Seeking efficiency and productivity in health care

Completed Research Paper

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Abstract

In this study, we show that the challenging service processes in the health care sector can be improved similarly to those of any other business sector when seeking efficiency and productivity. Two separate case organizations (acute neurology ward and children's dental clinic) from the health care sector were analyzed with the 3VPM (Three View Point Model) methodology that has also been used in several other businesses. A multi-method approach was used to acquire data for the analyses, including interviews and observation completed with numerical data. The first case represents a case where an ICT-related issue acted as a bottleneck, while the second case focuses on renewing the provisioning processes. In both cases, the analysis showed that improvement is possible and also pointed out benefits from different changes. However, the main result is dependent on the decision: will the proposed changes be made or not?

Keywords

Health care sector, process improvement, efficacy, productivity, ICT, bottleneck, multi-skilled teams

Introduction

The purpose of the study was to point out usable ways to seek improved business efficiency and productivity improvements in the health care sector. In so doing, it regenerates the efforts of the successful implementations of health information technology (Cresswell et al. 2013).

The study reveals that improvement is possible, but knowing this is not enough. The study shows that the role of leadership is crucial when aiming at process improvements, because even the best innovations have no value if they are not implemented at the end.

This study paid particular attention to policy makers, managers and leaders who have strategic responsibility for both quality and efficiency interventions in health care services. The reason for this approach was concern about the practical realization of process improvements in the health care sector.

The public health care sector is influenced by a lack of resources in its business. However, the World Health Organization (WHO 2006) claims that it's not a question of local readiness and actions with respect to organizational changes, but frequently, it's about the way that actions are carried out in an insufficient policy and strategic environment.

Rising costs in health care have led both researchers and practitioners to pay more attention to efficiency and productivity. To improve health care, both reliable performance measures and successful approaches for improvement are needed (Perla et al. 2011). In a recent study, 265 efficiency measures in health care were compared, but almost all of these measures reflected only the cost of care and not efficiency (Hussey et al. 2009). According to WHO (2006), there is clear evidence that even where health systems are well developed and resourced, quality remains a serious concern, because expected outcomes are difficult to predict, with wide variations in standards of health care delivery processes.

From earlier studies, we know that measuring, modeling and improving the performance of health care processes is one way to increase their productivity (e.g. Plsek 1997; Locock 2003; Langabeer et al. 2009; de Mast et al. 2011). Analyses of processes may reveal better ways of organizing the workflow, better division of work between employees, redundant tasks and bottlenecks. Improvements based on such analyses may increase output for fixed resources.

Furthermore, Carroll and Edmondson (2002) speak up for organizational learning when improving organizational performance in health care. Similar to Fiol and Lyles (1985), Carrol and Edmondson define organizational learning as a process of increasing organizational action with the help of knowledge and understanding. Specifically, they emphasize leadership as an enabler for organizational learning.

In this study, the research question was: "How could efficiency and productivity in health care sector be improved, and what would the most important actions to achieve the improvement be?" To find the solution, we applied a multi-methodological approach consisting of the Three View Point Model (3VPM) approach (Martikainen 2007).

The main finding in our study was the observation that business processes in the health care sector can be improved similar to the way in which they are improvable in any other business sector. In other words, even if the health care sector differs significantly, for example, from the construction sector, its business processes can be evaluated and improved like any others. Our study also emphasized the importance of leadership in the improvement process, to ensure that the best possible results are achieved from new information communication technology (ICT) investments. Without full support from the leading management, the recognized improvements may be neglected at the end.

Earlier Knowledge

To create improvements to the system studied, information about the mechanisms inside the system and about their possible problems is helpful. In manufacturing, there is a long lasting tradition of analyzing organizational capabilities and their fit to product-process architecture (Fujimoto 2007). In Japanese manufacturing, multi-skilled labor and organizational problem solving cycles have been essential in developing productivity (Clark & Fujimoto 1991). Traditionally, queuing models have been used in analyzing the industrial production processes (Nyhuis & Wiendahl 2008). Similarly, queuing and operational analysis models can be applied in the performance analysis of organizational processes (Denning & Buzen 1978; Gelenbe & Pujolle 1998).

