disposizioni-attuarie-anno-2013.pdf>

⁶ The UVM can, in principle, decide to allow some benefit for individuals in groups 1 and 2 (Regional law D.G.R. n.370, Attachment A). This is, however, not specified in the legislation, and we assume no benefit is allowed.

ISO-GROUP	functional deficit								
	light Behav. deficit			moderate Behav. deficit			severe Behav. deficit		
cognitive deficit	L	M	S	L	M	S	L	M	S
L	1	2	3	2	3	4	4	4	5
M	2	2	3	3	3	4	4	4	5
S	3	3	4	3	4	5	4	5	5

Note: L=light dependency; M=medium dependency; S=severe dependency

Table 2. ISO-eligibility groups, Toscana

The amount of the benefit depends on individuals' income (ISEE). For an average-earning individual, the average monthly benefit amounts to (minimum-maximum in brackets):

- ISO-group 1-2: €0
- ISO-group 3: € 140 [€80-€200]
- ISO-group 4: €240 [€170 – €310]
- ISO-group 5: €355 [€260 – €450]

3 The proposed modified fuzzy approach

The Toscana system is an ideal case study for a Fuzzy Inference System application. Subdivision in ISO-groups is a popular strategy in welfare-benefit systems (see, for example, the existing LTC legislations in France and Germany [7]). However, it suffers from some undesired drawbacks. Namely, the crisp border between contiguous classes implies sharp discontinuities (“jumps”) in the output: a small marginal change in one basic health-indicator can shift an individual to the next ISO-group, with a significant variation in the cash-benefit (e.g., ISO-4 provides €100 more than ISO-3). Such a sharp discontinuity in the benefit allocation has no clear economic justification, and may be perceived as a driver of inequity in care-access. Moreover, it can incentivize strategic and, in extreme cases, illegal behaviors.

On the other hand, this method assigns the same benefit to individuals in the same ISO-GROUP, even though some may be characterized by more severe limitations than others.

For such reasons, we claim that ISO-group clustering does not allow for an adequate degree of granularity and smoothness, to guarantee **(i) strong monotonicity of benefit-eligibility to health; and (ii) pseudo-continuity of benefit-eligibility to health.**

As an example, let us consider three hypothetical individuals:

- individual A, scoring 15 in the functional scale (medium), 0 in the cognitive scale (low), and 4 in the behavioral/depression scale (medium); ISO-group 3.
- individual B, scoring 20 in the functional scale (medium), 7 in the cognitive (medium) scale and 7 in the behavioral/depression scale (medium); ISO-group 3.
- individual C, scoring 20 in the functional scale (medium), 7 in the cognitive scale (medium), and 8 in the behavioral/depression scale (severe); ISO-group 4.

Individuals A and B both belong to ISO-group 3 (€140), albeit the former has better health scores and a lower loss-of-autonomy than the latter. The eligibility rule fails to satisfy the (strong) benefit-health monotonicity assumption, thus increasing care-access inequality.

Individual C is otherwise similar to B, but for a lower behavior score by one point, which makes C eligible for ISO-group 4 (€240). A marginal increment in one dimension causes a large change in the monetary outcome, thus violating the pseudo-continuity property.

We argue that a Fuzzy-Logic Inference System (FIS) can enhance both the granularity and the smoothness of the eligibility rules, basing on the existing ISO-group clustering (see Kukolj [12], Takagi and Sugeno [13] for further details). This way, a personalized benefit can be assigned ad-hoc to each eligible person.

Pseudo-continuity is linked to granularity; monotonicity is linked to smoothness.

Through a FIS, monotonicity can be obtained by using a Sugeno-type with L-R type and unimodal fuzzy numbers [14, 15], as triangular fuzzy numbers, with MIN t-norm, defined on the universe set of each of the 3 ISO-GROUP class. Pseudo-continuity can be obtained by differentiating the output within each group, thus increasing its granularity.

