**A Structured Method for Collaborative Decision-making in In-hospital Cardiac Telemetry Quality Improvement**

by

**Varun Sharma**

B.S., Pennsylvania State University, 2010

Submitted to the Graduate Faculty of

Department of Health Policy and Management

Graduate School of Public Health in partial fulfillment

of the requirements for the degree of

Master of Health Administration

University of Pittsburgh

2015

**ABSTRACT**

UNIVERSITY OF PITTSBURGH

GRADUATE SCHOOL OF PUBLIC HEALTH

This essay is submitted

by

Varun Sharma

on

June 29, 2015

and approved by

Essay Advisor:

Nicholas Castle, PhD \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Professor

Department of Health Policy and Management

Graduate School of Public Health

University of Pittsburgh

Essay Reader:

Rosemary L. Hoffmann, RN, PhD \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Associate Professor

Clinical Nurse Leader Program

School of Nursing

University of Pittsburgh

Copyright © by Varun Sharma

2015

Telemetry is a hospital service which is delivered by many different hospital professionals acting in concert. These inter-connections challenge telemetry work designs to account for each actor’s role and his effect on the system. Other difficulties in designing safe, efficient telemetry arise from the nature of telemetry. The ergonomics of device interfaces and operational idiosyncrasies can contribute to the instability of systems when employees react to stresses by departing from the ideal protocol. If that occurs too frequently, organized quality improvement becomes necessary to resolve the aggregate uncertainty surrounding the structure-process relationship. Thus, an equilibrium may be restored between caregivers and hospital structures.

Nicholas Castle, PhD

**A Structured Method for Collaborative Decision-making in in-Hospital Cardiac Telemetry Quality Improvement**

Varun Sharma, MHA

University of Pittsburgh, 2015

A structured method is proposed to facilitate front-line employee participation in collaborative decision-making throughout all stages of quality improvement. Employees are encouraged to conduct improvements within a decision space between the minimum regulatory requirement (resource minimum) and break-even budget constraint (resource maximum.) Decision-making occurs in two stages after employees are grouped by department. A nominal group technique is conducted within departments to generate ideas. These are sent to the hospital level. There, a modified Delphi technique includes a representative from each department.

After consensus has been established, the group delineates an implementation path consistent with its other needs. Because a larger number of employees has participated in their creation, the structures resulting from this improvement initiative are likely to decay more slowly. But once they do, there will be a need for further modifications. Then, formal and informal infrastructure for quality improvement collaboration will still exist.

Non-profit healthcare organizations create quality improvement infrastructure with partial subsidization by the community. Thus, the opportunity cost in the marketplace must be outweighed by decision-making infrastructure’s benefits to the total welfare. These benefits range across subjective and objective dimensions. More individuals’ preferences may be addressed, increasing aggregate utility. If the breadth of data collection contributes to a net allocative efficiency, objective outcomes may improve in the furtherance of public health.

TABLE OF CONTENTS

[**preface ix**](#_Toc424645678)

[**1.0 Introduction 1**](#_Toc424645679)

[1.1 The Effects of Telemetry 1](#_Toc424645680)

[1.2 Quality Improvement 3](#_Toc424645681)

[1.2.1 Uncertainty in Quality Improvement 4](#_Toc424645682)

[1.2.2 Telemetry 5](#_Toc424645683)

[1.2.3 Quality Improvement in Telemetry 7](#_Toc424645684)

[1.2.4 Summary of Telemetry Quality Improvement Literature 12](#_Toc424645685)

[1.2.5 The Sociology of Telemetry Improvement 13](#_Toc424645686)

[**2.0 Program 15**](#_Toc424645687)

[2.1 Objective 15](#_Toc424645688)

[2.2 Rationale 15](#_Toc424645689)

[2.3 Content 17](#_Toc424645690)

[2.3.1 Education 17](#_Toc424645691)

[**2.3.1.1 Basic Quality Improvement Terms 18**](#_Toc424645692)

[**2.3.1.2 Systems-thinking 19**](#_Toc424645693)

[2.3.2 Structured decision-making 20](#_Toc424645694)

