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Healthcare complexity: redesigning care with systems modeling

Meral Binbasioglu, *Hofstra University, Meral.Binbasioglu@hofstra.edu*
Edward J. Zychowicz, *Hofstra University, Edward.J.Zychowicz@hofstra.edu*

Abstract

This paper proposes a conceptual modeling approach based on qualitative system dynamics modeling to help unveil the dynamic behavior of complex systems when implementing process changes and policy decisions. As cited in the literature, most IT projects result in substantial changes to current organizational processes but not all IT projects deliver the expected outcomes. The proposed approach is applied to the healthcare application domain, which exhibits significant adjustments to existing information systems' portfolios given the efforts to cope with rising cost structures or other ongoing process changes and improvements. The proposed approach has the potential to highlight the key issues to consider when undertaking information system projects, including identifying undesirable or inadvertent consequences of policy changes on stakeholders. The paper proposes the use of a qualitative system dynamics modeling approach as a framework to detect likely undesirable outcomes in systems analysis and design context. We illustrate the approach with the help of a case study (Madlabana and Petersen, 2020) which reports the experiences of nursing staff during process changes as part of a "performance management system" implementation which is deployed within broader healthcare reforms context.

Keywords: healthcare, system dynamics modeling, systems modeling, performance management, systems analysis and design, business process management.

Introduction

The paper proposes a conceptual modeling approach based on qualitative system dynamics modeling (Forrester,1992; Lyneis, 1997; Senge and Sterman, 1992; Senge, 1994; Sterman, 2000) to help unveil the dynamic behavior of complex systems when implementing process changes and policy decisions. As cited in the literature, most IT projects result in substantial changes to current organizational processes but not all IT projects deliver the expected outcomes (Dennis et al., 2022).

The proposed approach is applied to the healthcare application domain, which exhibits significant adjustments to existing information systems' portfolios given the efforts to cope with rising cost structures or other ongoing process changes and improvements (Kaplan et al., 2017). The proposed approach has the potential to highlight the key issues to consider when undertaking information system projects, including identifying undesirable or inadvertent consequences of policy changes on stakeholders.

Detecting inadvertent outcomes early on is critical in decision making since they have the potential to become dominant over time due to their iterative reinforcing behavior. Delayed effects add additional complexity to implementing change since unfavorable or inadvertent outcomes may emerge over time.

Viewing the information systems analysis and design process (Dennis, Wixom, and Roth, 2022) from systems thinking perspective has the potential to help guide better solutions when complex dynamic systems are designed by explicating the relationships among affected components, such as stakeholders, resources, and performance measures. The proposed approach aims to help in assessing the impact of potential changes (i.e., policy changes, structural changes, and process changes) on the overall system including delayed unforeseen consequences. The approach also aims to facilitate determining correct performance measures and strategies that would contribute to achieving expected long-term results.

The paper proposes the use of a qualitative system dynamics modeling approach as a framework to detect likely undesirable outcomes in systems analysis and design context. We illustrate the approach with the help of a case study (Madlabana and Petersen, 2020) which reports the experience of the nursing staff during process changes as part of a "performance management system" implementation which is developed within broader healthcare reforms context.

The paper is organized as follows. First, the paper discusses the relevant literature. This is followed by a discussion on methodology. The following section describes an overview of the proposed approach including system dynamics modeling basics. In the next section, the paper provides an overview of the published case study. Next section illustrates the proposed approach using the findings of the case study represented in system dynamics framework. The paper ends with a discussion and concluding remarks.

Literature Review

Many hospitals are undertaking process redesign in patient care including revamping information systems applications (Best, 2016; Wietmarschen, 2016; Farid, et al. 2019; Renmans, 2017; Rwashana, 2014; Hilmola, 2016; Ishikawa, 2017) . Process redesign impacts many healthcare participants and requires proper implementation of change management efforts (Lee and Cosgrove, 2014). Drastic changes to organizational structure elevate the importance of change management and critically impact the hospital workforce, especially nurses and physicians.