Sedera et al. (2002) introduce a model to be used when evaluating process modelling. To evaluate, one needs four main elements to be defined: the unit of analysis, the definition of process-modelling success, the approach of the evaluator and the ideal timing of views of success. Sedera et al. point out that the role of the evaluator—the "correct" stakeholder—influences the items that are included in the model.

Organizational change can also be planned instead of an output of ICT implementation (see Markus & Benjamin 1996), as reported by Cummings et al. (2013). They emphasize the role of leadership and describe a project that was built due to the need to be accountable in health care service delivery and in a health care community that consisted of managers, leaders and staff. Even if they could not yet see a greater influence on organizational culture, climate or networks, they found that leadership practices were enhanced. As a final output, Cummings et al. note the need for support that comes with implementing strategies that help leaders to cope with uncontrolled varieties of change and stagnation.

Niehaves et al. (2014) introduce a new way to model business process management that pays attention to internal and external contingencies. They utilize the six core elements described by Rosemann and Von

Brocke (2010, cited in Niehaves et al. 2014): strategic alignment, governance, methods, information technology, people and culture. Niehaves et al. (2014) apply their model in a case company and report implications based on their study, such as the way existing models used in business process management fail to include organizational characteristics and external factors. They conclude that the use of developmental theories for business process management should be further discussed.

Analysis of health care processes (or workflows) is a demanding task, as the processes are complex in nature (Plsek 1997; Malhotra et al. 2007). In health care processes, human resources play a large role in determining process performance, and payroll forms a large share of costs; therefore, quantitative analyses of the optimal use of health care resources have often been conducted using queuing analysis (see e.g. Green 2006). For instance, examples of applications used are nurse staffing for time-varying demand (Green et al. 2007) and the optimal number of beds in an intensive care unit (McManus et al. 2004). Most of the models consider only one resource at a time, for example, nurses. However, Yankovic and Green (2011) include both beds and nurses simultaneously in the analysis. They note that allowing for heterogeneous resources would be potentially valuable, since in reality, two types of nurses are used, and the tasks they are allowed to perform differ from each other.

More than ten years ago, Carrol and Edmondson (2002) reported that they had seen signs of innovation in the health care sector in the form of creativity and leadership. To support the signs, they presented three arguments (p. 51):

1. Health care organizations can improve quality and other outcomes by enhancing their capabilities for organizational learning.

2. Organizational learning requires leadership from executives, line (middle) managers, and informal network leaders throughout organizations.

3. Leaders are more effective when they take a broad view of the interdependencies among individuals, teams, task flows, systems and cultural meanings.

Carrol and Edmondson (2002) list key messages based on their study of leading organizational learning in health care. They have recognized several obstacles to organizational learning such as tradition and outdated processes, values and structures. They also point out that leaders should have the wisdom to understand their role in creating conditions for quality in the organization.

Likewise, in their study about quality improvement for patient safety, Rivard et al. (2013) focus on organizational learning that differs a lot among their four case organizations. In addition, they notice differences in executive leadership in the organizations, and they assume that that leadership influences the differences.

Another approach is presented by Berente and Lee (2013), who propose four concepts to drive explorative activity in organizations: "Direct," to explain how exploratory forms of process improvement can directly drive innovativeness; "Resource Capacity," to describe how process improvement can increase the resource capacity that drives innovativeness; "Knowledge," to tell how process improvement efforts can strengthen knowledge resources that drive innovativeness; and "Management Vision," to show how process improvement efforts can influence the managerial vision that moderates the effect of process improvement efforts on innovativeness. More than twenty years earlier, March (1991) listed learning, analysis, imitation, regeneration and technological change as major components of any effort to improve organizational performance or to strengthen competitive advantage.

