



Efficiency and quality in services: empirical results from Data Envelopment Analysis in Nursing Homes in Italy

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Abstract

Measuring quality and efficiency in nursing homes (NHs) is becoming a strategic issue for the health care system due to an ageing population with higher incidence of chronic diseases as well as economic resource constraints in public spending budgets. This paper analyses the efficiency of 41 NHs based in Tuscany (Italy) by considering not only structural characteristics but also quality of care, including residents' relatives and staff satisfaction. Data were collected by the regional performance evaluation system of the NHs that collected and benchmarked. Indicators were used to run a classic DEA model with:

- as inputs number of total work hours for 1.nursing assistance, 2.nursing and 3.rehabilitation representing labour and daily cost for services representing economic resources;

- as outputs quality of care measures (such as number of ulcers, number of falls, number of catheter), satisfaction measures (residents', relatives' and professional's satisfaction), quality of life (days of recreational activities).

Furthermore, we run a multivariate regression model to analyse the efficiency score considering institutional factor (number of beds and type of ownership), managerial factor (training) and clinical factor (patient's severity).

Preliminary results show that around 20% of nursing homes are efficient. Moreover, only management factor (measured by the staff trained in end of life support) is significant in explaining the efficiency score, while nature of ownership, size and patients' condition are not significant.

Keywords: DEA model, nursing homes, efficiency, quality, satisfaction

1. Introduction

Quality and efficiency measurement in nursing homes (NHs) has become an important issue in the international debate. However, productivity improvements in services, and in particular in long term care, are harder to achieve than in manufacturing industries. As a result, tools like benchmarking are vital when considering performance in service organizations. Moreover, there is growing recognition of resident- and family-reported measures as quality outcomes for NHs, considering not only clinical quality measures but also consumer satisfaction measures at state and facilities level in terms of family, residents and professionals satisfaction (Kane 2003; Barsanti et al 2017). One method successfully used to perform benchmarking in service industries is Data Envelopment Analysis (DEA).

The DEA technique, introduced by Charnes, Cooper, and Rhodes (1978), is nowadays commonly used to calculate a single efficiency score based on multiple inputs and multiple outputs, referring to technical efficiency of decision-making unit. A valuable feature of the use of DEA method is the applicability of inputs and outputs with different unit of measures, thus no transformation into a single metric is needed (Huan YL, McLaughlin CP 1989; Shimshak et al 2009). However, the evaluation of NHs with the DEA method encountered some difficulties in the literature related to the measure of quality of services provided (Shimshak et al 2009).

Results in the literature generally show that quality is associated with technical efficiency in different ways, suggesting that multiple dimensions of quality should be included in the efficiency analysis of NHs. They also suggest that patient care can be enhanced through investing more in improving care delivery rather than simply raising the number of staff per resident (Dulal 2018).

The discussion on quality measures as output to run the DEA model is a topic of current interest. Our study is unique, to the best of our knowledge, because it uses satisfaction (residents, relatives and professionals) measures as proxy for quality output in the DEA model and it used measures related to staff management, such as training, as predictors of the efficiency scores. The study setting of our paper is Italy (Tuscany Region), where both the public system and private companies manage NHs.

2. Efficiency and quality in nursing homes

The study of the quality of NHs has been the focus of numerous publications during the last few years. This is partly because the NHs sector has been under increasing pressure for improving not only the quality of its services but also its productivity. Large amounts of data are collected and reported on numerous aspects of NH performance, which includes costs, case-mix severity, satisfaction of residents and quality of professionals (Shimshak et al. 2010, Barsanti et al. 2017).

Data Envelopment Analysis (DEA) is a non-parametric linear programming model that creates a frontier of best performing NHs. DEA model uses information about multiple inputs and outputs into a single efficiency measure to identify the set of efficient unit (in our case

NHs) based on how each facility actually used inputs to produce outputs. In this way, efficient structures are the reference points for identifying good practices within the sample; moreover is possible to identify the factors that determine which are the best performers (Duffy et al. 2006; Nuti et al. 2011). The healthcare sector in general and providers (hospitals and others facilities as NHs) in particular represent a main application area for DEA.