Lee and Cosgrove (2014, p. 106) state that *"... many hospital administrators believe that their true 'customers' are the physicians who bring them patients – not the patients themselves*". Thus, healthcare organizations need to craft the redesign efforts to properly address the concerns of all stakeholders including the healthcare workforce.

Managing change suggests the importance of identifying the principal stakeholders that the change will affect. Omitting patient preferences in prioritizing those of physicians (or vice-versa) may produce sub-optimal distortions that may be amplified over time if not addressed. This suggests that any IT implementation approach must have a preeminent role for monitoring as a seamless and integrative component of the overall process.

Organizations aim to improve performance by applying innovative approaches and technologies to monitor efficiency and effectiveness measures (Cokins, 2009; King, 2001; Levine, 2001; Malone, et al., 1999; Malone and Crowston, 1994; Santos, 2008). Complex policy changes require capturing dynamic relationships among multiple stakeholders and performance measures. However, emphasizing certain measures may negatively impact other measures, resources, and stakeholders. Thus, policy makers need to carefully determine the impact of short-term "quick fix" approaches on organizations to avoid potential inadvertent negative outcomes.

The proposed approach recommends qualitative system dynamics modeling for analyzing these domain interactions. These include analysis of the impact of policy changes by understanding the interrelationships among stakeholders, resources and performance metrics. In addition, long-term consequences of policy changes need to be further examined, including detecting unforeseen negative outcomes, if any. Given the likelihood that undesired outcomes are amplified due to the iterative nature of behavior reinforcing the undesired effect over time, it is important to uncover potential unintended negative consequences early on to prevent them from becoming dominant forces over time (Senge and Sterman, 1992).

System dynamics modeling is centered in "learning organizations" (Argris and Schon, 1978). "Single-loop" (first-order or lower-level) learning focuses on results (i.e., performance measures); when results are not at target levels corrective actions are considered. In contrast, "double-loop" (second-order or higher-level) learning challenges the decisions and the underlying assumptions by exploring the objectives, criteria, and decision variables (Senge and Sterman, 1992).

Thus, second-order learning aims to gain insight into application domain interactions. Most business process management (BPM) metrics are based on single-loop (first-order) learning and concentrate on measuring results, usually referred to as Key Performance Indicators (KPI's). In comparison, system dynamics modeling aims to deliberate the impact of policy decisions on performance metrics and resources by unveiling the complex interactions among them and likely long-term consequences by employing double-loop learning. This contrasts with BPM where the focus is measuring key performance indicators.

Complex semi-structured policy decisions require altering resource (such as personnel, money, material, customer, patient) levels to improve performance metrics and related attributes such as quality of care, capacity issues like waiting times and bottlenecks, employee satisfaction, and resource utilization; and in turn, these decisions may adversely or favorably impact other resources and performance attributes (Binbasioglu, 1994).

Given the unpredictable characteristics of reinforcing dominant behavior in the long run, it is challenging to directly foresee likely second or higher order effects of decisions. Qualitative system dynamics reasoning supports this deliberation process to an extent; however, quantitative system dynamics modeling provides more concrete assessment of the long-term dynamic behavior outcomes.

The term qualitative system dynamics refers to non-simulation based system dynamics models (Wolstenholme, 1999). Quantitative system dynamics modeling employs simulation studies; and can be utilized when solving operational problems such as capacity planning for hospitals (Grida and Zeid, 2019).

The proposed approach employs qualitative system dynamics modeling to gain an understanding of the potential outcomes of process changes by uncovering underlying assumptions and complexities. A qualitative approach using causal loop diagram representation provides *"insight into managerial issues by inferring, rather than calculating, the behaviour over time of the system represented"* (Wolstenholme, 1999).

Given the importance of qualitative inference about potential system behavior when analyzing and designing IT systems, the paper recommends the proposed approach as a tool to supplement system analysis and design efforts.