Furthermore, ten years ago Sambamurthy, Bharadwaj and Grover (2003) introduced a multi-theoretic view where ICT investments and capabilities influence firm performance through three dynamic organizational capabilities (agility, digital options and entrepreneurial alertness) and three strategic processes (capability building, entrepreneurial action and co-evolutionary adaptation). Ten years later, Berente and Lee (2013) stated that managers with vision or business sensitivity will set more exploratory process improvement metrics to enable investments in radical innovations than managers without the vision or sensitivity.

One can conclude that when looking for improvements in efficiency and productivity in health care, one must analyze the processes of the organization from several angles and viewpoints. Earlier research has shown that improvement is dependent on available resources and their usage. The resources consist of, for example, the physical environment, such as the number of beds (McManus et al. 2004) and personnel, (Yankovic and Green 2011) but also consist of skills the personnel have and the modes or processes (Plsek 1997; Malhotra et al. 2007). The analysis of the versatile resources and processes requires an approach that takes them all into account at the same time instead of analyzing them one at a time. In the next section, we describe a research approach that includes several methods and therefore enables a multi-method approach.

Research Approach

In this study, a multi-method approach called Three View Point Model, or 3VPM (Martikainen 2007), was used in two separate analyses. 3VPM was necessary, as traditional models apply only one viewpoint at a time, and without a systemic approach, the required analyses could not have been done. In 3VPM, the service processes are analyzed as a system from three viewpoints: the process structure, the performance and the costs. The approach is independent of the business (Martikainen & Halonen 2011), and each viewpoint requires different research methods. The process structure is explored by a qualitative approach, using interviews and observation and utilizing existing documents such as official process descriptions or statistical data. Mathematical analyses are used to analyze the existing performance and to propose theoretical performances. The costs are revealed based on the performances (existing and theoretical) and the processes (existing and modified or theoretical).

Figure 1 clarifies the main tasks required to discover the improvements. Diagrams are based on information retrieved from people and from existing data such as lists of working hours and other performance documentation.

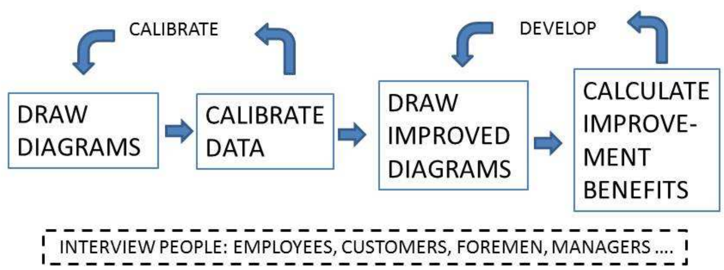

Figure 1. Phases in 3VPM.

The information collected is used to define a stochastic queuing network model of the processes. The key building blocks that are needed are customer arrival intensities in the system for each patient class, patient classes served, activities or tasks, transition probabilities from task to task, service times for activities, resources, requirement of resources in the team and the service rate in the activity. This information can be gathered through interviews, as outlined above. The created model is then analyzed, and the obtained results are calibrated to the existing data. Based on the calibrated model, possible improvements can be studied.

The improvements can be analyzed by changing the model parameters (incremental changes) or the model structure (radical changes). The performance and the costs of the improvements can then be compared to the original model. In practice, the number of changes in the processes is not limited, due to the theoretical approach in 3VPM.

Mathematical formulation[1]

The model

In the previous section, we explained how to collect data for defining a stochastic queuing network model of the processes studied. The key building blocks that are needed are customer arrival intensities (λ_n) in the system for each patient class, patient classes (E_c) served, activities or tasks (A_n), transition probabilities from task n to task j (p_{nj}), service times for activities (T_n), resources (R_l), requirement of resources l in team m (r_{ml}), and the service rate of m in activity n (π_{nm}). This information can be gathered by interviews, as outlined above.