[**2.3.2.1 Panel Selection and Weighting 20**](#_Toc424645695)

[**2.3.2.2 Nominal Group Technique 22**](#_Toc424645696)

[**2.3.2.3 Panel Voting 22**](#_Toc424645697)

[**2.3.2.4 Quality Improvement 23**](#_Toc424645698)

[**3.0 Conclusion 25**](#_Toc424645699)

[3.1 real-world application 26](#_Toc424645700)

[3.2 Public Health Relevance 27](#_Toc424645701)

[**Appendix A : AMERICAN HEART ASSOCIATION INDICATIONS FOR TELEMETRY 28**](#_Toc424645702)

[**Appendix B : FORMULAS FOR VOTE WEIGHTING 29**](#_Toc424645703)

[**appendix c: examples of program applications 30**](#_Toc424645704)

[**bibliography 31**](#_Toc424645705)

# List of figures

[**Figure 1. 2004 Electrocardiography Guidelines** 28](#_Toc424646104)

# preface

I owe a debt of gratitude to my advisor and reader for this document. Drs. Nick Castle and Rose Hoffmann, respectively, devoted a significant amount of time and expertise to this ambitious project. More broadly, the entire faculty of the Graduate School of Public Health contributed by offering an eclectic education and being patient enough to indulge my inquisitive mind.

But before I even set foot in this city, I had the good fortune of being indulged by two parents who lived as to ensure the success and happiness of the next generation. I have certainly received quite a bit of material support along the way, but it pales in comparison to the unspoken lessons I was lucky enough to collect from my role models. These are the most useful tools I have acquired thus far in the quest for future happiness.

It seems fortuitous, then, that Pitt’s sample figure to help format this document was Guayasamin’s *Mother and Son*. The same inquisitive mind that was nurtured by my parents and indulged by my professors led me to a cursory Wikipedia search of Oswaldo Guayasamin. Per Wikipedia, Guayasamin’s “Chapel of Man” is meant to document the worst tendencies of human nature but also demonstrate humanity’s potential to achieve ascendancy. That innate contradiction is a fundamental truth of the human experience which the reader will recognize as he proceeds through this document.

# Introduction

Decisions made by hospital policymakers have appreciable consequences for the well-being of patients and success of employees. Since these decisions are made under uncertainty, there is some likelihood that a policy will have negative consequences after it is implemented. If negative consequences occur, they are usually addressed by quality improvement programs that introduce new uncertainty into the decision-making process.

Because it is a wide-ranging hospital service which can strain caregivers and the subject of national expert recommendations, cardiac telemetry is used to illustrate decision-making in the field of hospital quality improvement. The implementation of these decisions requires coordination of caregivers, as well as other hospital professionals. Collaboration between these actors may allow them to use their diverse viewpoints to counteract the aggregate effects of predictive uncertainty and operational complexity. A model of collaborative decision-making is proposed with the aim of reducing cognitive bias and clarifying organizational preferences.

## The Effects of Telemetry

Cardiac telemetry comprises one of the predominant types of physiologic monitors in hospitals[1](#_ENREF_1). Monitor alarms became a widespread target of quality improvement efforts when the Joint Commission issued a Sentinel Event Alert (SEA.) That alert described instances when poor alarm design and inappropriate interaction with alarm systems delayed care of monitored patients. The SEA described patient outcomes ranging in severity from falls to cerebral anoxia[2](#_ENREF_2). However, noise’s episodic effects are less common than its subacute effects on patients and chronic effects on employees.

In a hospital environment which includes unfamiliar background noises punctuated by intermittent alarm noises and voices, patients may be unable to rest well. During waking hours in loud environments, increased heart rate and blood pressure results from autonomic arousal[3](#_ENREF_3). At night, this increased sympathetic tone predisposes patients to disruptions in sleep. Disruptions may occur with any type of stimulus, but the ambient stimuli most likely to wake patients are electronic alerts like beeping alarms and telephones[4](#_ENREF_4). Even healthy persons report a decrease in subjective quality of sleep when critical care unit noises are played in the background during sleep[4](#_ENREF_4),[5](#_ENREF_5).