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Methodology

Qualitative Modeling

This paper explores the use of qualitative system dynamics modeling as a framework when implementing IT systems. The term qualitative system dynamics refers to non-simulation-based system dynamics models (Wolstenholme, 1999).

> Wolstenholme *"addresses the issue of what are the wise uses of qualitative mapping and what are the conditions that require formal quantitative modelling within System Dynamics"* (1999, p. 422). According to Wolstenholme *"the need for quantification is relative and depends on the purpose of analysis, which, in turn, is related to the methods used and the audience addressed"* (1999, p. 422). According to Wolstenholme (1999, p. 423), "*The assertion that causal loop diagrams alone could add value to issue structuring and behaviour assessment was based on the fact that even in this mode such diagrams were sufficiently rigorous to provide a significant increase in assistance to thinking compared with many other emergent diagrammatic tools for this purpose."*

Qualitative system dynamics may also use generic model structures, called system archetypes (Senge, 1994).

> Wolstenholme defines these generic structures as*: "These were patterns of loops related to patterns of behaviours (for example, 'limits to growth' and 'fixes that fail'), which emerged from extensive cumulated simulation modelling experience"* (1999, p. 423). Wolstenholme (1999, p. 424) indicates the role of generic loop structures by stating *"it enables potential unintended consequences to be anticipated and hence increases the chances of plans being achieved. The methods bring much needed tools to the strategic areas of management and allow a wide range of managers to access the power of feedback thinking."*

Wolstenholme (1999) recommends communicating the essence of the model using an archetypal representation. This paper explores the use of qualitative system dynamics modeling as a framework when conducting system analysis and design studies.

Case Study

A case study, published by Madlabana and Petersen (2020), reports a qualitative research study regarding the nursing staff's view in response to implementation of a performance management system. The paper uses the documented content as a secondary source when illustrating the proposed approach. The paper employs the case study findings to help explain the implementation failure within qualitative system dynamics framework. Birley and Moreland (1998, p. 36) state that:

> *"a case study may be a case study precisely because it has an exceptional (the exception) emphasis. The aim of any case study is to describe and understand the phenomenon 'in depth' and 'in the round' (completeness)".*

Representing the Case Study with a System Dynamics Model Archetype

The paper recommends using qualitative system dynamics prior to implementing IT systems to foresee likely outcomes when conducting system analysis and design studies. Since these models provide insight to application domain dynamics, they can be helpful in:

> *"thinking by introducing circular causality and providing a medium by which people can externalise mental models and assumptions and enrich these by sharing them. Furthermore, it facilitates inference of modes of behaviour by assisting mental simulation of maps. By identifying policy links in maps, it allows focussed speculation of how to intervene to redesigned systems"* (Wolstenholme, 1999, p. 424).

After reviewing the documented case study, the findings are diagrammed by adopting a generic qualitative model archetype that captures the essence of the application domain interactions. Given that the generic archetypes "*emerged from extensive cumulated simulation modelling experience"* (Wolstenholme, 1999, p. 423), they retain knowledge about the nature of interactions and potential outcomes. That is, they can guide the modeler since they encapsulate likely behavior of model components. In other words, they serve as knowledge components guiding the qualitative inference process based on past quantitative simulation experiences (Wolstenholme, 1999).

Figure 1 represents the findings of the published research study (Madlabana and Petersen, 2020) modeled using system dynamics representation. The model in Figure 1 is formulated using a generic qualitative model structure, called "shifting the burden" (Senge, 1994). O'Connor and McDermott (1997) refer to this generic pattern as "when the curse is worse than the disease". In IT implementation context, this model structure corresponds to IT systems rendering some solutions but not delivering the anticipated outcomes yet breeding unexpected new challenges while gradually weakening the ability to attain fundamental solutions.