Based on the process description and the variables above, we can define a queuing network model M .

$$M = \left(A_n, E_c, p_{nj}, T_n, \pi_{mn}, r_{ml}\right) \tag{1}$$

The throughput of the network depends on the allocation of teams m to activities n. This allocation is given by the matrix $\mathbf{X}$. The aggregate production of teams allocated to activity n is given by $\eta_n(\mathbf{X}) = \sum_{m=1}^{M} \pi_{nm} x_{nm}$. The network throughput is defined by $\lambda(\mathbf{X}) = \min_{1 \le n \le N} \frac{\eta_n(\mathbf{X})}{w_n}$, where w_n is the total expected workload in task n . Thus, the throughput is determined by the task for which production in relation to workload is the smallest. The total expected workload, in turn, depends on customer arrival rates and routing probabilities. Thus, this variable captures the important aspects of the workflow.

The problem is to choose the matrix $\mathbf{X}$ in order to maximize the throughput of the network while satisfying resource constraints. Formally, the problem is the following:

Maximize

$$\lambda(\mathbf{X}) = \min_{1 \le n \le N} \left(\frac{1}{w_n} \sum_{m=1}^{M} \pi_{nm} x_{nm} \right)$$

subject to:

$$\sum_{n=1}^{N} \sum_{m=1}^{M} \sum_{l=1}^{L} x_{nm} r_{ml} c_l \le C,$$

$$\sum_{m=1}^{M} x_{nm} \le B_n, \; n = 1,2,\ldots,N,$$

$$x_{nm} \ge 0, \; n = 1,2,\ldots,N, m = 1,2,\ldots,M .$$

The first constraint states that we cannot use more of resource l in teams m which serve in task n than the allowed maximum total cost of resources. Here, c_l is the cost of type l resources, and C is the total budget. The second constraint states that we cannot exceed the maximum number B_i of different servers allowed in the processes (boundary condition).

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[1] This section draws on Naumov and Martikainen (2011a) and Naumov and Martikainen (2011b).

Solving the model

The optimal fractional allocations of the teams of resources in the model M with resource constraints is solvable (Naumov and Martikainen 2011b, Naumov and Martikainen 2011a) and gives the optimal solution G, which maximizes customer throughputs in tasks λ_{cn} , minimizes the utilizations of resources ρ_l and also provides the utilization of teams ρ_m and the utilization of tasks ρ_n in the system:

$$(\lambda_{cn}, \rho_l, \rho_m, \rho_n) = G(\lambda_n, R_l, M) \qquad (2)$$

The utilization rates measure the fraction of time the resources are employed.

Performance analysis

Solving function G for the model M and the variables λ_n and R_l in Formula (2) does the performance analysis. The calculation reveals the performance and cost measures and also the optimal allocation of resources to teams that can be assigned to the activities. The joint use of resources that is specified for the teams, including the optimization algorithm, enables the analysis of externalities caused by resource sharing. For instance, an improvement in one process releases resources that can be moved to other processes in the organization.

When the processes are analyzed using model M and function G , the modeling results can be calibrated with the process performance data of the real process. The calibration means the comparison of existing real process performance statistics to the corresponding results given by the analysis tools. If the calibration does not succeed, iterative interviews are needed in order to correct the process diagrams and their variables. This creates more insight into the process behavior. In some cases, experimenting with the process variables such as "incorrect delays" or possible "hidden work times" has been needed to reveal and correct the factors that prevent successful calibration. Only after successful calibration can the possible process changes be modeled and their effects be analyzed.

Process improvements

Now we can study the impact of different possible changes made in model M . The changes may concern any of the inputs to the model, including the process descriptions. Here we illustrate the analysis of process improvements by considering an abstract alternative model called M_1 .

Before the comparison of the original and improved models can be made, the functions G have to be solved for each of the models. If resources in teams are used, then the optimal functions $\underline{G}$ can also be obtained for the models. Let us denote the resulting variables of the solution $G(\lambda_n, R_l, M)$ of Formula (2), using the following notation, $\lambda_{cn} = G(\lambda_n, R_l, M)(\lambda_{cn})$.