The literature about quality of care in NHs with DEA model usually takes into account ownership status, quality of care, resident condition and costs. For instance, some studies (Fizel et al. 2016; DeLellis 2013) propose an analysis of the ratio of cost to quality of services offered by NHs. Moreover, some authors argue that privately managed structures have better performance in terms of efficiency than publicly managed structures (Fizel et al. 2016; Lin, Chen, and Peng 2017; Luasa, Dineen, and Zieba 2018). Others instead propose a comparison between facilities that are efficient and structures that are less efficient, with the aim of understanding the relationship between the quality and efficiency of structures (Delellis 2013).

The DEA technique has also proved useful in studies about NHs that have focused in terms of performance on various other aspects of their activity such as space organization, strategic assistance groups, quality of care and staying.

A review of the literature proposed by Garavaglia and Lettieri (2011) highlights that many of the DEA studies apply process analysis and that they preferred to work on regulatory standards as quality indices. Another element identified in the literature is the very definition of quality of care. In fact, studies often refer to care and assistance activities, without mentioning aspects that generally concern residential services (Garavaglia and Lettieri 2011). In this sense, is it worth mentioning the work of Kooreman (1994), who has taken into account the study of claims management to measure quality by applying proxy measures (as the presence of a patient's council, a council of patient relatives, presence of a procedure for handling complaints and an absence of restrictions on visiting hours). These variables were negatively related to efficiency: for the authors quality of care negatively relates to efficiency because they absorb inputs. Shimshak et al (2009) selected output measures of both quantity of services and quality of services provided. To represent the quantity of services provided, they used the total number of residents along with the case-mix severity. They chose three measures of quality that focus on the prevalence of various conditions among the residents of a NH: the number of residents with an indwelling or an external catheter, residents who require physical restraints, and residents with pressure sores. Some authors use some proxy of quality of life in NH such as procedures for complains or patient/relatives council (Garavaglia et al 2011) for DEA analysis.

In general, difficulties in DEA studies in NHs are the definition and collection of measures of quality, especially resident quality of life. The analysis of residents and relatives' satisfaction in NHs is widely investigated in literature; Chesteen et al. (2005) have included customer satisfaction studies in their work to analyse the quality of care in NHs services. The research shows that the quality of the process is higher in non-profit NHs than in profit-oriented NHs, though the quality of inputs is lower (Chesteen et al. 2005). Barsanti et al (2016) compare the residents' satisfaction between Italy and Canada, considering staff



relation a main issue to consider for optimizing the willingness to recommend. However, very few studies including satisfaction measures in the DEA.

As Kohl (2018) underline, “to foster the acceptance of the method, the consideration of healthcare quality in the estimation of efficiency is crucial, as the mere number of treated cases does not reflect the true output a hospital should deliver. [...] If quality indicators are not included as proxies into the efficiency analysis, the best practice examples might support critics who argue that hospitals discharge patients quicker but sicker”.

Our aim is to run DEA on a set of different NHs, considering both quality of care and quality of life performance measure as output variables in the Italy long term care system. As outputs quality of care measures we use clinical data, such as number of ulcers, number of falls, number of catheter, and as quality of life satisfaction measures (residents’, relatives’ and professional’s satisfaction). We used consumers’ ratings on overall quality satisfaction on NHs, while for professional we use ratings on satisfaction to work in their NHs. Furthermore, we used different level of predictors in order to estimate the efficiency, considering institutional predictors (i.e. ownership and size), management predictor (i.e. trained staff) and clinical need predictor (i.e. residents’ severity considering mini-mental test).

3. Study setting

In Italy, quality measures in long term care have been mostly limited to measures of service coverage for older people; however, quality measures in some regions, such as Tuscany, include patient reported and quality indicators. We focus on Tuscany (Italy) because the region has a strong interest in health care quality measurement both in primary care and long term care (Nuti et al 2011; Nuti et al 2013; Barsanti et al 2016; 2019; Bonciani 2017) and because NHs are managed both by the public system and by private companies (both profit and non-profit).

