20th Conference of the International Federation of Operational Research Societies (IFORS), Barcelona, Spain, 13-18 July, 2014

Efficiency and Quality implications in Health Care Management

Ioannis Mitropoulos, Panagiotis Mitropoulos
Department of Business Administration,
Technological Educational Institute of Western Greece

European Union
European Social Fund
OPERATIONAL PROGRAMME
EDUCATION AND LIFELONG LEARNING
investing in knowledge society
MINISTRY OF EDUCATION & RELIGIOUS AFFAIRS
MANAGING AUTHORITY
Co- financed by Greece and the European Union
NSRF 2007-2013
programme for development
EUROPEAN SOCIAL FUND

This research has been co-financed by the European Union (European Social Fund - ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: ARCHIMEDES III. Investing in knowledge society through the European Social Fund.

Outline

- Introduction: Health care & Quality
  - In developed countries, quality has become one of the central issues in efforts to measure and improve health system performance
  - It is difficult to obtain precise measurement of quality since the complexity of quality indicators are difficult to capture by a single measure
  - Different bases for the construction of indicators further complicate comparison between them
- Quality indicators in terms of Patent Satisfaction
- Data and study area
- Analytical models (Cluster and DEA)
- Results (Cluster and DEA)
- Regression of the DEA scores with the satisfaction clusters
- Conclusions

Motivation

- Main questions
  - Are “health results” satisfactory in terms of quality considering the amount of resources allocated to this activity?
  - Could we have better quality using the same resources?
  - Can we measure the primary health centers (HC) inefficiency and quality?
  - Can we explain measured inefficiency?
    - a systemic component,
    - and an environmental or non-discretionary component based on the patient satisfaction.
- Objectives
  - Understand fundamental concepts in efficiency improvement
  - Identify the environment and key steps for a successful quality improvement project

Patient satisfaction

- During the last decade, healthcare managers, politicians, and other decision makers have emphasized the importance of the patient perspective as an indicator of quality of healthcare
- Thus, patient satisfaction is one of the major factors of certification in measuring quality of health services
- Satisfaction can be defined as the extent of an individual's experience compared with his or her expectations
- Patients' satisfaction is related to the extent to which general healthcare needs and condition-specific needs are met
- Therefore the ultimate goal of patient satisfaction assessment is to improve the quality of healthcare service delivery
- Typically, variation in patient satisfaction between different healthcare units is thought to reflect differences in efficiency and other organisational factors
- The amount of literature investigating variability in patient satisfaction with hospital care and its association with organisational factors is limited

Patient Satisfaction Survey

- The measurement of satisfaction in HCs was performed using a structured questionnaire with 51 questions
- The questionnaire consists of closed-ended questions measured on a 5-point Likert scale
- Six dimensions of patients satisfaction
  1. Appointment and scheduling
  2. Accessibility
  3. Waiting conditions
  4. Doctor services
  5. Lab services
  6. Facilities
- 416 questionnaires were completed in the 14 HCs operating in Cyprus

Cluster analysis

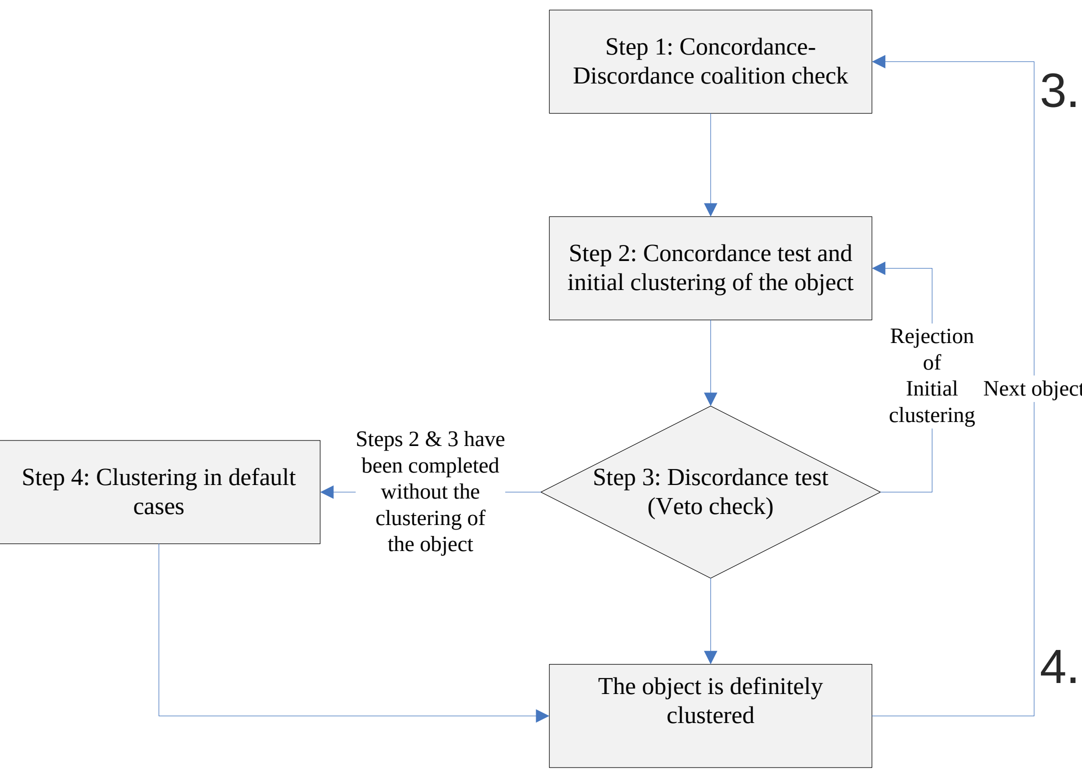
- Cluster analysis is a branch in statistical multivariate analysis and unsupervised learning in pattern recognition
- The essence of clustering is to partition a set of objects into disjoint and homogeneous clusters, such that objects belonging to the same cluster are more similar to each other than those belonging to different clusters
- Objects to be clustered are represented by a set of attributes, thus an object is considered as a conjunction of attribute values
- Most clustering algorithms are procedures that minimise total dissimilarity, with k-means