We can analyze several types of improvements. Here we consider three types. The first type considers the throughput achieved with models M and M_1 with the same resources. The service level obtained by a customer class c in model M can be expressed as the throughput λ_{cn} for some activity n. The service level or throughput improvement of model M_1 compared to model M is calculated by Formula (3):

$$\Delta\lambda_{cn} = G(\lambda_n, R_l, M_1)(\lambda_{cn}) - G(\lambda_n, R_l, M)(\lambda_{cn}) \qquad (3)$$

The second type of improvement is resource savings with a constant service level. We obtain the resource improvements $\Delta R_l = \underline{R}_l - R_l$ related to a constant service level λ_{cn} from Formula (4):

$$G(\lambda_n, \underline{R}_l, M_1)(\lambda_{cn}) = G(\lambda_n, R_l, M)(\lambda_{cn}) \qquad (4)$$

The third type considers the utilization of resources with a constant level of service. The utilization improvement of resources l related to a constant service level λ_n can be calculated from Formula (5):

$$\Delta\rho_l = G(\lambda_n, R_l, M_l)(\rho_l) - G(\lambda_n, R_l, M)(\rho_l) \tag{5}$$

Similar formulas can be written for other variable improvements by keeping the reference variable constant.

The Study

To respond to our research question, "How could efficiency and productivity in the health care sector be improved, and what would the most important actions to achieve the improvement be," we present two examples. The examples are from the health care sector, and in both cases, the organizations were seeking for improvement in efficiency and productivity.

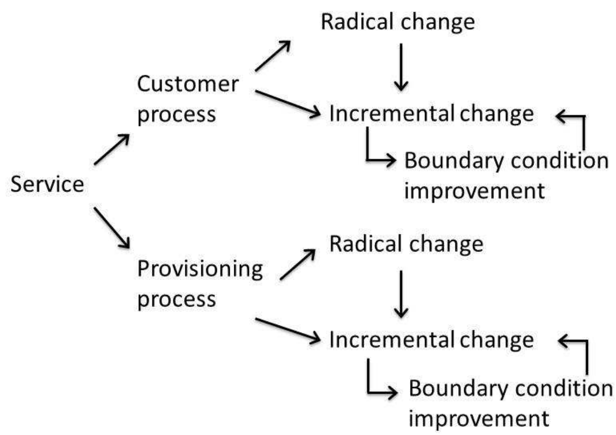

Figure 2. Service improvement.

To start with, we analyzed the processes. This was done from the viewpoint of service that consists of a customer process and a provisioning process. The service improvement may focus on either of them or both. Moreover, the improvement can be either incremental or radical in nature (see Figure 2).

The Acute Neurology Ward at the University Hospital

At the acute neurology ward, there were 13 different employee categories: 1) nurses, 2) practical nurses, 3) physiotherapists, 4) speech therapist, 5) neuropsychologist, 6) occupational therapist, 7) social worker, 8) orderlies, 9) head nurse, 10) secretary, 11) pharmacist, 12) doctors and 13) senior physician. These 13 employee categories worked in 21 different multi-skilled teams. The skills on the teams were complementary; for example, the doctor could not be replaced by a nurse.

The information presented here was gathered through semi-structured interviews. At least one person from each occupational group was interviewed, resulting in a total of 14 interviews. All interviews (average duration was 1.5 hours) were recorded and transcribed. The purpose of the interviews was to collect detailed data on the work tasks of the employees. For the modeling, one needed to characterize the tasks, know the duration of the tasks and know who could perform different tasks. In our model, we had identified more than 90 tasks, and this acted as a good pool within which to make changes.

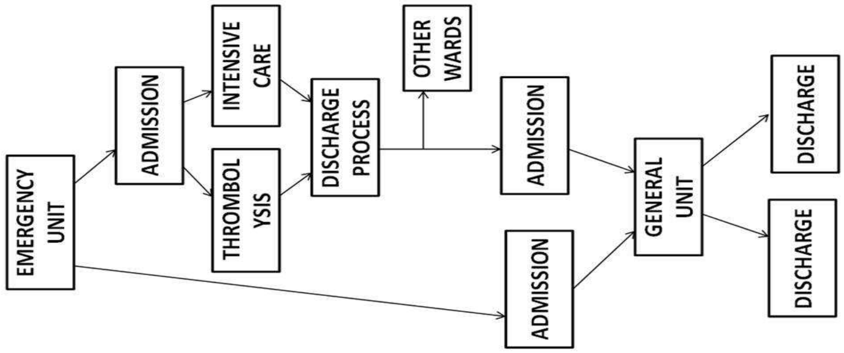

Figure 3. Patient flow.