3.1 Structure of the proposed FIS

We propose a FIS tailored for this type of problem, whose parameters are inspired by the Toscana legislation. In order to enhance granularity and smoothness in the eligibility rules, we make use of a zero-order Sugeno model (aka as TSK, Takagi-Sugeno-Kang model) with MIN t-norm and trapezoidal/triangular membership [16].

We use trapezoidal fuzzy numbers (rather than triangular). For each of the three input variables, Functional Deficit (Func), Cognitive Deficit (Cogn) and Behavioral/depression Deficit (Behav) we used three membership functions (trapezoidal fuzzy numbers), corresponding to the linguistic terms-sets Low, Medium and Severe, which correspond to the actual terms used in the legislation (Table 2), and represented in Figure 1.

To increase the granularity, we substituted the class values in Table 2 (natural numbers 1 to 5) with the monthly benefit in €, inferred from the average values in the legislation, suitably modified to differentiate the elements within a class.⁷ Results are reported in Table 3.

However, in order to avoid a complete departure from the actual legislation, we do not force the maximum granularity, and we allow some cells of the rule block to contain the same level of allowance (for instance, in Table 3, the amount €140 appears in the second row, third column, but also in the third row second column). The FIS is implemented in Matlab.

⁷ The monetary value of the benefit in each cell needs to be determined by the Public Authority, perhaps requiring participatory decision methods (e.g., focus groups). In this paper, the allocated benefits are purely indicative.

ISO-GROUP	functional deficit								
	light Behav. deficit			moderate Behav. deficit			severe Behav. deficit		
cognitive deficit	L	M	S	L	M	S	L	M	S
L	0	0	100	0	140	240	200	240	300
M	0	0	140	140	180	280	240	280	355
S	100	140	280	140	280	355	280	355	400

Table 3: Output of the Sugeno FIS (monthly benefit in € for each class)

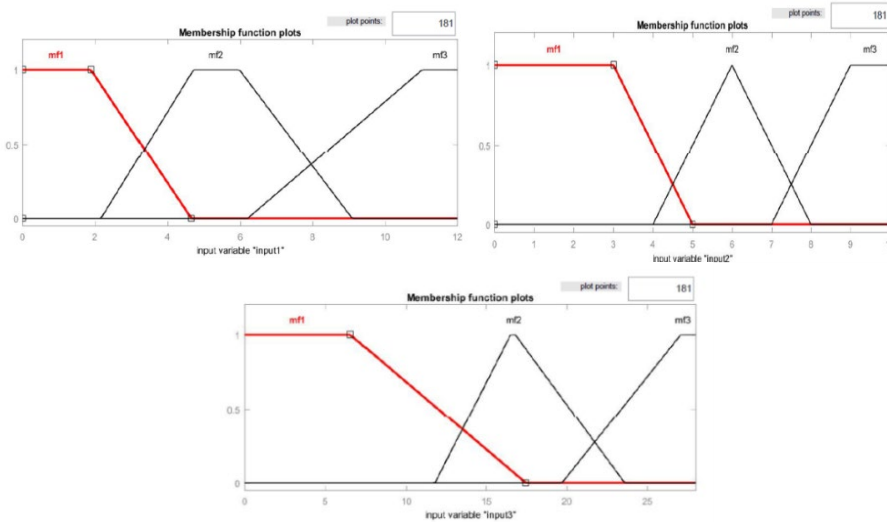


Figure 1: Membership functions for the Behaviour, Cognitive, Functional input variables (Input1, Input2, Input3 respectively)

4 An applied simulation using SHARE data

We evaluate the proposed zero-order Sugeno FIS by using microdata from the SHARE (Survey of Health Ageing and Retirement in Europe), a large cohort study representative of populations aged 50 and older in 27 European countries.[17] We use data on Italian respondents in waves 6 (2015) and 7 (2017), as SHARE is not representative at regional level, and focus on the population aged 65 or older. Our sample includes 3,883 observations.