Tuscany has approximately 3.7 million of residents, 23% of whom are over 65. The prevalence of ADL disability is approximately 81 per 1,000 older people. There are 13,769 beds in 324 charitable, public, and private for-profit and not-for-profit NHs in Tuscany, resulting in an average of 45 beds per NH and 1.3 beds every 100 inhabitants over 65. Individuals who cannot live independently and require assistance with their personal care at frequent intervals throughout the day and access to onsite 24-hour nursing care and supervision are eligible for these NHs. Each resident maintains their own general practitioner who is paid directly by the regional health service. The social care daily rate, by contrast, is set by municipalities and includes services such as catering, laundry, cleanliness entertainment, activation or recreation and support services.

Regulation and quality assurance for NHs is the purview of the national and provincial governments; other activities, including distributing funding and access to NHs, have been regionalized. NHs receive public funding for nursing and personal care. However, residents are required to contribute a co-payment, equal to an amount conditional on the resident’s and, in Tuscany, also their family’s ability to pay. For families with financial difficulties, this amount is subsidized by the government. While NHs are publicly funded, there are both privately and publicly owned facilities.

4. Methodology

4.1 Data collection

In 2011, all 298 NHs in Tuscany were invited by the Regional Authorities to participate in the development of a performance evaluation system (PES) on their quality and 90 NHs started to collect voluntary data on four different domains (Barsanti et al 2019):

1. clinical quality (i.e. number of falls; ...);
2. efficiency (i.e. social daily costs, costs per professionals,...);
3. satisfaction and experience for residents, relatives and professionals;
4. organizational variables (i.e. recreation activities...).

In 2017, 41 NHs collected all the data for each domains and they were selected for this study (while the other 49 NHs did not participate in satisfaction surveys but collected data on other domains). Data for clinical quality, efficiency and organization variable were collected by NHs using a structured web questionnaire. Data regarding satisfaction were collected by face-to-face interviews for residents, telephone interviews for relatives and web questionnaire for professionals. All the surveys were conducted, using a structured questionnaire. The number of residents/relatives/professional approached in each NHs was a function of its size. Residents were pre-screened by NH staff for inclusion in the study using the Pfeiffer Test, with the exclusion of residents with 7 or more errors to the test. Trained interviewers approached residents/relatives seeking their participation.

The three questionnaire were pre-tested in a NH not participating in this study. The questionnaire for residents/relatives included about 60 closed-ended questions covering the following nine domains (the number of questions pertaining to each domain is shown in parentheses): 1. reception and orientation (3); 2. environment and comfort (7); 3. services (8); 4. leisure activities (9); 5. external relationships (4); 6. assistance and care (12); 7. staff (9); 8. privacy (3); and 9. overall quality (2). The questionnaire for the professionals included questions about: 1. the structure (13), 2. working conditions (13), 3. management (9), 4. relationship with the residents and their families (3), 5. communication (5), 6. training (3), 7. overall evaluation (4), 8. improvement (8). Most questions used a “Yes, always”, “Yes, sometimes” and “No, never” rating scale.

The table shows the frequency and the response rate for each of the three surveys.

Table 1. Frequency and response rate for each of the three surveys.

Surveys	Frequency	Response rate
Residents	1.537	56.74%
Relatives	1.723	75.00%



Professionals	1.501	57.8%
Total	4.761	-

In order to consider quality of life in the DEA we used the following questions from the surveys:

- residents' satisfaction in terms of willingness to recommend;
- relatives' satisfaction in terms of willingness to recommend;
- professionals' satisfaction in terms of overall quality of the job.

The summary statistics are shown in table 2.

4.2 DEA model and regression analysis

The work is divided in two stages. Firstly, we compute the efficiency scores. Secondly, we analyse the possible impact of some factors on the efficiency scores. For the traditional method, we applied the “dea” function from the “rDEA” package in R software. For the bootstrapped efficiency scores we used the “dea.robust” function with 1000 repetitions and 95% confidence level. The Spearman ranking correlation test was computed using the “cor.test” function.