However, this experimental result should be interpreted in context. Stress is a subjective psychological response to noise, so all patients are not equally likely to feel stressed by the same stimulus[6](#_ENREF_6). Patients with noise sensitivity[7](#_ENREF_7) are more likely to enter the cycle of stress and sleep disruption described above. After some time passes, sleep patterns can adapt to disruptive stimuli[8](#_ENREF_8) and the stress response can habituate. The consequences become observable when patients are exposed to environments where intermittent noise or extremely high-intensity sounds preclude adaptation. During noisy times in the recovery room, patients are more likely to request pain medication[9](#_ENREF_9). High-amplitude construction sounds on inpatient wards are associated with an increased length of stay[10](#_ENREF_10).

These responses to noise-induced stress increase the workload of caregivers who are attempting to work in the same hospital environment that causes patients’ stress. In addition to increasing the volume of work, noise affects the nature of work. Transferring information accurately between colleagues becomes more difficult[11](#_ENREF_11), and the increased challenge of communicating with patients contributes to an erosion of empathy[12](#_ENREF_12). Furthermore, increased exposure to electronic alerts has been associated with higher rates of employee burnout, independent of an employee’s intrinsic noise sensitivity[13](#_ENREF_13). Though there are personality characteristics that may help to keep an employee’s noise-induced stress from progressing to burnout[14](#_ENREF_14), a chronic lack of control over the work environment perpetuates the psychological stress that employees experience[15](#_ENREF_15).

## Quality Improvement

But the hospital environment is not uncontrollable. Quality improvement (QI) comprises a set of techniques that organizations can use to achieve desirable ends. This entails management of organizational entities to ensure that goals are achieved within resource constraints. In so doing, QI elucidates the relationship between key organizational components and modifies relationships to achieve the desired level of quality. In the field, a good working definition of *quality* medical care is generally taken to be the one proposed by the Institutes of Medicine in its seminal Crossing the Quality Chasmreport in 2001. That is, medical care should be “safe, timely, effective, patient-centered, equitable and efficient[16](#_ENREF_16).”

This concise phrase belies the challenges of creating a broad definition to apply to a diverse set of diseases and healthcare settings. Likewise, the diverse organizations in which healthcare is provided can be composed of complex levels and separate functional groups. A healthcare organization seeking to coordinate quality improvement efforts across organizational levels and departments can use a framework to organize its efforts. To this end, Avedis Donabedian’s “structure-process-outcome” model may be helpful.

In the Donabedian framework[17](#_ENREF_17), processes of care take place within organizational structures to produce an outcome. However, processes of care are more than the natural interaction of an unthinking actor and his surroundings; as processes are shaped by the environment, they engage and modify it in a bidirectional relationship. .

### Uncertainty in Quality Improvement

Quality improvement activities include predictions about organizational actors and structures, their complex inter-relationships and the influence of external environmental factors on the organization. Each prediction consists of the expected value and an error term. Furthermore, these predictions do not occur in isolation; they have complex patterns of interaction. The error range surrounding each individual prediction tends to grow once organizational components begin to interact.

Thus, predicting quality is a complex undertaking when there are multiple outcomes by which the Institutes of Medicine defines quality and multiple actors whose interdependent roles are mediated by ever-shifting machine interfaces.

### Telemetry

Telemetry is a uniquely dynamic hospital service. Providers form an interconnected web of hospital operations to provide telemetry services and interact with the interfaces of equipment that monitors patients whose clinical status may change from moment to moment. Allied health professionals’ and nurses’ contribution to telemetry includes patient care, EKG lead placement and heart rhythm interpretation. The role of each physician specialty has changed over time. Prior to 1991, patients were monitored at the physician’s discretion. In 1991, the American College of Cardiology (ACC) issued guidelines[18](#_ENREF_18) which delineated indications for telemetry. These indications included several non-cardiac conditions but when the American Heart Association (AHA) issued guidelines[19](#_ENREF_19) in 2004 (see Appendix A), conditions related to ischaemic heart disease received the strongest indication for monitoring. With this reduction of scope, the patient care tasks were expected to become more clinically homogenous. Even then, smooth execution of these patient tasks relies on telemetry equipment’s predictable behavior. Hospital departments like facilities management and engineering ensure this by maintaining machinery and attending to structural concerns.