Figure 3 reveals the process of patient flow at the acute neurology ward. The patient enters via the emergency unit and leaves after care is given. The patients are classified into three categories: 1) patients for thrombolysis who stay one day in the Stroke Unit; 2) patients for intensive care who stay three days in the Stroke Unit; and 3) patients who pass the Stroke Unit. All the patients continue to the General Unit before the process is discharged (Kauhanen et al. 2013).

When the processes of the ward were modelled and analyzed, it was found that the processes were optimal with respect to given boundary conditions, which included the number employees in each skill group, the available IT services and the other available resources. The personnel had improved their work incrementally, and the performance corresponded to the theoretical maximum of their service process model. However, the boundary conditions were far from optimal. Firstly, the IT services were too fragmented, and user access was so slow that 30–45 minutes per day of the working time of each nurse was lost simply to performing login or logout to services. Secondly, the process was so overloaded that an unexpected sick leave of two nurses forced the ward to close. Thirdly, the employee distribution between the skill categories was so far from optimal that a 35% improvement could be possible with constant salary costs.

As 3VPM allows the analysis of changes due to potential or suggested improvements, an example technological change was proposed. In theory, the model proposed changes in the log-in time, as the reality involved 30–45 minutes for each nurse to log in. In practice, the log-in time could be zero if the nurses were identified by fingerprint.

Interestingly, despite the statistics and figures that showed the potential improvement in the service process at the Acute Neurology Ward at the University Hospital, the changes were not implemented at the time of the study. Now, later, the log-in time improvement is under consideration.

Children's Dental Clinic

The Children's Dental Clinic represented a small organization in our study. However, the organization had realized the need to improve its efficiency and productivity. Based on earlier experience and statistics, a problem was identified in the organization: that children were afraid of the dentist, and there was a 7% no-show of customers. The no-shows meant that not all services were produced that were planned. In other words, the problem was not related to the ICT-related issues of lacking information or problematic delays in information sharing. However, after the solution for improving efficiency and productivity at the Children's Dental Clinic was put into place, it appeared that ICT also had to be considered, because the modifications in the process revealed frictions in the ICT functionalities.

In the beginning, the problem was about delivering the service (see "Provisioning process" in Fig. 2).

There were three employee categories at the Children's Dental Clinic: 1) dental hygienists, 2) dental assistants and 3) dentists. The service process was simple to describe, and it appeared rather straightforward. When analyzed with 3VPM, it was seen that there were only a few possibilities for making incremental changes. When analyzed, only a 5% improvement through employee distribution was possible. However, it was found that a radical change would be possible with a clear performance improvement (between 14% and 26%). This change was then implemented, and because new features had to be implemented into the ICT functionalities, it seemed probable that the final performance improvement would increase even more.

The process was improved so that the two first visits of customers were combined into one, and the dentist was shared among four parallel dental hygienists. In so doing, the organization implemented a radical change that was possible due to the empowerment of the personnel, enabled by full support from the management. In practice, the customer flow was made more fluid, as the dentist could serve several customers with only a little waiting time. As a result, the no-show probability of customer visits also decreased, since the first customer visit included the operations of two visits in the old process model.

The final benefit from the change is not available, as the improved process was under testing at the time of this writing.

Discussion

The purpose of the study was to seek ways to achieve more efficiency and productivity in health care. Earlier studies report that measuring and remodeling is one way to experience more productivity (e.g., Plsek 1997; Locock 2003; Langabeer et al. 2009; de Mast et al. 2011). The paper points out that one of the important tasks is to identify bottlenecks in the processes. In our study, we applied the 3VPM approach that—among other things—includes means of finding potential and existing bottlenecks (see Figure 1; Martikainen and Halonen 2011).