Proposed Approach

The paper explores the role of qualitative system dynamics modeling as a framework to detect likely undesirable outcomes when conducting systems analysis and design studies. The goal is to improve understanding application domain interactions among all stakeholders during process changes to improve IT implementation results. The proposed approach has the potential to highlight the key issues to consider when undertaking information system projects, including identifying undesirable or inadvertent consequences of policy changes on stakeholders. The following discussion provides an overview of the system dynamics modeling approach and demonstrates its use when conducting systems analysis and design studies in healthcare application domain.

System dynamics models use causal loop diagrams (CLD) to show the impact of policies on performance metrics and resource levels; and capture short-term and long-term system behavior including unintended consequences. Figure 1 depicts a causal loop diagram. In causal loop diagrams (CLD) the arrow indicates a causal relationship between variables. A positive (+) causal relationship occurs when both variables change in the same direction; that is, an increase (decrease) in one variable causes an increase (decrease) in the other variable. A negative (-) causal relationship represents the opposite relationships between variables; that is, an increase (decrease) in one variable causes a decrease (increase) in the other variable (Vennix, 1994).

The feedback loops can be negative (-), balancing; or positive (+), reinforcing. Balancing loops exhibit goal-oriented behavior. Accordingly, they are of stabilizing nature and keep the system in balance. In contrast, reinforcing loops amplify the initial change in the same direction. Thus, reinforcing loops indicate accelerating growth as well as accelerating decline depending on the initial change (Senge, 1990). The model may also depict delayed behavior, shown as "=", which further hinders foreseeing system outcomes. This is due to not observing policy impacts in a timely manner; and not having the ability to take appropriate corrective actions.

