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A Roadmap to Evaluate Lean Six Sigma E-Health Reference Architectures Using a Fuzzy Group Bi-Objective LINMAP

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ABSTRACT

Purpose: In recent years, although several studies have focused on Lean Six Sigma project selection, none of them have applied a Lean Six Sigma approach to evaluate e-health reference architectures. Therefore, there is a significant gap of Lean Six Sigma application for e-Health architectures in e-Health care quality improvement literature. In this paper, we present a Lean Six Sigma approach to select e-health reference architectures for high-quality healthcare in modern medicine.

Design/methodology/approach: At first, a novel model is presented to evaluate core e-Health modules and layers of e-Health reference architectures from a Six Sigma perspective. Then, the proposed model is used to evaluate core e-Health modules and layers of e-Health reference architectures from a Lean perspective. In order to overcome issues related to imprecise or vague judgments in, the proposed e-Health decision making model is presented in the fuzzy environment.

Findings: Findings from this paper develop the Linear Programming techniques for Multidimensional Analysis of preference (LINMAP) model to a Fuzzy Group bi-objective LINMAP to integrate Lean and Six Sigma perspectives and select the best practice Lean Six Sigma e-Health reference architecture.

Keywords

Lean, Six Sigma, e-Health Reference architecture, Fuzzy Group Bi-Objective LINMAP.

INTRODUCTION

In 1993, Chaufournier et al. reported that 44% of 1,083 hospitals surveyed in the U.S. were embracing some kind of quality management approach such as CQI (Continuous quality improvement), Kaizen, and TQM (Total Quality Management) to improve health care quality [3]. Since the release of the Institute of Medicine report To Err Is Human, which estimated that as many as 98 000 medical errors are committed per year, there has been a strong push by consumers, payers, and the federal government for health care organizations to increase accountability and improve quality of care. (Institute of Medicine, 2000) For many health care managers, this push for increased accountability and quality has led to a re-emergence of evidence-based management in health care. [15] Although there are many quality improvement tools used in health care management today, Six Sigma and Lean are 2 relatively new, but popular quality improvement tools being used in the health care industry. [4, 13] The Figure 1 presents the annual number of citations for Lean and Six Sigma by year [5]:

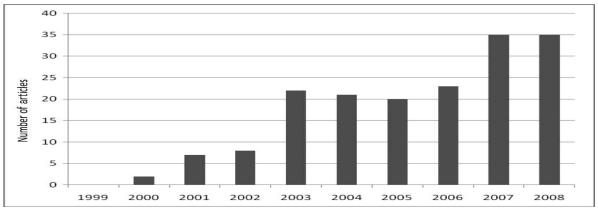

Figure 1: Six Sigma and Lean diffusion in healthcare, articles over time. (DelliFraine, and et. al, 2010)

Six Sigma is a powerful approach to quality improvement that can be used in healthcare organizations to meet needs and expectations of patients as well as to improve profitability and cash flow. Despite the challenges in using Six Sigma in the healthcare industry, many hospitals within the healthcare industry is beginning to use Six Sigma approach to improve patients' satisfaction [12]. Implementing some pertinent uses of Lean Six Sigma in e-Healthcare facilities alone can help reduce e-Healthcare costs by billions of dollars each year. These costs can significantly decrease by cutting the red tape, preventing medical mistakes, providing improved patient care and initiating cost-saving efficiencies. Hospitals and other healthcare organizations can use Lean to simplify and standardize e-Health modules. The uses of Lean Six Sigma in e-Healthcare include, reducing waste, shortening wait times, preventing medical mistakes, decreasing mortality rates, improving patient care and lowering healthcare costs due to inefficiency, inappropriate care, duplicative care and incomplete information, improving productivity of e-Health module. On the other hand, the e-Health Architecture sets out modules to incrementally information technology to support the delivery of improvements to care. This e-Health Architecture: (1) enable the early continual monitoring of patient transfers without disruptive wires; (2) make data available in real time in follow-up care locations as soon as the patient arrives; (3) enable the continuous, unbroken monitoring of the patients' condition; and (4) provide doctors and nursing staff with the ability to access patient data anywhere within the coverage area of the wireless network.

