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The Lean-DEA Approach: Enhancing the Efficiency of Hospital Processes

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ABSTRACT

This paper proposes an integrated approach combining Lean Healthcare (LH) and Data Envelopment Analysis (DEA) to enhance hospital efficiency, addressing the current lack of systematized methodologies in the literature. The Lean-DEA approach unfolds in four stages: (1) constructing hospital profiles to support LH-based improvements; (2) assessing efficiency using inputs and outputs aligned with LH and DEA principles; (3) analyzing LH effectiveness and projecting inefficient hospitals onto the efficiency frontier using an ideal adjustment mechanism; and (4) identifying tailored improvement cases for each inefficient hospital based on benchmark gains. A key innovation is the introduction of the Lean-DEA ideal DMUs, derived from the performance values of efficient hospitals. This integration ensures consistent and robust target-setting, distinguishing the proposed method from existing models and contributing a novel perspective to hospital performance evaluation.

KEYWORDS. Data Envelopment Analysis (DEA). Lean Healthcare. Unify approach.

Paper topics Data Envelopment Analysis (DEA), Lean Healthcare, Public health.

1. Introduction

Lean principles have demonstrated applicability across various sectors, provided they are appropriately adapted. In healthcare, this philosophy became known as Lean Healthcare (LH), driven by increasing pressure on managers and policymakers to contain rising costs without compromising service quality [Colldén et al., 2017]. Hospitals, due to their organizational complexity, social relevance, and budget constraints, represent a particularly suitable environment for Lean implementation [Raimundo et al., 2014]. However, LH implementation requires resource allocation, which can temporarily hinder the efficiency gains it seeks to achieve.

In parallel, Data Envelopment Analysis (DEA) has emerged as the leading non-parametric method for evaluating efficiency among Decision-Making Units (DMUs), introduced by [Charnes et al., 1978]. DEA assesses relative efficiency by comparing multiple inputs and outputs, offering not only performance scores but also variable multipliers and benchmark targets for inefficient units [Emrouznejad e Yang, 2018].

While LH is centered on continuous improvement through waste elimination, DEA evaluates the extent to which inputs are effectively transformed into outputs. The combination of these two approaches offers mutual benefits: DEA provides structured benchmarking that can support and standardize LH efforts. Nonetheless, studies that integrate LH and DEA tend to apply DEA only after LH implementation, merely quantifying before-and-after differences without offering structured, prescriptive guidance for improvement [Ngee-Wen et al., 2020].

This paper proposes an integrated approach combining Lean Healthcare (LH) and Data Envelopment Analysis (DEA) to enhance hospital efficiency, addressing the current lack of systematized methodologies in the literature. Building on prior evidence that the integration of LH and DEA can improve hospital performance [Drei and Angulo-Meza, 2024], this study advances the field by introducing the Ideal Lean-DEA Adjustment — a refinement tailored specifically to the healthcare context.

This adjustment is based on a threshold calculated from the performance of hospitals within the set of DMUs, resulting in realistic and achievable benchmarks. By incorporating this ideal adjustment into the Lean-DEA framework, the proposed approach offers a more practical and context-sensitive method for performance improvement, filling a critical gap in the literature regarding the operationalization of benchmarking in hospital environments.

2. The Lean-DEA approach methodology

The proposed Lean-DEA Approach is structured into four sequential stages, each designed to address specific objectives within the methodology. This segmentation ensures a systematic implementation, with each phase comprising distinct steps that contribute to the overall process (FIGURE 1).

The Lean-DEA Approach is structured into four sequential stages, each comprising specific steps to guide hospitals toward improved efficiency through the integration of Lean Healthcare (LH) and Data Envelopment Analysis (DEA). In Stage 1, the **Development of Lean Hospital Profiles**, hospitals are characterized (Step 1.1) by their size, location, public or private status, and LH adoption. The LH intervention is then detailed (Step 1.2), including tools used, types of waste addressed, implementation timeline, staff adaptation, and involved departments. Performance indicators are presented (Step 1.3), ideally comparing pre- and post-LH data through DEA inputs and outputs. Finally, stakeholder perceptions are gathered (Step 1.4), with managers, staff, and patients contributing strategic, operational, and experiential insights.

