Assessment of Relative Technical Efficiency of Small Mental Health Areas in Bizkaia (Basque Country, Spain)

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Abstract: Mental disorders cause an enormous burden to society. Considering the current economic context, an efficient use of scarce inputs, with an appropriate outcome production, is crucial. This situation defines a classical Relative Technical Efficiency (RTE) problem. A well-known methodology to assess RTE is the Data Envelopment Analysis, although it presents some limitations. These may be overcome through a hybrid strategy that integrates Monte-Carlo simulation and artificial intelligence. This study aims to (1) design of a Decision Support System for the assessment of RTE of Small Mental Health Areas based on DEA; and (2) analyse 19 mental health areas of the Bizkaian Healthcare System (Spain) to classify them and to identify potential management improvements. The results have showed higher global RTE in the output-oriented orientation than in the input-oriented one. This suggests that a decision strategy based on improving the input management, within the ranges of the expert-driven model of community healthcare, could be appropriate. A future research line will focus our attention on the validation process through the analysis of micro-management interventions and their potential impacts in the real system.

1 INTRODUCTION

The current high levels of mental disorders prevalence cause an enormous burden to the society and a devastating impact on health and economy (WHO, 2003). The factors involved in the development of these psychopathologies are not only individual features; social, economic and political determinants, such as national policies and community support, have also a relevant influence in the manifestation of the symptomatology (WHO, 2016). Unfortunately, in high-income countries, 35%–50% of people who suffer mental disorders do not receive any treatment; in middle and low-income countries, this percentage increases till 76%–85% (WHO, 2016).

To face this problem, the World Health Organization (WHO) and United Nations (UN) are carrying out specific macro-level strategies. Firstly, the WHO designed a ‘Mental Health Action Plan 2013-2020’ (WHO, 2013), in which was emphasized the importance of assessing the evidence and developing a deeper research. In addition, this action plan highlighted the provision of health and social care from a community-based perspective. On the other hand, the UN is also supporting the shifting of mental health treatments from hospital to community-based care (United Nations, 1991). The community-based mental health care is focused on caring for individuals with mental illness from institutional environments to the community (Moran & Jacobs, 2013; Shen & Snowden, 2014). This paradigm of intervention presents better outcomes and is more cost-effective than institution-based care (Gutierrez-Recacha, Chisholm, Haro, Salvador-Carulla & Ayuso-Mateos, 2006; WHO, 2005). According to this model, an increase in outpatient and day care services and a decrease in inpatient services is expected. Therefore, the integration of care and treatment in general hospitals and primary care as well as the collaboration between professionals and informal care providers is fundamental.

In Spain, both the Mental Health Strategy of the Spanish National Health System (Ministerio de...
of the balance between inputs and outputs in a complex, interrelated and dynamic system under uncertainty. Sherman (1984) introduced Data Envelopment Analysis (DEA) for assessing hospital Relative Technical Efficiency (RTE). Nowadays, there is a growing interest in the evaluation of RTE in health systems (Färe, Grosskopf, Lundström & Roos, 2008; Hollingsworth, 2008; Hollingsworth & Parkin, 2001; Kaya & Cafari, 2015; Pelone et al., 2012.), but little is known about it in mental health (Torrres-Jiménez et al., 2015; Tyler, Ozcan & Wogen, 1995;). Although DEA models have been successfully applied in health, several relevant drawbacks of this analysis have been identified in the literature (Salvador-Carulla et al., 2007; Zhu, 2013): (i) frequently decision makers have difficulties in interpreting DEA results, (ii) DEA models are not appropriate for analysing datasets with low number of decision making units (observations) and high number of inputs (usually resources) and outputs (outcomes of the system), (iii) the management of the inner uncertainty of the real systems is statistically complicated (Monte-Carlo simulation) and very computer demanding and, finally, (iv) real data values (inputs and outputs) have to be interpreted according to expert knowledge for avoiding biased results (this process needs to formalise explicit knowledge in a knowledge-base).

The main goals of the current research are: 1. The design of a Decision Support System for the assessment of RTE of Small Mental Health Areas based on DEA; and 2. The analysis of 19 mental health areas of the Bizkaia (Spain) Healthcare System for identifying potential performance improvements.