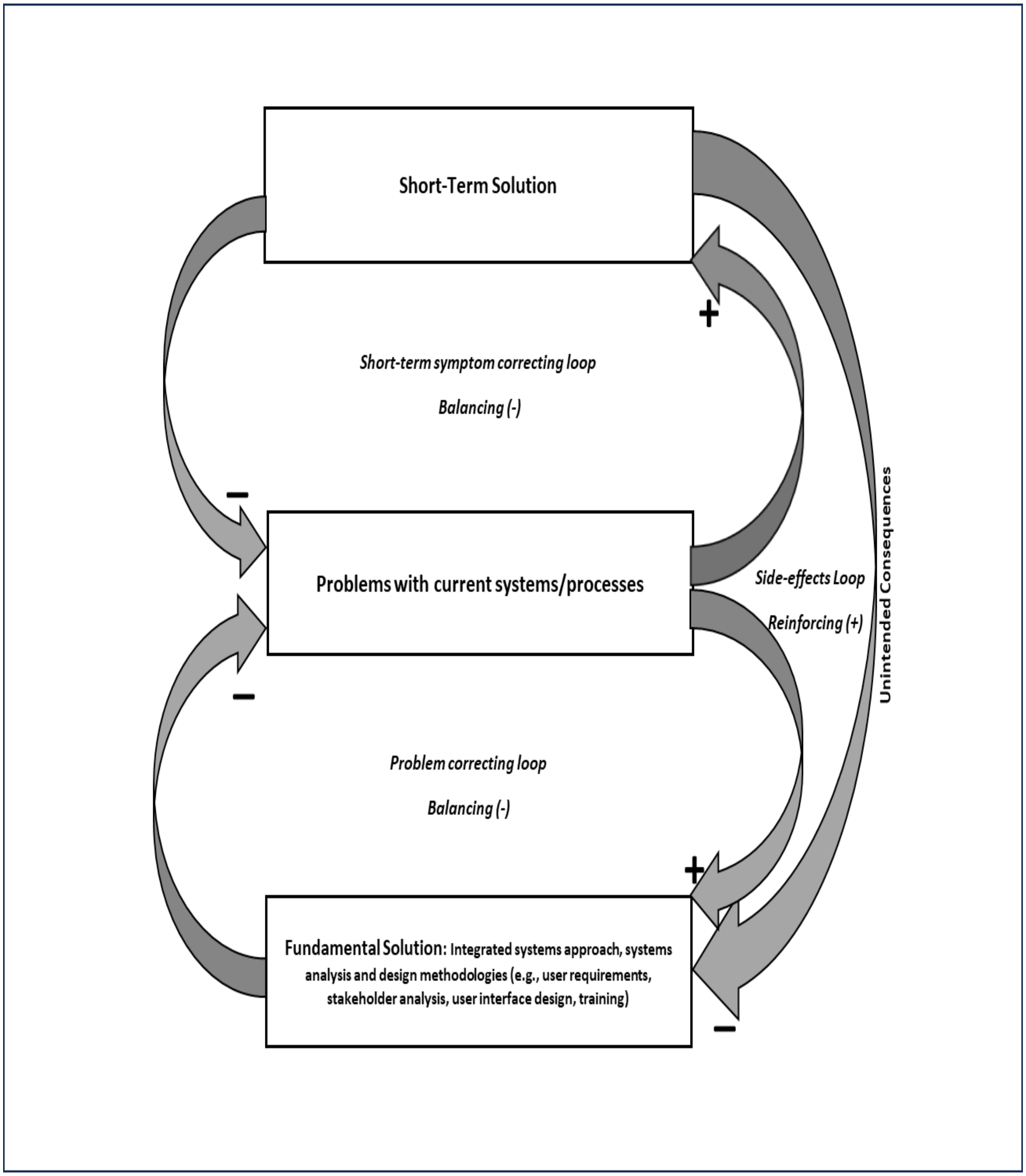

Figure 1: Systems Dynamics Causal Loop Diagram

Figure 1 depicts two balancing loops and one reinforcing loop. "Short-term symptom correcting" balancing loop reflects solving existing problems with "short-term" quick fix solutions. "Problem correcting" balancing loop refers to tackling the existing problems with fundamental solutions. Reinforcing loop corresponds to the side-effects generated by "short term" solutions, and amplifies the initial change as follows: "Short-term" choices negatively affect the fundamental solutions through "unintended consequences"; in turn, not formulating appropriate fundamental solutions increase existing problems, shown as "problems with current systems/processes"; an increase in existing problems increase the need for more "short-term" solutions.

In systems analysis and design context, a fundamental solution refers to conducting a comprehensive study that employs proper systems analysis and design techniques such as identifying user requirements, stakeholder interests, user interface issues, training needs, among others (Dennis, Wixom, and Roth, 2022). As shown in "problem correcting loop", responding to existing problems with fundamental solutions decreases existing problems, indicated as "problems with current systems/processes". In contrast, a "short-term" solution refers to piecemeal attempts that are derived by focusing on limited application domain relationships. The limited "short-term" solution may offer some immediate results since it offers partial solutions. "Short-term symptom correcting loop" corresponds to responding to problems with short-term solutions.

If a short-term solution creates unintended outcomes, fundamental solution is negatively impacted; in turn, existing problems increase; an increase in existing problems initiates more "short-term" solutions. Similarly, additional unintended side-effects may emerge impacting other stakeholders. This behavior is represented in "side-effects" reinforcing loop.

The "short-term" solution aims to solve the problem by offering stand-alone solutions. In healthcare application domain, for example, as a response to patients experiencing long waiting times prior to being seen by a doctor, hospitals may consider allowing less time per patient, encouraging overtime or offloading parts of patient treatment to nurses. If the hospital institutes comparable "short-term" solutions as a remedy, the extra load on doctors and nurses may lead to "burnout" and further worsen the problem when medical personnel leave, resulting in human capacity shortage. In addition, allowing less time per patient strategy may lead to not providing proper medical treatment, an increase in number of sick patients, and patient unhappiness. Thus, to circumvent similar reinforcing side-effects, organizations must focus on fundamental solutions.