Stage 2, **Efficiency Assessment**, begins with the selection of DMUs (Step 2.1), classified as pre-LH (RA), post-LH (RD), or non-LH (RN). Inputs and outputs are defined (Step 2.2) to capture resource usage and value creation. DEA feasibility is confirmed (Step 2.3) by checking the ratio between DMUs and variables. The DEA model is selected (Step 2.4) based on the hospital context, followed by defining the model orientation (Step 2.5) and scale assumption (Step 2.6). The model is executed (Step 2.7), classifying hospitals as efficient or inefficient.

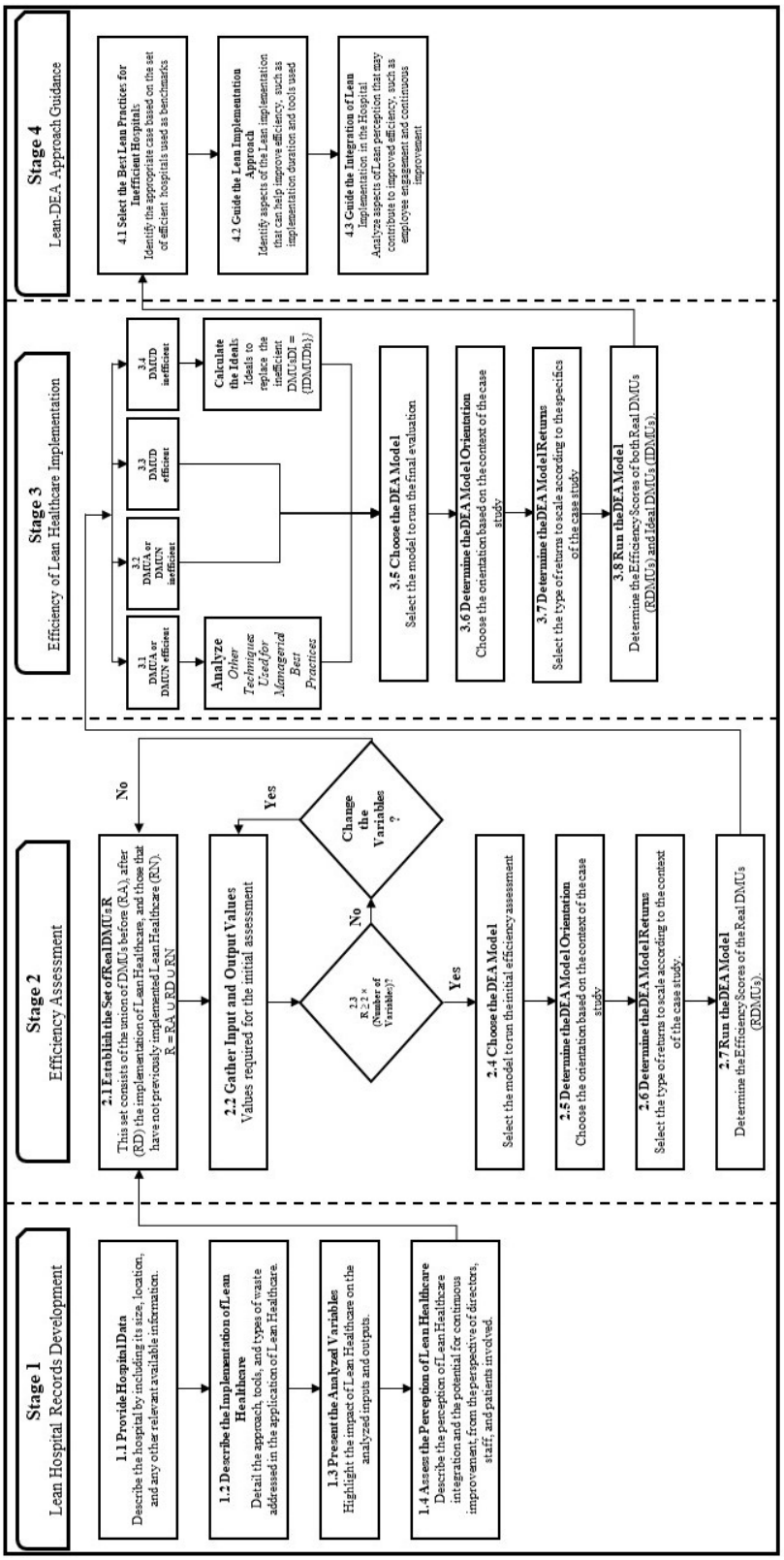


Figure 1: The Lean-DEA approach.

In Stage 3, **Analysis of Lean Healthcare Efficiency**, DEA results are refined for more accurate benchmarking. Efficient non-LH hospitals are retained (Step 3.1) as valuable references,

while inefficient non-LH hospitals are kept (Step 3.2) to maintain sample size and enable cultural alignment with Lean. Efficient LH hospitals remain in the model (Step 3.3) as benchmarks. Inefficient LH hospitals are replaced by Ideal DMUs (IDMUs) (Step 3.4), constructed by adjusts based on Entani and Tanaka (2006)—to ensure realistic targets aligned with Lean's principle of gradual improvement (1) – (4).

$$\frac{x_{ik} - \bar{x}_{i0}}{x_{ik}} \geq 0.5 \quad \rightarrow \quad x_{LD} = \frac{\bar{x}_{i0} + \hat{x}}{2} \tag{1}$$

$$\frac{x_{ik} - \bar{x}_{i0}}{x_{ik}} < 0.5 \quad \rightarrow \quad x_{LD} = \bar{x}_{i0} \tag{2}$$

$$\frac{\bar{y}_{j0} - y_{jk}}{y_{jk}} \geq 0.5 \quad \rightarrow \quad y_{LD} = \frac{\bar{y}_{j0} + \hat{y}}{2} \tag{3}$$

$$\frac{\bar{y}_{j0} - y_{jk}}{y_{jk}} < 0.5 \quad \rightarrow \quad y_{LD} = \bar{y}_{or} \tag{4}$$