2 METHODS

2.1 Inputs, Outputs and Decision-making Units

Original data were collected from “Mental Health Atlas of Bizkaia” (Pereira, Gutiérrez-Colosia & Salinas-Pérez, 2013). In total, the dataset included 52 variables, 39 inputs and 13 outputs, which described the Mental Health Care System in Bizkaia (Spain). This system is structured in 19 Small Health Care Areas that were identified as Decision Making Units (DMU) (19×52 data matrix). The variables were coded into main types of care (Table 1) according to the DESDE-LTC codification system (Salvador-Carulla et al., 2011) and each code was classified based on the Basic-Mental Health Community Care (B-MHCC) paradigm (Salvador-Carulla et al., 2007).
Table 1: List of inputs/outputs analyzed for each group of main types of care (DESDE-LTC) and scenario assigned.

Table 2: Description of the scenarios.

2.2 The Monte Carlo DEA Model and the Decision Support System (DSS)

A hybrid model was used to assess the RTE of the small mental health care areas in Bizkaia. This model integrates classical statistics, mathematical programming and an approximation to artificial intelligence. Regarding classical statistics, Monte-Carlo simulation was used: (1) to incorporate...
uncertainty in variable measuring by using statistical
distributions rather than the original variable values
(i.e. the original value 0.299 was transformed into
triangular distribution $T[0.2691, 0.299, 0.3289]$ and
(2) to artificially multiply the number observations
(500 replications of each area and scenario) which
makes RTE analysis be more discriminant. In the
proposed model, the Monte-Carlo engine allows the
simulation of inputs and outputs and offers the
statistical distribution of the RTE for each area in
each scenario and, by extension, the corresponding
one for the global system (Torres-Jiménez et al.,
2015).

Once inputs and outputs values were produced by
the Monte-Carlo engine, they are mathematically
(linear monotone increasing/decreasing functions)
interpreted based on expert knowledge formalised in
a $IF \ldots THEN \ldots$ rule-base (knowledge-base), an
embryo of a fuzzy inference engine (Torres-Jiménez
et al., 2015). The rule design was based on the B-
MHCC paradigm (Salvador-Carulla et al., 2007).

Finally, and using the transformed variable
values, the operational algebraic model was designed
and solved. The BCC-DEA model, variable returns to
scale, was selected because there is no evidence of a
constant returns to scale rigid behaviour (Salvador-
Carulla et al., 2007). Both input and output
orientations of the BCC-DEA model were used. Input
orientation refers to maintaining a stable level of
outputs, while trying to minimize the resources
utilized. Output orientation aims to maximize the
outcomes for a constant amount of inputs.

In conclusion, for each scenario and BCC-DEA
orientation, the Decision Support System analysed 20
times (or repetitions) a $19 \times 25 \times V$ (being: 19 the
number of areas, 25 the number of simulations and $V$
the number of variables –inputs and outputs- in the
corresponding scenario) datasets. The number of
simulations and repetitions was controlled by the
Nakayama’s error (Torres-Jiménez et al., 2015) that
should always be lower than 2.5% over the RTE
average.

RTE for each area (19), scenario (15) and
orientation (2) has a probabilistic structure that can be
statistically studied. By aggregation, the global RTE
of the system can also be statistically determined and
studied.

3 RESULTS

The results of the analysis showed the statistical RTE
assessment of mental health services provision and
use in 19 Bizkaia’s small areas. 15 different technical
perspectives (scenarios) of the RTE problem were
taken into account in addition to the two BCC-DEA
orientations: input and output. The analysis of the
resulting RTE statistical distributions allowed to: (1)
rank the areas, and (2) identify and assess potential
improvements in key variables by using a
benchmarking process (the area that showed the best
RTE average and the bigger probability of being
efficient is considered the benchmark).

In DEA models, a RTE equal to 1 means that the
analysed DMU is efficient (when the sum of the
slacks is equal to 0) or weak efficient (when the sum
of the slacks is greater than 0). Values lower than 1
show different levels of inefficiency, the lower the
value the lower the efficiency. Figures 1 and 2 plot
the minimums, maximums, confidence intervals
(two-tailed $t$-Student, $\alpha=0.95$ and 29 freedom
degrees), averages and outliers of the resulting ETR
statistical distributions for each scenario (S#) in both the input and output orientations.