A. First stage:

a. the DEA efficiency scores, traditional model

To our data, we apply the CCR model (Charnes, Cooper and Rhodes, 1978) with constant returns to scale. Due to the small number of NHs available for the analysis (less than 50) (Banker et al (1996)), we choose not to use the variable returns to scale model (Banker et al. 1984). In Tuscany the NH system focuses on maximising the outputs, especially in terms of quality of care and customer satisfaction. For this reasons, we use an output-oriented model. The CCR output-oriented model uses a linear system which maximizes the ratio of outputs to inputs to generate efficiency scores. This consents to measure the gap that the inefficient NHs have to fill in order to become efficient throughout proportional augmentation of outputs, while keeping inputs fixed.

b. the DEA efficiency scores, Bootstrap model

After the computation of DEA efficiency scores with the traditional method, we generate the bootstrapped efficiency scores with Simar and Wilson's (1998) bias-correction. By resampling the observations, the method goes beyond the simple classification of NHs in “efficient” and “inefficient”. It provides confidence intervals necessary to deal with uncertainty surrounding traditional estimations. (Cooper et al 2011; Kneip et al. 2008, 2011; Simar and Wilson 1998, 1999a, b, 2000a, b, 2008, 2009). To test for robustness of the traditional DEA scores we applied the Spearman correlation test (Garavaglia et al 2011).

B. Second stage: regression on DEA scores

At this second stage, we are interested in finding which variables might explain the efficiency of the obtained NHs. For this purpose, we use the Tobit model after correcting the efficiency scores for bias. In the regression, we include the number of beds, training for end

of life, type of NH (private or public) and mini-mental test scores. We include the mini-mental test scores in the second stage of the analysis among the explanatory variables of the efficiency scores because we are interested in understanding whether the severity of the residents influenced the efficiency.

5. Results

5.1 DEA model and regression: input, outputs and explanatory variables

We include in the DEA model one input related to labour (the sum of total work hours for 1.nursing assistance, 2.nursing and 3.rehabilitation) and the daily cost for residential services such as food and lodging (“minimum social quota”) as a proxy for the capital. We have to insert amongst the model’s inputs only those elements that the management can control (Kooreman 1994). As outputs we include three quality of care measures (number of ulcers, number of falls, number of catheter)¹, three satisfaction measures (residents, relatives and professional) and one quality of life measure (days of recreational activities). Then the inputs and outputs were selected to avoid strong correlation (Pearson test > 0.7) among the variables included in the DEA model.

Table 2. Summary statistics of input and output values

	DEA Variables	Median	Mean
INPUTS	Total work hours	43646	53603
	Daily cost for services (€)	52.50	50.40
OUTPUTS	Residents’ satisfaction	86.67	85.52
	Relatives’ satisfaction	90.91	90.19
	Professional’s satisfaction	90.91	87.78
	Number of ulcers	3.00	5.80
	Number of falls	5.00	7.90
	Number of catheter	5.00	5.31
	Days of recreational activities	289	288

The summary statistics of the variables included in the DEA model highlight the existence in our sample mainly of NHs with total work hours between 40.000 and 60.000. However, NHs of only 20.000 or almost 200.000 total work hours are also present in the sample. The minimum daily cost is on average around 50€. Yet, as already pointed out, there are consistent differences among the NHs, from a minimum of 20€ up to a maximum of almost 58€.

The descriptive analysis emphasises also differences in levels of satisfaction among the three analysed categories. No low levels of satisfaction were expressed for the analysed

¹ Number of ulcers, falls and catheters are considered with negative sign due to the inverse relationship of the variables with the efficiency score.

NHs. While for no NH relatives' satisfaction reaches 100%, the minimum satisfaction score for this group is the highest (72.7%). The other two group score have a lower satisfaction score on average with the lowest percentage registered for residents with 59% and 65% for professionals.

Finally, all three variables of quality of care (number of ulcers, falls and catheter) and organization of activities (days of recreational activities) vary considerably in the sample from 0 to respectively 37, 43 and 18 for quality of care and from 147 to 365 for day of activities.