Six Sigma methodology can be implemented in many modules throughout a health care organization. Some institutes started Six Sigma initiative in Radiology Department by improving CT throughput [7], improving the film library, or reducing the turnaround time [2]. The successful experience is then disseminated to other departments or modules in an organization, such as emergency department, billing or admission modules, human resources, call center, staffing, and surgery modules. Six Sigma projects were performed in various departments within the healthcare organization: from emergency department to surgical rooms, from purchasing to billing department, from pharmacy to radiology department.

Medical and policy literature reports many successful cases of Lean Six Sigma implementation at specific health care organizations. Additionally, although several studies have focused on Lean Six Sigma project selection, none of them have provided Lean Six Sigma approach to e-health architectures. Therefore, there is a significant gap of Lean Six Sigma implementation in e-Health reference architectures in e-Health care quality improvement literature. In this paper, we present a Lean Six Sigma approach to e-health reference architectures to have high-quality healthcare in modern medicine.

This paper is organized into four sections. In Section 2, we illustrate the details of the proposed framework. In Section 3, we present a case study to demonstrate the applicability of the proposed framework and exhibit the efficacy of the procedures and algorithms. The paper presents conclusions and future research directions in Section 4.

THE PROPOSED FRAMEWORK

The modular model depicted in Figure 2 along with the following mathematical notations and definitions are used to select the best practice Lean Six Sigma e-Health reference architecture:

$A(i)$	The e-Health reference architecture i
L_h	The layer h of e-Health reference architecture
M_i^h	The Module i of the layer h of e-Health reference architecture
$w(L_h)$	The importance weight of the layer h of e-Health reference architecture
$w(M_i^h)$	The importance weight of the Module i of the layer h of e-Health reference architecture
q	The number of e-Health layers
g_h	The number of e-Health modules of the layer h of e-Health reference architecture
$c_j(l)$	The Lean criterion j

$c_j(6\sigma)$	The Six Sigma criterion j
$w\left[c_j(l)\right]$	The importance weight of the Lean criterion evaluated by the Lean e-Health team
$w\left[c_j(6\sigma)\right]$	The importance weight of the Six Sigma criterion evaluated by the Lean e-Health team
r_1	The number of Lean criteria
r_2	The number of Six Sigma criteria
m_1	The number of the Lean e-Health team members
m_2	The number of the Six Sigma e-Health team members
$T_k(l)$	The member k of the Lean e-Health team
$T_k(6\sigma)$	The member k of the Six Sigma e-Health team
$w\left(T_k(l)\right)$	The voting power of the Lean e-Health team member k
$w\left(T_k(6\sigma)\right)$	The voting power of the Six Sigma e-Health team member k
$\tilde{r}_{g_h}\left[A(i), c_j(l)\right]$	The fuzzy weighted collective ordinal rank of the e-Health module g_h of the reference architecture i with respect to the Lean criterion j evaluated by the Lean e-Health team
$\tilde{r}^k_{g_h}\left[A(i), c_j(l)\right]$	The fuzzy individual ordinal rank the e-Health module g_h of the reference architecture i with respect to the Lean criterion j evaluated by the Lean e-Health team
$\tilde{r}_{g_h}\left[A(i), c_j(6\sigma)\right]$	The fuzzy weighted collective ordinal rank of the e-Health module g_h of the reference architecture i with respect to the Six Sigma criterion j evaluated by the Six Sigma e-Health team
$\tilde{r}^k_{g_h}\left[A(i), c_j(6\sigma)\right]$	The fuzzy individual ordinal rank of the e-Health module g_h of the reference architecture i with respect to the Six Sigma criterion j evaluated by the Six Sigma e-Health team