The input orientation shows a less number of outliers than the output one. The differences between areas are greater in S1 and S6 to S15 in both orientations, S2 to S5 have a relative homogeneous behaviour.

The mental health areas 4, 6 and 11 appear in three scenarios as outliers in the input-oriented model. On the other hand, areas 6 and 15 are the most recurring as outliers in the output-oriented model. Thus, the area 6 can be considered as a RTE outlier. The area 15 is also an outlier in the most output-oriented scenarios because of several missing data (highly penalised in DEA models) because a private health organization manages this area under contract agreements with the public health system so its information is not integrated.

The most efficient areas reach RTE average values greater than 0.85 in most scenarios and in both orientations. The worst RTE average values are lower than 0.7 in the input orientation a 0.85 in the output one (Figures 3 and 4).

The global input-oriented RTE average is 0.78 (Figure 3). Four areas have a RTE average values greater than 0.85, while the lowest value is around 0.6. In the output-oriented model (Figure 4), results are more homogenous and the RTE average is 0.88. There are five areas above 0.95 and an outlier (area 15) close to 0.5 (due to its missing values).

4 DISCUSSION

4.1 The Monte Carlo DEA Model and the Decision Support System (DSS)

The Monte-Carlo DEA model overcomes several limitations of the traditional DEA models. Firstly, the expert-based interpretation of input and output values makes the result interpretation easier for decision makers (Salvador-Carulla et al., 2007; Torres-Jiménez et al., 2015) because it includes the specific interrelations and particular characteristics of mental health systems. For instance, the classical assumption: “a situation which combines a low input consumption with a high outcome production is positive for the system performance” may not be always correct or appropriate in mental health care (Torres-Jiménez et al., 2015). Expert knowledge is formalised in a rule-base by using the B-MHCC paradigm (Salvador-Carulla et al., 2007), which determines an appropriateness degree for each variable value (“non-appropriate” values are penalised in their mathematical transformation).

Secondly, the Monte-Carlo DEA model makes RTE assessment more discriminant by the artificial replication of the observation number. Datasets are generated by the Monte-Carlo engine according to variable values statistical distributions. The Monte-Carlo simulation engine explores the variable values spectrum and offers a RTE probabilistic view.

4.2 Strengths of the Study of the Relative Technical Efficiency in Bizkaia

Previous RTE studies have mainly assessed the efficiency of complete systems (Kaya Samut & Cafrı, 2015); specific services, such as nursing homes (Garavaglia, Lettieri, Agasisti & Lopez, 2011; Kleinsorge & Karney, 1992), hospitals (Dash,

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Vaishnavi, & Muraleedharan, 2010; Mogha, Yadav & Singh, 2016) or primary care (Cordero et al., 2015; Kirigia et al., 2011). However, they have not allowed to know performance differences within the whole health system. This research has studied different RTE scenarios designed to describe the behaviour of both the partial (i.e. residential care) or mixed (i.e. day and outpatient care jointly) typologies based on the B-MHCC paradigm. Thus, these scenarios incorporate an integrative vision of mental health care, including all the types of care (from a holistic perspective) in which health and social care are highlighted. This fact lets us to understand and assess specific mental health care itineraries that patients should follow in order to increase RTE and quality care. Results include all the RTE statistical distributions as well as the global RTE of the system.

This study has analysed the provision and utilisation of mental health services in a real system through an exhaustive data collection from the Integrated Mental Health Atlas of Bizkaia (Pereira et al., 2013; Salvador-Carulla et al., 2011). The use of a standardized model for mental-health care description and assessment was absolutely essential because the name of the service was not enough for describing its management structure and for making comparisons. The Mental Health Atlas collected information about the availability of specific types of care, placement capacity, availability of workforce and utilization indicators. The Monte-Carlo DEA model integrates the uncertain information with an operational model for assessing RTE and potential managerial improvements.

4.3 Analysis of the Mental Health System RTE in Bizkaia

Efficient mental health areas may be identified as references for benchmarking. The assessed potential improvements can guide management interventions on the provision (inputs) and outcomes (outputs). On one hand, the provision of mental health care in inefficient areas could be adjusted to the values of the efficient ones. On the other, interventions on the service utilization could be direct such as the optimization of facilities, placements and staff; or indirect such as economic incentives, training activities, policy design or good practices promotion.