Table 3. Descriptive statistics for explanatory variables

Explanatory Variables	Median	Mean
Number of beds	45.00	56.85
Training for end of life	64.75	56.99
Ownership	1.00	1.49
Mini-mental test	20.40	20.43

As already pointed out, the size of NHs in term of number of beds is variable from a minimum of 20 to a maximum of 225, with around 57 beds on average and only 4 structures with above 100 beds. In terms of ownership, the sample is composed by 23 public NHs (1) and 18 private NHs (2). However, almost all the private NHs included in the sample are non-profit. Thus, our results refer to a comparison between the public sector and the private but non-to-profit sector.

Training for end of life is measured as the percentage of professionals that received training regarding end of life management in the last three years prior to survey. The range is from 0% to 100%, with 57% on average.

Finally, the mini-mental test measures the severity of the patients in terms of cognitive function, with 30 the maximum score representing most mentally healthy. The minimum score in the sample is 9.50.

5.3 DEA scores

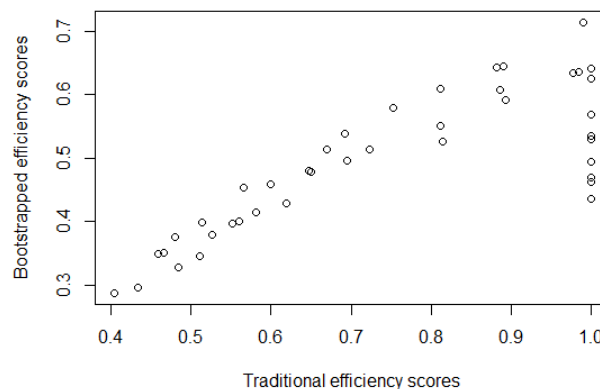
The analysis finds 9 efficient NHs (19%) with a the difference in mean between traditional and bootstrapped efficiency scores around 25%, meaning 0.74 for traditional and 0.49 for bootstrapped. In other words, the NHs should augment their outputs by 26% considering the traditional method or 51% considering the bootstrap method. The Spearman correlation test of 0.74 indicates a strong positive relationship between the traditional and the bootstrapped DEA scores. This confirms the robustness of the traditional DEA scores.

Table 4. Traditional versus bootstrapped DEA efficiency scores

Nursing Homes	Traditional efficiency score with CRS	Bootstrapped Efficiency score with CRS and confidence intervals
1	1	0.62 (0.36 ; 1.05)
41	0.8819045	0.64 (0.49 ; 0.83)
Min	0.4043	0.2871
1st Quantile	0.5595	0.4005
Median	0.7232	0.4937
Mean	0.7445	0.4919
Std. D	0.20717	0.10896
3rd Quantile	0.9849	0.5788
Max	1.0000	0.7136
Spearman Rho	0.74812 (p_value: 1.883e-08)	

Examining the characteristics of the two groups (efficient and inefficient) created with the traditional DEA method, only for the residents’ satisfaction no difference is found, whereas the relatives’ and professional’s satisfaction are on average higher for the efficient NHs. Also for the daily cost and the days of recreational activities, we find a small difference in averages for the two groups. Contrary, inefficient units have double total work hours on average, whereas the number of falls, ulcers and catheter are considerably lower in the efficient units compared to the inefficient ones.

Figure 1. Comparing DEA efficiency scores



5.4 Determinants of efficiency

The results allow the use of DEA scores to rank the NHs in order to investigate the factors that describe the best and worst NHs.

The Tobit regression highlights only one significant association that regards trained staff on end of life support.

Our results show how in the Tuscany NH system the efficiency score is not significantly influenced by the type of ownership (private versus public), contrary to some case studies (Garavaglia et al. 2011). Although the data refers to private but non-to-profit NHs in a different location compared to other studies in the literature, our study emphasises the efficiency of the Tuscany system of public NHs. Furthermore, the efficiency scores are not associated to complexity of residents: this can reflect that NHs can adapt their organization and clinical assistance based on patient's need, without preferring high or low severity classes.

As Garavaglia et al 2011, our studies suggests the no significance of the relationships between efficiency and size; these results confirms the hypothesis of constant returns to scale.

Finally, our results shown a positive association with trained staff on end of life care: this has important implications in term of quality and management of facilities. In particular, the staff is one predictor of efficiency in terms of skilled competences.