If the required adjustment is less than 50% (2) and (4), the ideal Lean-DEA value (x_{LD} – inputs and y_{LD} – outputs) assume the calculation proposed by Entani and Tanaka (2006) ($\bar{x}$ and $\bar{y}$). If it is 50% or more (1) and (3), the value assumes the average between the ideal value of the authors and the original DEA target, calculated in the second stage of Lean-DEA approach. The DEA model is then reapplied (Step 3.5), keeping the same scale assumption (Step 3.6) and orientation (Step 3.7).

Stage 4, **Lean-DEA Strategic Guidance**, provides actionable Lean recommendations based on the final benchmark composition. Depending on whether the inefficient hospital's references are real DMUs (c1), ideal DMUs (c2), or both (c3), different strategies are defined (Step 4.1). For LH hospitals that remained inefficient, scenarios include benchmarks with other DMUs (c4) or exclusively their own IDMUs (c5). Practices adopted by benchmark units are analyzed (Step 4.2), and internal gaps between current and ideal performance are identified (Step 4.3), forming a basis for customized Lean strategies.

3. Final Considerations on the Lean-DEA approach

This study proposes an integrated approach combining LH and DEA to enhance hospital efficiency, addressing the current lack of systematized methodologies in the literature. In addition, the Lean-DEA ideal adjustment introduces a more appropriate threshold for the healthcare context, that had not been previously identified in the literature.

Therefore, future research should focus on applying the Lean-DEA approach in real hospital settings to generate tangible and beneficial outcomes for society. Such applications can validate the methodology's practical value and contribute to the continuous improvement of healthcare systems.

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