Complexity of Needs Model (DEA)

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Data Envelopment Analysis (DEA) (../../../../8642) is a powerful non-parametric engineering tool for estimating technical efficiency and the production capacity of service units. The Complex-of-Needs Allocation Model proposed by Nepomuceno et al. (2020) is a two-step methodology for prioritizing hospital bed vacancy and reallocation during the COVID-19 pandemic.

The framework determines the production capacity of hospitals through Data Envelopment Analysis (../../../../8642) and incorporates the Complexity of Needs in two categories for the reallocation of beds throughout the medical specialties. As a result, we have a set of inefficient health-care units presenting less complex bed slacks to be reduced, i.e. to be allocated for patients presenting more severe conditions.

Keywords: Data Envelopment Analysis ; COVID-19 ; Hospital Efficiency ; Bed Allocation ; Complexity of Needs

The Model Explained [1]

The first step consists of applying non-parametric frontier estimations for the full production capacity of the health service units (the maximum feasible production configuration for each hospital) based on hospital internments as the main output and hospital beds as one of the many discretionary resources. Similar to many assessments of health systems efficiency, the number of beds is considered a proxy for hospital capital [2][3][4]. That way, the lower the usage of this resource means the higher efficiency for the health service unit. The objective in this assessment, however, is to provide an optimal number of beds to be evacuated and allocated for potential COVID-19 cases, instead of reduced.

For the second step, the optimal number of beds to be reallocated (based on the best practices) are prioritized according to the Complexity of Needs for each medical specialty. The Complexity of Needs in the Brazilian health system is the degree of complexity each health problem presents, and the requirement for specialized knowledge. There are three categories: Basic Care, Moderate Complexity and High Complexity. Each category is defined in the Box 1.

Box 1: Complexity of Needs Categories

Basic Care: The first level characterized by a set of actions and practices using low-density technologies to solve health issues of greater frequency but low severity, including a list of simpler and cheaper procedures. The procedures in this category are capable of meeting most of the community's common health problems.

Moderate Complexity: composed by actions and services aiming at meeting the main public health issues whose assistance in the clinical practice requires the availability of specialized professionals and the usage of technological resources for diagnostic, support and treatment.

High Complexity: common for more severe health issues, this category is characterized by a set of procedures involving high technology and high cost, aiming at providing access to high-specialized knowledge and qualified services.

Hospitalizations have moderate (e_{low}) or high (e_{high}) Complexity of Needs admissions. Consider a set of j = 1, 2, 3, … m health service units using x_i| i = 1, 2, 3, …, n hospital inputs to produce y_r| r = 1, 2, 3, …, s outputs. Consider ‘o’ the service unit under evaluation and ‘e’, the sum of both moderate and high Complexity of Needs hospitalizations, a proxy for the prioritization of beds evacuation. The optimal feasible contraction (evacuations) of high complexity hospitalization beds is:

$$Ev_{a+} = \begin{cases} e(1-\ominus) - e_{low}, when: e(1-\ominus) - Ev_{a+} > 0 \\ 0, otherwise \end{cases} \quad (1)$$

The optimal feasible contraction (evacuations) of moderate complexity beds is:

$$Ev_{a\text{-}\perp} = \begin{cases} e_{low}, when: e(1-\ominus) - e_{low} \geq 0 \\ e(1-\ominus), otherwise \end{cases} \quad (2)$$

Where: $\ominus = min(\theta) | \sum_{j=1}^{m} z_j x_{ji} \leq \theta x_{oi}; \sum_{j=1}^{m} z_j y_{jr} \geq y_{or}; \sum_{j=1}^{m} z_j = 1; z_j \geq 0$ is the efficiency score for the production technology under variable returns to scale [5][6].

Equation (1) and (2) states that the optimal number for bed evacuations of high complexity internments depends on the number of evacuated beds of moderate complexity. In other words, the optimal number for bed evacuations of high complexity internments is the remaining feasible contraction of beds after all moderate complexity internments are evacuated. As an example, considering an efficiency score = 0.8, the service unit may improve efficiency by producing the same result using (1 – 0.8) = 20% fewer resources. Considering 100 hospital beds allocated to internments of both Complexity of Needs as the discretionary input | = 15 & = 85, the number of beds to be evacuated having moderate complexity is = = 15 beds; and the number of beds to be evacuated having high complexity is = = 20 – 15 = 5 beds.

Full concepts and definitions concerning the Complexity of Needs assistance in the Brazilian Health System and a list with the related medical specialties can be accessed in CONASS (2020) [7].

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