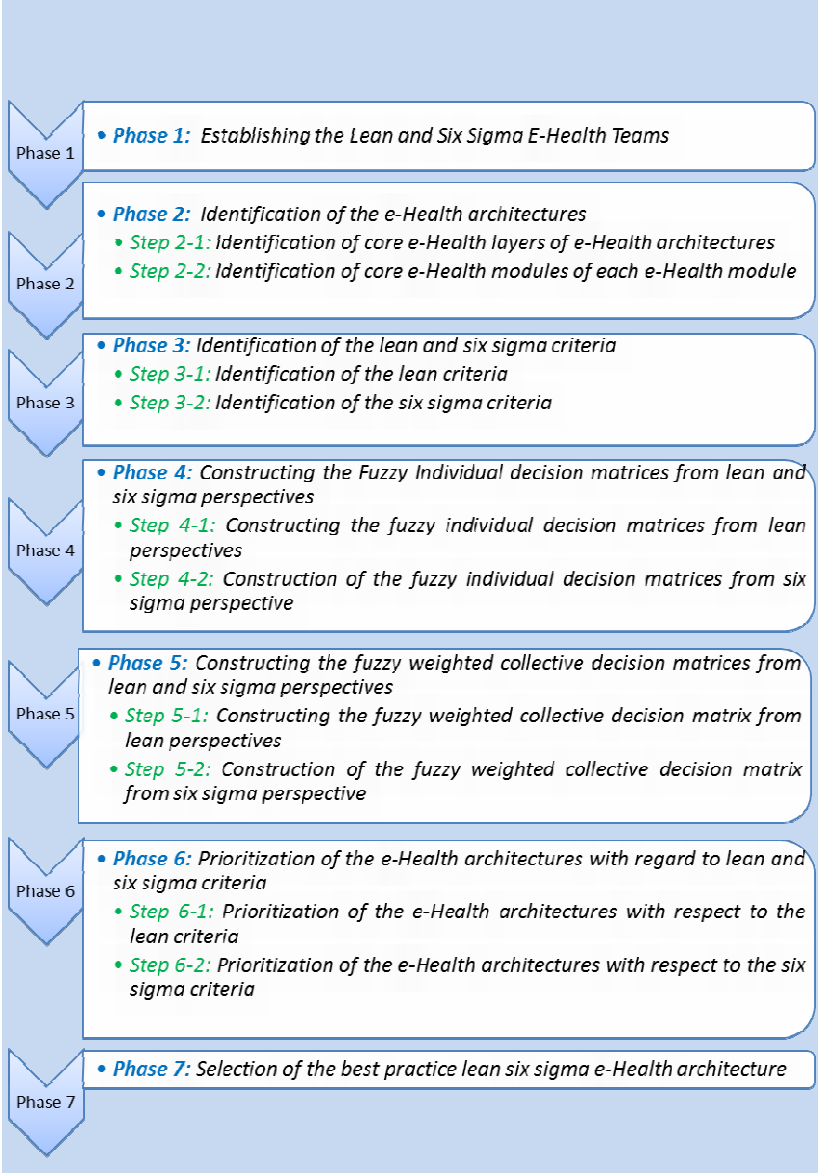

Figure 2: The proposed framework for selection of the best practice Lean Six Sigma e-Health Reference architecture

As shown in Figure 2, the proposed framework is divided into the following seven phases:

Phase 1: *Establishing the Lean and Six Sigma e-Health Teams*

In the first phase, the top manager establishes Lean and Six Sigma e-Health teams to evaluating core e-Health modules and layers of each e-Health reference architecture as follows:

$$\underline{T_{E-health}(l)} = [(T_1(l)),(T_2(l)),...,(T_{m_2}(l))] \quad (1)$$

$$\underline{T_{E-health}(6\sigma)} = [(T_1(6\sigma)),(T_2(6\sigma)),...,(T_{m_2}(6\sigma))] \quad (2)$$