In the following section, qualitative system dynamics modeling approach is applied to a real-life IT implementation case study (published by Madlabana and Petersen, 2020). Using the findings of this case study, the paper illustrates the application domain relationships and related performance measures. In addition, the case study helps in establishing the importance of a fundamental solution approach and points out the drawbacks of "short-term" attempts together with identifying the side-effects that exacerbates the original problem.

Case Description

Introduction

In the following, we discuss an overview of a performance management project in healthcare domain published by Madlabana and Petersen (2020). This research reports nursing staffs' view in response to the performance management system implementation.

Reviewing Madlabana and Petersen (2020), the performance management system is part of a health system reform effort for comprehensive and integrated care, which also aims to deliver person-centered care. The healthcare system restructuring efforts are in progress in South Africa, including the need for a team-based person-centered care which aims to provide a holistic patient care as opposed to disease-based approach. This need is triggered given the presence of multi-morbid conditions which cannot be suitably addressed by focusing on isolated disease treatment, rather require a team-based integrated approach. The shift in healthcare strategy in this reform effort is critical since it cannot be confined only to medical aspects of patient care but also necessitates subsequent changes in related health systems such as performance management system for nurses. Thus, all aspects of healthcare delivery systems need to be consistent with the reform strategy.

Summarizing Madlabana and Petersen (2020), the performance management research study exposed many shortcomings of the implementation environment. These include accuracy, transparency, vulnerability to organizational fairness in performance assessment. In addition, reward systems are not adequately aligned with overall project goals; and disparities exist when using the system for career advancement and performance improvement.

Case Methodology

Madlabana and Petersen (2020) report the findings of a qualitative research study. The study was conducted in South Africa. The data was collected from eighteen professional nurses through semi-structured interviews and analyzed using thematic analysis. Please refer to Madlabana and Petersen (2020) for details.

Implementation Outcomes

Madlabana and Petersen (2020) studied the reform effort from nurses' point of view in order to understand the extent the newly implemented performance management system accommodates the needs of the nurses for fair performance assessment when simultaneously achieving team-based person-centered patient care strategy. The following discussion summarizes the shortcomings observed by Madlabana and Petersen (2020):

System/Performance/Perception:

The system has inconsistencies. It sets unrealistic performance goals, creates a disappointing working atmosphere and job dissatisfaction. Questionable input data entry in reward system results in preferential treatment. There are discrepancies in rewards and not clear application of reward computations. Also, the system does not provide feedback to nurses about their performance. Moreover, friction and conflict among workers emerged since the system is associated with favoritism; in turn, team collaboration is impacted which is contrary to the strategic goals of team-based person-centered care.

***User Interface Issues**:*

Data entry interface is not clear and consistent.

Training:

Nurses need to input performance data. Those nurses who have prior experience in similar systems, for example those who are familiar with a template for data entry, were able to enter performance data. Other nurses experienced difficulties since they were not clear about the data categories or performance appraisal methods. Though inputting performance data is critical to Performance Management system, nurses indicated lack of training.

Performance assessment issues:

Managers focus on meeting goals rather than supporting nurses to improve performance. The system is designed to assess individual nurse-level performance rather than team-level performance. This is contrary to strategic team-based person-centered collaborative care. Furthermore, due to emphasis on individual performance, some nurses favor activities that lead to additional financial compensation based on performance scores. In turn, the system caused conflict among nurses given the pay discrepancies.

Other quality of care reforms:

Since healthcare reform covered extensive areas, the staff was exposed to many process changes such as improving quality of care and using treatment guidelines and manuals. Some nurses indicated training related to new “competence treatment protocols” was conducted but was not sufficient. Though these process change efforts are viewed positively by some nurses, other nurses felt that the organization is undertaking too many changes, and that the increase in workload is not commensurate with simultaneous increase in staff levels. Staff shortage led to long lines in clinics; in turn, patients relinquished treatment. Not seeking medical help is contrary to health reform effort and has the potential to impact community well-being.