k-modes algorithm

- The k-modes algorithm (Huang,1998), on the other hand, extends the k-means paradigm to cluster categorical data byusing
- a simple matching dissimilarity measure for categorical objects (Kaufman and Rousseeuw, 1990)
- modes instead of means for clusters
- a frequency-based method to update modes in the k-means fashion clustering process to minimise the clustering cost function.

The CLEKMODES algorithm

Mastrogiannis et al. (2009) ‘CLEKMODES: a modified k-modes clustering algorithm’, *Journal of the Operational Research Society*, Vol. 60, No. 8, pp.1085–1095



1. Selection of the k initial modes, one for each cluster
2. Assignment of each object to the proper cluster according to a four-step dissimilarity measure. After each assignment, the mode of the cluster is updated
3. After all objects have been assigned to clusters, the dissimilarity of objects against the current modes is retested. If an object is found such that its most suitable mode belongs to another cluster rather than its current one, the object must be re-assigned to that cluster and the modes of both clusters must be updated
4. Phase 3 is repeated until no object has changed clusters after a full cycle test of the whole dataset

Data Envelopment Analysis

- Efficiency measurement:
  - Comparison of resources used to provide certain services, the **inputs**;
  - with **outputs**, or results.
  - **Efficiency frontiers** are estimated …
  - … and inefficient situations detected (**efficiency scores** are computed).
- There are different techniques to deal with efficiency frontier estimation. We have used Data Envelopment Analysis (DEA)
- **Non-discretionary inputs:** Socio-economic differences play a role in determining heterogeneity and influence outcomes

Empirical results

- Two step procedure

First stage:

- Data envelopment analysis (inputs, outputs)
- Inefficient scores are computed for each HC
- DEA method: CRS
- DEA procedure: bootstrap (to estimate confidence intervals)

Second stage:

- Regression analysis
- Inefficient scores are explained by environment variables
- Efficiency scores (δ) are regressed on non-discretionary factor (z):
- Regression method: bootstrap (Truncated regression)

$$\hat{\delta}_i = z_i \beta + \varepsilon_i$$

The DEA Bootstrap

Monte Carlo simulation experiments are often used to estimate the sampling distributions of econometric estimators. Such experiments typically involve several steps:

Specify a data generating process (DGP)

1. Use the DGP to generate data (i.e., simulate)
2. Apply the estimator to the generated data
3. Repeat from Step 2

The distribution of the estimates obtained in step 3 approximates the sampling distribution of the estimator. The bootstrap is a form of Monte Carlo experiment where the DGP is unknown

Bootstrapping the Second stage

Problems with tobit traditional procedure: $\hat{\delta}_i = z_i \beta + \varepsilon_i$

- Each efficiency score estimate depends on all observed inputs and outputs: ε_i is serially correlated
- The environmental variables are correlated with both inputs and outputs: ε_i is not independent from z_i

Simar and Wilson (2007) propose alternative estimation and inference procedures based on bootstrap methods. They assume:

$$\delta_i = \psi(z_i, \beta) + \varepsilon_i \geq 1,$$

where ε_i is a left truncated normal random variable

Variables in DEA model

- **Input variables**
  - Number of doctors
  - Number of nursing/paramedical staff
  - Number of administrative/support staff