SHARE includes detailed information on ADL limitations, which closely match the Toscana BADL scale. It includes information on cognitive limitations in orientation (knowledge of day-number/day-week/month/year) and working memory (numeric exercise) which allow us to simulate the cognitive scale in the Toscana legislation. It includes a validated measure of behavioral anomalies and depression status (EURO-D), which we use to compute the behavioral/depression score. From such a clinical profile (the individual score in the Functional, Cognitive, and Behavioural dimensions), it is

possible to simulate the implementation of the Toscana LTC rules, determining whether each SHARE respondent would be eligible to receiving the LTC benefit according to the Toscana legislation.[7, 18] We follow a methodology already adopted in the recent literature, and refer to those studies for advanced methodological details, given the short space allowed by this publication.

We first allocate each respondent to the five ISO-GROUP according to the original Toscana rules. Then, we implement the FIS on the same sample, assigning to each respondent a monetary amount (in €) based on the FIS system described above.⁸

Our results (Table 4) show that, with the original rules, 2% of the sample would be classified as eligible to a LTC benefit (ISO-GROUP 3 or higher), a very low coverage already discussed in the literature.[7] Under the fuzzy rules, 14.4% of the sample would be entitled to a positive monetary benefit, resulting in a much larger coverage. Moreover, the original legislation allocates a larger average amount to a much narrower population: the average benefit among those receive any is significantly higher under the original legislation (€216) than under the fuzzy rules (€132). However, due to a much larger population of recipients, the fuzzy LTC rules are costlier: we estimate that the per-capita LTC benefit among the whole sample amounts to €19 under the fuzzy rules, compared to €4 in the original rules.

We now investigate how the distribution of LTC entitlements is affected by the adoption of the fuzzy LTC rules. As summarised in Figure 2, around 86% of the sample is not eligible to LTC under both rules. However, 12.4% of the sample is not eligible to LTC allowance under the original rule, while they would be eligible under the fuzzy rules. This is because the fuzzy algorithm evaluates the individuals' need-of-care with higher granularity and continuity than the original rules. For example, 4.3% of the sample would receive a benefit lower than €100, signalling a low need-of-care. Around 8% would be entitled to receive an allowance of €100 to €200, and 1.7% would receive more than €200. Those individuals have significant limitations in at least one dimension, yet they were ineligible under the original legislation, due to the functional form of the eligibility algorithm. Figure 2 also illustrates how a fuzzy system can better allocate individuals that were already entitled to receive a benefit. While the original legislation assigned a single monetary amount to each ISO-GROUP, the fuzzy rule differentiates between individuals with higher or lower need-of care.

(N=3,883)	Original rules	Fuzzy rules
% Italian sample eligible to any benefit	2%	14.4%
Average monthly benefit whole sample (including zeros)	€4.5	€19
Average monthly benefit among eligible	€216.8	€132.5

Table 4: main results from the original vs FIS eligibility rules

⁸ Due to data limitations, we cannot include income as a determining variable in the original nor in the FIS eligibility rules. However, this does not affect our results as our objective is to assess the change in coverage rates when substituting the original eligibility algorithm with the FIS, and both rules are applied to the same sample.