Even if the aforementioned professionals coordinate their activities and telemetry operations occur as intended, the equipment interface can be an ergonomic challenge in a busy hospital. The negative effects of alarm noise on patients and staff were discussed above. If the detrimental effects of noise are not counterbalanced by telemetry’s benefits to workflow, there will be a net inefficiency. If inefficiencies aggregate at the unit level, monitored beds may be unavailable for patients to be transferred off of un-monitored units. Then, patient flow in the hospital will slow down.

The hospital which can maintain operational flow with an increased number of monitored patients may increase the demands on its infrastructure and staff as the hospital census’ average acuity increases. In that case, electronic monitors must allow providers to provide care more efficiently. Electronic monitoring was initially instituted in lieu of the ideal condition where each patient would have human attention in the room, in case they suddenly decompensated[20](#_ENREF_20). In order to allow caregivers to leave the patient’s room, alarms are set at a high sensitivity. However, there is an associated loss of specificity and increase in false alarms. Now, overburdened staff rank excessive false alarms as the most important issue facing monitored units[21](#_ENREF_21),[22](#_ENREF_22).

Alarm frequency and other duties may combine to create an excessive task load[23](#_ENREF_23). In that case, employees intuitively allocate[24](#_ENREF_24) less attention to the monitors they have observed or expect to be nuisance alarms. This is the “cry-wolf” phenomenon[25](#_ENREF_25) and is seen in clinical microsystems stressed[26](#_ENREF_26) by alarm fatigue. This kind of risk-stratification is an attempt by front-line employees to auto-regulate the environment and maximize well-being. It is part of a spectrum of behaviors which includes the outright silencing of alarms[27](#_ENREF_27).

Alarm fatigue and delayed response were cited in the Joint Commission’s Sentinel Event Alert as contributing factors to serious adverse events. In the same document, the Joint Commission recommended strategies that might address the problem of alarm fatigue. These included structural measures like the evaluation of acoustic environment, frequent changes of sensors (i.e. ECG leads,) and routine inspection of alarm-generating equipment. Recommended processes include the adoption of guidelines that allow clinical care teams to tailor monitor alarm settings for each individual patient[28](#_ENREF_28).

These recommendations are intended to be broadly applicable principles that may be adopted by any organization in the nation. As such, they represent a synthesis of studies from a variety of settings and conditions. However, the organization which is attempting to implement a new guideline confronts the uncertainties attendant with establishing goals, formulating strategy, forecasting the environment and planning implementation. There are many ways an organization may deal with these related necessities.

### Quality Improvement in Telemetry

Dandoy, *et al* describe an intervention which used Six Sigma principles to reduce alarms in a pediatric bone marrow transplant unit[29](#_ENREF_29). This intervention was designed by a multidisciplinary team of healthcare providers which reviewed the evidence base and analyzed the hospital’s practices. Simultaneously, representatives from the patients’ families contributed their input to the creation of a standardized hospital practice. The hospital instituted a policy that included specialization of staff roles, monitor order templates, personalized monitor alarm parameters and daily ECG lead changes. Compliance with the daily procedures mandated by the policy (e.g. lead changes and monitor parameter assessment) gradually increased throughout the study period and reached a weekly median of 95% by the third month after introduction. As expected, the increase in compliance during the first three months corresponded with a reduction in alarm frequency; the number of alarms per patient went from 140 to 110. The reduction in alarms continued to a nadir of 60 alarms per patient per day. Staff perception of noise was not assessed during this time. However, the authors report maintaining sustained noise reduction over 18 months. This was done with the maintenance of clearly defined roles, some role redundancy, clinical routines and routine education for nurses[30](#_ENREF_30).