Table 5. Results of Tobit regression

Pearson residuals:					
	Min	1Q	Median	3Q	Max
<i>mu</i>	-2.5747	-0.3311	0.0257	0.67025	2.761
<i>loglink(sd)</i>	-0.7068	-0.6903	-0.4346	-0.02196	4.683
	Estimate	Std. Error	z value	Pr(> z)	
(Intercept):1	0.5272238	0.0773188	6.819	9.18e-12 ***	
(Intercept):2	-2.3940622	0.1118035	-21.413	< 2e-16 ***	
n. beds	-0.0006911	0.0003971	-1.74	0.08183 .	
trained staff	0.0013055	0.0004075	3.204	0.00135 **	
ownership	-0.0077437	0.0294775	-0.263	0.79278	
mini-mental	-0.0027898	0.0030461	-0.916	0.35974	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Log-likelihood: 39.0049 on 74 degrees of freedom

6. Discussion

Care in NHs has garnered attention owing to the aging demographic. There are two competing pressures resulting from this: 1. ensuring the use of resources as efficiently as possible while providing good outcomes of care; and 2. a shift for a culture of care more

resident-directed and homelike (Stadnyk 2009). In this sense and recognizing that NHs are places where people both live and receive care, our paper presents an approach for incorporating quality variables related to care and satisfaction of consumers and professionals in the analysis of a service organization using DEA methodology for benchmarking. Few DEA studies focus on quality as perceived by consumer (residents and relatives) and by professionals in terms of work place. Some studies used proxy for consumer satisfaction (Garavaglia et al 2011). Our model included these set of variables that measured quality of the services with different domains in order to estimate the efficiency of a set of public and private NHs in Tuscany Region, as following:

- quality of care, measured by number of falls, ulcers and catheters;
- quality of life, in terms of organizational factors as recreational activities;
- quality of life, in terms of satisfaction of residents and relatives;
- quality of workplace, in terms of satisfaction of professionals in the facilities.

Their presence may reflect a NH's commitment to take into account the opinions of residents, relatives and of staff to optimize not only the quality of care, but also the efficiency. Twenty percent of all NHs operate efficiently, according to the theoretically preferred frontier. However, the different domains of quality are not necessarily associated to efficiency. The efficiency scores are statistical different only for relatives and professionals satisfactions in terms of quality of life and for quality of care. While residents satisfaction is quite the same in the two groups.

This may identify possible managerial implication in terms of quality management. Firstly, the quality of clinical care is one of the main determinants to gain in efficiency. In particular, we argue that a better quality does not seem to imply necessarily higher costs. Supporting the classic theory on cost-quality trade-off, results show that NHs do not have a trade-off between cost efficiency and both clinical care and experiential quality in terms of relatives' satisfaction. The finding of this study shown that efficiency is also related with staff job satisfaction and the quality of care they deliver.

Moreover, the analysis of predictors of efficiency reveals interesting results for the discussion. In particular, efficiency seem not to be associated neither with the institutional factor, such as size and ownership, nor with clinical and health needs factors such as residents' severity. Only managerial level, measured by the staff trained in end of life assistance, is significant related to the efficiency scores. In this sense, managers have the chance to run efficiency not only in terms of quantity -cost saving and use of resource (economic and human)- , but also in terms of quality management of professionals (training).

7. Conclusions

NHs are often investigated in term of quality and efficiency with DEA score. However, the definition of quality and the collection of data are quite difficult. Our study suggest a multidimensional definition of quality to measure efficiency in NHs with DEA model. Moreover, results show positive association with efficiency and clinical care and satisfaction of relatives and professionals. Finally, trained staff on soft skills (such as end of life support) is a predictor of efficiency.



Legislators, policy makers, regulators, payers and administrators can be confident that the setting of standards that encourage striving for both quality and efficiency simultaneously is indeed realistic (Delellis 2013).

In terms of managerial implication, both policy makers and managers of NHs can run DEA to highlight efficiency ratings and develop goals based on the performance of the efficiency group and thereby improve their competitive position. Finally, by considering data aggregated over the homes in each regions (in Italy) or other geography or responsibility model, DEA can identify which regions/models are performing best and which should be considered models of best practice.

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