The global RTE of the system is greater in the output-oriented model than in the input-oriented one. This suggests that a decisional strategy based on optimizing the input amount, within the ranges established by the B-MHCC paradigm, may be more adequate for the Mental Health System of Bizkaia.

In the input-oriented analysis and in spite of the existence of outliers, the scenarios where the RTE scores are more homogeneous are those that evaluated the residential non-acute care and day hospitals (S2 to S5 and, by extension, S13). This characteristic is the result of the current and careful political planning. Obviously, RTE scores can be improved in each scenario by designing specific policies, especially on the outlier areas.

In the output-oriented analysis (more homogeneous), the most efficient scenarios are S11 and S12 (community mental health 1 and 2) and S4 (health-related day care). According to the results, S2 (non-acute residential and hospital care), S3 (residential care), S5 (non-health-related day care) and S6 (outpatient care) could be main the targets in a decisional environment based on the improvement of the RTE. In this DEA orientation, the area number 15 has a relevant impact on the RTE scores because it was a highly penalised due to the lack of information.

It is highly recommended to increase the day care resources to be equal, at least, to medical ones. This intervention should increase both the RTE and the mental health care quality, in addition to an expected decrease in the economic burden of the system. In this sense, there are empirical evidences that show that community-based care is more cost-effective than institutional-based care (WHO, 2005).

The proposed DSS can assess the impact of an almost infinite number of planning interventions. This process can decrease the intrinsic managerial risk associated to any real management decision. For example, it can evaluate the effects on the system of transferring some professionals from a mental health area, or areas, to other/s: this implies changes in the provision, utilization and outcome variables. This analysis understands that any intervention in a specific geographical area will probably have an impact on the others because of the interrelations between them.

4.4 Limitations

The analysis of RTE in specific mental health areas is relevant and useful but insufficient to evaluate the global situation of mental health care. The pathway of care that should be followed by a specific user has to be designed depending on his clinic status. In Spain, the first point of contact in the health care system is usually located in a primary care service or in a hospital. From these units, the patient can be derived to a secondary care service afterwards. All the mentioned services have been include in this study. Nevertheless, until the patient arrives to this
secondary level, he has followed an itinerary that ought to be studied if RTE scores have to be increased. To avoid an increase in the re-hospitalization number, in the number of stays at the hospitals, in the frequentation, the prevalence or even in the incidence of mental disorders, a most efficient care coordination and an integrative professional practice have to be highlighted (Burns, Goldsmith, & Sen, 2013; Cordero et al., 2015).

In conclusion, it should be necessary to include primary care services in RTE assessment in order to have a complete picture of the mental health system under analysis.

5 CONCLUSIONS

In the decision making processes based on empirical evidence, the intrinsic decisional risk decreases. Therefore, it is fundamental to provide the decision maker as much reliable information as possible to understand the real situation (Gibert, Garcia-Alonso & Salvador-Carulla, 2010).

The Monte-Carlo DEA model has provided high-level and empirical informed-evidence on the RTE based on the provision and utilization of mental health services in small geographical areas of the Bizkaian Health System. Based on the results, it has been possible to identify and analyse potential improvements that can be transformed into decisional interventions to be checked by modifying input or output values (statistical distributions) in the DSS. The obtained results may help decision makers to prioritise them in an uncertain context dominated by economic restrictions.

Future research will be focused on the validation of the DSS analysing real decisional situations with multiple feasible alternatives. Selected micro-management interventions, those that imply a relative small number of variables, based on policymaker interests will be selected to assess potential improvements and risks on the system management prior their implementation. Following this process, the decision making process is supported by empirical evidence. This feature matches with the strategies established in the Mental Health Action Plan 2013-2020 (WHO, 2013).

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Hart, C. et al., 2015. The Monte-Carlo DEA model has provided high-level and empirical informed-evidence on the RTE based on the provision and utilization of mental health services in small geographical areas of the Bizkaian Health System. Based on the results, it has been possible to identify and analyse potential improvements that can be transformed into decisional interventions to be checked by modifying input or output values (statistical distributions) in the DSS. The obtained results may help decision makers to prioritise them in an uncertain context dominated by economic restrictions.