The case of the Acute Neurology Ward revealed that if the resources are diverse and the number of tasks is large, there are more possibilities of making changes in the service process. In such a case, the changes can be made in the work processes of the employees or in the customer processes (see Figure 2). The work processes of multi-skilled personnel in particular can be improved significantly. As described in Figure 1, the approach allows calculations based on potential changes in an organization. Due to the versatile structure of such an organization, it is crucial to have proper tools for the analysis. The recent study of Niehaves et al. (2014) utilized individual interviews, direct observations and documentary information in data gathering. In our study, we did the same. Niehaves et al. (2014) note the size of the organization in the study, while our study points out that the organizational size is not the issue. The issue is the versatility of the organization under study. This refers to the number of processes, the number of tasks, the multi-skilled employees and the product they produce. While the product of the company in the study of Niehaves et al. (2014) had remained the same for decades, in our study, the product was a service that never was the same, since it was the customers—patients—that differed.

In the Acute Neurology Ward case, we could verify that the productivity in the organization could have improved 35% if the proposed incremental changes were implemented. More than ten years ago, Carrol and Edmondson (2002) pointed out organizational learning as an important factor when pursuing improved organizational performance in health care. In our case, the reason for not implementing the changes was never questioned. This phenomenon was not explained by earlier knowledge either. One reason one could propose is that the resources were lacking to let the organization learn.

On the other hand, the role of leadership was emphasized by Carrol and Edmondson (2002), who mentioned leaders particularly in the role of creating conditions for change. Later, Berente and Lee (2013) also used a concept of "management vision" in relation to process improvement efforts. Furthermore, Rivard et al. (2013) noted in their study how differences in leadership influenced the outcomes of quality improvements in patient safety. As Japanese organizational problem solving cycles (Clark & Fujimoto 1991) can be seen as tools to teach organizations, projects that focus on improvements in organizational output could also produce outputs that verify organizational learning. In the current study, the Acute Neurology Ward needed to change, but it did not do so at the time. In other words, the role of management is seen behind organizational learning and—as in our case—process improvement.

The case of the Children's Dental Clinic proved to be positive, even if the original process was near optimal. The organization was simple, with only three employee categories, and it seemed to be flexible and willing to change. Even if one cannot generalize based on experiences at the Children's Dental Clinic, one could suppose that the simple structure of the organization made it easier to change and learn. Despite its few employee categories, it was possible to suggest radical changes in the process (see Figure

2). The crucial enabler was the empowerment of the personnel given by the management. Fujimoto (2007) reported about the same kind of actions used in manufacturing for decades.

Clark and Fujimoto (1991) note that multi-skilled employee teams in particular offer possibilities for improvement when analyzed properly. The same idea was applied in our study, though the Children's Dental Clinic did not benefit from incremental changes, as its processes were already near optimal. However, the Acute Neurology Ward was evaluated to suggest a benefit of 35% in productivity if the suggested incremental changes had been implemented.

Conclusion

Today, health care is suffering from a lack of resources. This paper introduces a solution that seeks efficiency and productivity in health care. We carried out two different case studies that were analyzed using the 3VPM approach. The cases show that it is possible to analyze and evaluate improvements even if the improvements are not implemented. Process improvement has been under study for decades, and earlier research shows several examples of it. The earlier research particularly points out challenges that complicate the improvements. However, our study reveals that despite the business or size of the organizations, it is possible to tackle the challenges. Furthermore, our study verifies the role of leadership and the readiness of the organization to change, as mentioned in earlier research. Despite the difference between the cases, the role of management is significant: the first case neglected the proposed changes, while the second applied them. Our study also showed that sometimes an improvement can lead to further changes, as was realized by the second case.

Further studies are needed to find out whether it is possible to improve joint efficiency and productivity in separate businesses or sectors as in health care and social care.

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