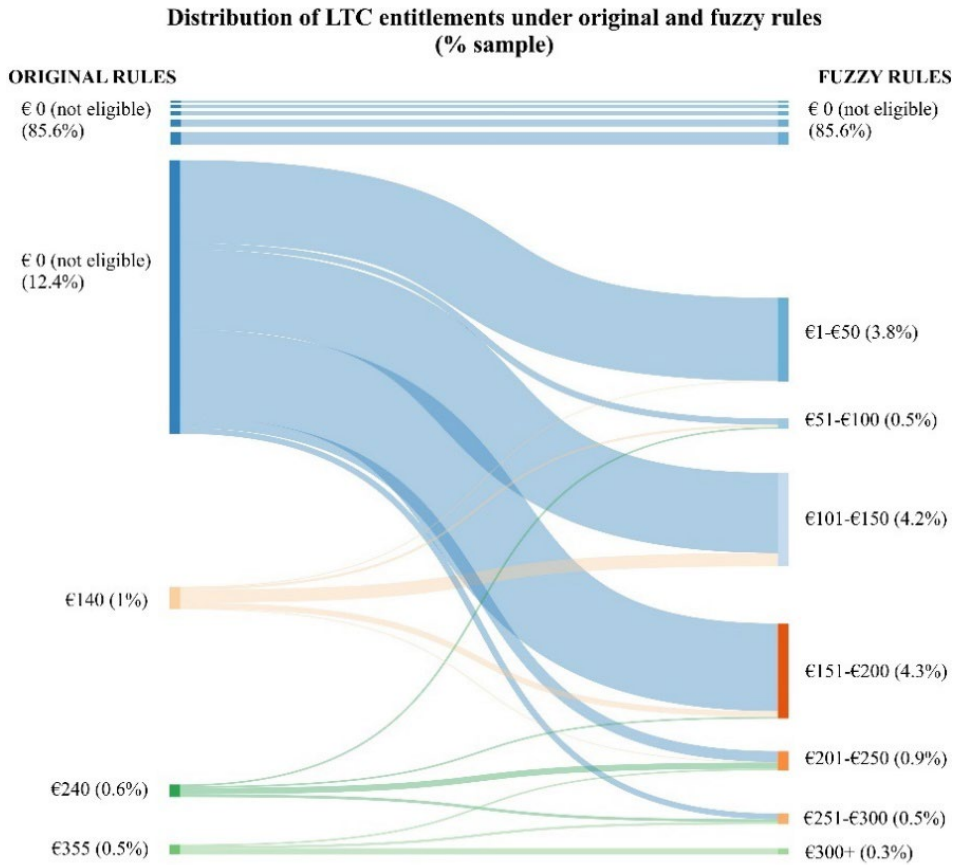


Figure 2: distributional effects of different LTC rules

5 Conclusion and future research

Governments are implementing policies to improve the wellbeing of older vulnerable people in Europe, by promoting home care (age-in-place).(2) A crucial part of such policies includes provision of public services or benefits. However, there are concerns related to, on one hand, adequacy of such public support, on the other hand, budget sustainability, particularly in light of population ageing. In Italy, most regions have established cash-for-care schemes based on rule-based approaches.[7] Among the most encompassing eligibility legislation is the Toscana’s LTC programme, which allocates individuals to fixed benefits (ISO-GROUPS) based on their performance in three health indices (Functioning, Cognition and Behavior/Depression).

In this paper we showed how such eligibility algorithm violates basic desirable properties, thus potentially increasing inequality in care access, and incentivizing strategic behaviors. We showed that a Fuzzy Inference System (FIS) eligibility algorithm increases granularity and smoothness in the Decision System. Using microdata from SHARE, we predicted that a FIS system would increase care-coverage, providing benefits to disabled individuals who were not entitled to any support under the original legislation,

due to the functional form of its eligibility rules. Similarly, we showed that a FIS algorithm allocates individuals from a same ISO-GROUP to different levels of allowance, based on a more granular definition of need-of-care.

Our proposal constitutes a prototype which requires several fine-tuning steps. First, we estimate that a FIS eligibility algorithm would increase total public spending. Although this increase could be reduced by giving no benefit to those individuals who would receive less than an estimated value (e.g., 3.8% of our sample would receive less than €50/month), further analysis is required to evaluate whether the increase in care-coverage is welfare-improving and cost-effective. Second, the parameters of the FIS (e.g., the membership functions and the granularity of the monetary amounts) need to be based on normative grounds. This could require preference elicitation through participatory methods with relevant Actors in the field of health and social care. Third, by widening the analysis to other regions' LTC rules, a more general FIS algorithm should be developed, to be adopted by the National Healthcare System.

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