Quality versus quantity:

Based on nurses account, pressure on meeting target measures had a negative impact on quality of care as well as person-centered care. The performance measurement system did not have components that measure these behavioral aspects such as patient-nurse relationships including counselling on treatment options. In fact, the system encouraged devoting less time to patients and lacked incentives and measures for achieving these goals.

Recommendations:

Review performance management system measures for all stakeholders so that measures will be aligned with strategic goals. Extend the system measures to cover quality aspects as well as team-based person-centered care. Provide training regarding performance measurement data entry and reward computation. Provide feedback to workers. Train all stakeholders regarding roles and responsibilities, and initiate change management. Utilize the performance management system to improve job satisfaction and design appropriate strategies to foster a team-based work environment that would deter conflict among workers. Carefully craft the performance measures to eliminate the possibility of individuals taking advantage of the system to the detriment of team-based care outcomes. In addition, improve reward measures and related process changes so that the system cannot be exploited with favoritism.

Illustrative Example

As outlined in the previous section, as part of the person-centered healthcare reform effort, the performance management system did not achieve the expected outcomes (Madlabana and Petersen, 2020). Moreover, the system created additional problems among nurses and inconsistent application among healthcare organizations (Madlabana and Petersen, 2020). In the following, we analyze the findings of the published case data in terms of system dynamics model representation depicted in Figure 1.

It appears that the attempt to fix performance management issues was treated as an independent system from broader healthcare reforms; and performance management system was implemented as a stand-alone system focusing only on individual nurse achievement. This part refers to a short-term correcting loop, which is a balancing loop, corresponding to solving existing problems with short-term solutions. The short-term approach had a narrow focus; and disregarded the main goal of the healthcare reform which is team-based person-centered care. In fact, the performance management system worked against this goal, since it lacked integrating nurse efforts towards team performance which was needed for achieving person-centered healthcare reform. Thus, the performance management system created inadvertent side-effects. The system triggered these side-effects due to its sole focus on individual nurse performance target outcomes since it excluded team-based person-centered behavioral measures.

Madlabana and Petersen (2020) states:

> *"The Performance Management system encouraged nurses to spend less time on each patient to achieve their targets and to ensure that all patients visiting healthcare facility are served."* According to Madlabana and Petersen (2020*), "the participants in this study perceived the system to be implemented unfairly and lacking impartiality – with the respondents questioning whether those receiving rewards truly deserved them."*

Additionally, there were concerns about the quality versus quantity of care. For example, Madlabana and Petersen (2020) states that many participants indicated that the Performance System *"overemphasized meeting targets (being outcome-based) and the neglect of consideration on the quality of care provided (behavioural-based)".* Additionally, Madlabana and Petersen (2020) quotes a nurse indicating the impact of long lines on community by stating *"In our clinic, patients are discouraged to come because of long queuing"*. Accordingly, these side-effects created a reinforcing (+) loop indicating that "short-term" solution negatively impacted the fundamental solution; in turn, not achieving fundamental solution exacerbated the existing problems by diverging from team-based person-centered care. The unfortunate scenario resulted in implementation failure as the reinforcing loop became dominant due to these side-effects.

Summarizing the findings in Madlabana and Petersen (2020) study, staff shortage may cause an increase in the number of patients to be treated causing long lines, which in turn may lead to community not using healthcare services. Other factors that contribute to job dissatisfaction are unfair and not clear performance measures, lack of feedback on performance, and focusing on outcome numbers rather than designing strategies to help workers in performance improvement and career advancement. Similar domain interactions are modeled in system dynamics applications in other settings such as staff shortage leading to burnout and job dissatisfaction leading to staff turnover (Senge, 1994; Senge and Sterman, 1997).

It appears that the case study implementation lacked some steps in identifying stakeholders, user requirements, user interface design issues and related expectations and training. Thus, aiming at fundamental solutions requires an integrated systems approach and applying systems analysis and design methodologies in conjunction with systems thinking. It eliminates unnecessary expenditures and potential side-effects that "short-term" approaches create. Given that cost is a critical component when assessing the feasibility of IT projects, inadequate "short-term" system implementations increase total project cost and deplete resources that could have been used for fundamental solutions.