- **Output variables**
  - Number of patient visits
  - Number of medical exams

Datasets Description and Clustering results

Datasets	No of Objects/HC	No of Attributes
Dataset 1 (Initial Dataset)	14	51
Dataset 2 (1st Dimension)	14	5
Dataset 3 (2nd Dimension)	14	6
Dataset 4 (3rd Dimension)	14	7
Dataset 5 (4th Dimension)	14	10
Dataset 6 (5th Dimension)	14	12
Dataset 7 (6th Dimension)	14	11

HC	Dataset 1	Dataset 2	Dataset 3	Dataset 4	Dataset 5	Dataset 6	Dataset 7
HC1	0	0	1	0	0	0	0
HC2	1	1	1	1	1	1	1
HC3	0	0	1	0	0	0	0
HC4	0	1	1	0	0	1	0
HC5	0	1	1	0	0	1	0
HC6	0	1	1	0	0	1	0
HC7	1	1	1	1	1	1	0
HC8	0	0	0	0	0	0	1
HC9	0	0	1	0	0	0	0
HC10	0	1	0	1	1	1	1
HC11	1	1	1	1	0	1	0
HC12	0	0	1	0	0	0	0
HC13	0	0	1	0	0	0	0
HC14	0	1	1	1	0	0	0

Efficiency results

HC	Original DEA	Bias corrected	Bias	Upper bound	Lower bound
HC1	0.755	0.682	0.073	0.635	0.749
HC 2	1.000	0.845	0.155	0.799	0.992
HC 3	0.659	0.588	0.071	0.532	0.655
HC 4	0.873	0.789	0.084	0.742	0.866
HC 5	0.938	0.854	0.084	0.784	0.933
HC 6	1.000	0.879	0.121	0.839	0.990
HC 7	0.856	0.759	0.097	0.702	0.850
HC 8	0.734	0.658	0.076	0.617	0.727
HC 9	1.000	0.744	0.256	0.687	0.992
HC 10	0.670	0.623	0.047	0.580	0.668
HC 11	0.909	0.846	0.063	0.771	0.905
HC 12	1.000	0.856	0.144	0.805	0.992
HC 13	0.958	0.874	0.084	0.823	0.951
HC 14	0.537	0.497	0.040	0.461	0.535
Average	0.849	0.749	0.099	0.698	0.843

Model 1

$$\theta_i=\beta_0+\beta_1 cluster_1+\beta_2 cluster_2+\beta_3\, cluster_3+\beta_4 cluster_4+\beta_5 cluster_5+\beta_6 cluster_6$$

Variable	Coefficient	z-statistic (p-value)	95% Confidence Interval	
			LB	UB
Constant	0.541	11.45 (0.000)	0.448	0.634
Appointment/scheduling	-0.260	-4.28 (0.000)	-0.379	0.141
Accessibility	0.210	5.58 (0.000)	0.136	0.283
Waiting conditions	0.006	0.22 (0.828)	-0.045	0.057
Doctor services	-0.103	-3.01 (0.003)	-0.170	0.035
Lab services	0.351	188.41 (0.000)	0.347	0.355
Facilities	0.102	2.98 (0.003)	0.035	0.169

Some possible explanations [1]

- the coefficients for appointment/scheduling and for doctor services are negative and statistically significant
- A possible explanation for the effect that appeared in doctor services is that the patients turn to primary services seeking for a stable and more personal care
- More satisfaction in the less efficient HCs may imply that doctors spend more time and have better personal acquaintance with their patients. Conversely, increased patient dissatisfaction and many complaints are due to breakdown in the doctor-patient relationship because of the busy environment that the efficient HCs operate
- Similarly the procedure of getting an appointment seems more difficult and complicated in efficient but busy HCs

Some possible explanations [2]

- On the other hand the coefficients of accessibility, lab services and facilities are positive and statically significant
- A possible explanation for these results is that the more efficient HCs may have been supported with better equipment and infrastructure than the less efficient ones, in order to service the increased number of patients
- Finally, the coefficient of waiting conditions has a positive sign but is not statistically significant

Model 2

$$\theta_i = \beta_0 + \beta \; cluster_{(overall)}$$

Variable	Coefficient	z-statistic (p-value)	95% Confidence Interval	
			LB	UB
Constant	0.731	58.88 (0.000)	0.933	0.997
Overall	0.085	1.84 (0.065)	-0.005	0.176

- the coefficient of the overall patient satisfaction cluster is positive and not statically significant
- This may be considered as an expected result since in model 2 the overall clusters are more general than the clusters inserted in model 1

Concluding comments

- Quality in Public Health Practice contains dimensions that are not usually considered in other sectors
- Patients' opinion and their satisfaction, is essential for the quality standards of the provided quality care
- Identifying the aspect of care that influences patient satisfaction may be useful to design changes in health delivery system
- According to our results the satisfaction of users for health services provided, is determined by factors relating to organizational and functional characteristics, but also by the actual interpersonal relationship and communication with health professionals and particularly the doctor-patient relationship.