Similar scenarios in IT projects can be prevented if the system analysis and design study capture the dynamic relationships among stakeholders, resources and performance measures. The system dynamics approach favors a thorough analysis of the system so that unintended consequences can be foreseen ahead of time and incorporated into the design (i.e., solution). The relationships among all stakeholders need to be analyzed when designing such systems and process changes, since many side-effects can happen all at once or over time triggering unexpected consequences. Thus, the proposed qualitative systems dynamics approach has the potential to help in designing and implementing systems that unveil and capture these inherent relationships.

Discussion

Solving problems by employing "short term" strategies negatively impacts the resources needed for "fundamental solutions." In contrast, a fundamental problem-solving approach favors uncovering the relationships among these components prior to undertaking projects or policy changes. Given the complexity of a thorough approach, a fundamental solution would require more resources than a "quick fix" approach, but the resources would be directed to viable solutions benefiting all involved parties; and most importantly unforeseen situations being uncovered early on and addressed as part of the fundamental analysis.

The capital allocated to short-term solutions may hinder the organization from seeking fundamental solutions; as well as promote and reward an organizational culture which values short-term results that would be detrimental in the long run. Thus, by penalizing fundamental approaches, the organization inadvertently cultivates a culture that initiates solutions that are not in the best interest of the organization in the long run.

Moreover, since the narrow focused "short-term" approach disrupts the other related measures or negatively impacts the stakeholders, additional unforeseen problems are likely to emerge such as discontent among workers or units. This is an inevitable outcome of the "short-term" approach since it lacks a proper understanding of the relationships among various components such as metrics, resources, and stakeholders.

The system dynamics model shown in Figure 1 captures the goals and outcomes of the actual large-scale implementation of a healthcare study. The sample model served us when interpreting the results and shortcomings of the study. Employing similar models prior to design and implementation of systems will help in preventing unsuccessful outcomes. Given the varying level of complexities and goals of each implementation environment, the model structure will differ but will portray sufficient context to debate policy changes, potential impacts, and unintended consequences, if any. Causal loop diagrams can be used to capture the system behavior prior to IT implementations.

The application of correct "learning organization" paradigm in qualitative system dynamic approach assists when unveiling and deliberating the complex relationships among decision variables given the policy changes (Wolstenholme, 1999). Thus, the proposed approach aims to promote a proactive approach favoring timely actions rather than reacting to unforeseen outcomes.

Concluding Remarks

The paper recommends using qualitative system dynamics modeling as a tool to enhance system analysis and design studies. Systems thinking approach is invaluable when assessing the implications of complex policy decisions or process and structural changes. The approach has the potential to help in understanding critical analysis of the relationships among stakeholders and facilitate discerning core issues early on prior to observing them as undesirable outcomes. The paper explores the role of system dynamics modeling approach in healthcare domain in the context of information system implementation.

We anticipate that educators can use the proposed qualitative modeling approach when teaching system analysis and design courses. Case studies can be presented using the diagramming tool, which may enhance deliberation of alternative solutions and their likely impact on stakeholders. Also, the proposed approach would be of interest to practitioners when understanding dynamic interaction of decision components (Wolstenholme, 1999). In contrast, quantitative system dynamics models use simulation studies and are generally applicable for solving problems such as capacity planning for hospitals or production scheduling (Senge and Sterman, 1997).

The approach presented in this paper uses a single documented case study, coupled with supporting literature sources, in identifying the potential benefits of a systems dynamics approach to navigating the challenges of IT implementation and change. We recognize and appreciate that more insights about the application of the approach can be gained through analyzing multiple case studies. This paper presents a modest first step in identifying the need for future work to empirically assess the benefits of the proposed approach.

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