A purely educational initiative is described by Crimlisk, *et al* in a 2015 article. Boston Medical Center sought to increase cardiac monitoring capacity with a program of standardized education to front-line providers. A cardiac rhythm workshop was offered to medical-surgical nurses to prepare them for the hospital’s expansion of telemetry services to those units. Nurses’ successful completion of the workshop was confirmed with a post-test. The increase in skill level allowed greater operational flexibility (via staffing and bed availability), leading to a “decompression of critical care units… and emergency care areas[31](#_ENREF_31).”

An educational intervention was compared to noise-reducing behavioral prompts and modifications to the physical plant in a 2008 parallel retrospective cohort study[32](#_ENREF_32). The former reportedly elicited a “willingness and eagerness[32](#_ENREF_32)” for the changes. In contrast, the machine which prompted staff to be quiet when the noise level rose too high was sometimes ignored or found unplugged.

Instead of conditioning staff to reduce noise, Boston Medical Center modified the processes that resulted in excessive noise generation by telemetry structures[33](#_ENREF_33). Equipment was observed to be a source of unnecessary electronic sounds, so a multidisciplinary task force created new in-hospital guidelines with the goal of reducing the ratio of patient status alert to patient crisis alarms. A combination of decentralized decision-making authority and heuristics was used to achieve this, as the new policy included order templates that risk stratified patients for the application of self-limited alarms and wider physiologic parameters. But with the resultant alarm specificity, clinical staff would have to respond to each audible alarm. Thus, coordination of personnel was central to assuring that the initiative was safe.

Aside from policies and job design, there are several ways an organization may coordinate its personnel. This diverse group of levers ranges from economic incentives to the purposeful distribution of information throughout the staff.

In their analysis of the cost-effectiveness of diagnostic technologies for coronary artery disease, Diamond *et al* describe how economic incentives may be used. Specifically, incentives may be used to encourage providers to direct services toward patients for whom services provide the highest benefit to cost ratio[34](#_ENREF_34). That ratio is calculated *a priori* with a Bayesian decomposition. In this framework, a patient’s pre-test probability of disease corresponds with his Bayesian prior probability. The posterior probability corresponds with the post-test probability of disease.

A patient admitted to telemetry under the American Heart Association guidelines will have a high pre-test probability of acute cardiogenic decompensation. If he has an uneventful hospital course and is discharged from the service, his post-test probability of disease should be equal to or less than the pre-test probability. Conversely, a similar patient’s hospital stay may include adverse events. In that case the post-test probability of disease might be lower, but the hospitalization represents a series of financial shocks from excess care and regulatory penalties. A health system’s incentive structure can confer net benefit on the system and providers if it balances potential regulatory penalties against the incremental clinical outcomes associated with increased telemetry resources.

These resources represent an opportunity cost throughout the whole hospital, even though a limited number of employees uses them directly. This group will be further sub-divided if organizational problem solving must occur; then, a “core element” will create innovations with the assistance of a “soft periphery.[35](#_ENREF_35)”

Within the core, these innovations may diffuse passively at first. Diffusion proceeds via social norms and direct contact. A study by Huesch contrasts the sharing of information between affiliated and non-affiliated physicians in a hospital catheterization lab. Response to adverse events does not occur more quickly among physicians in the same practice group, suggesting that shared infrastructure allows information sharing among core providers from other practice groups[36](#_ENREF_36).

However, the soft periphery must be reached by dissemination of hospital policies. These policies are most likely to have the desired effect when peripheral actors have enough slack resources and decision-making autonomy to adopt the new procedure. In that situation, new processes will be adopted widely if there is a good “innovation/cultural fit[37](#_ENREF_37).”

In contrast, the Total Quality Management (TQM) approach is to purposively align all of the hospital’s elements. The conscious regulation of structures and processes is intended to facilitate care at the highest possible level[38](#_ENREF_38). Hanna describes a TQM initiative to improve telemetry services at a large hospital[39](#_ENREF_39) in 1997. The initial step was to define the quality problem; here, a lack of monitored beds was ascribed to the length of monitored admissions. The median length of stay in monitored units was measured before the intervention began. Physicians were notified of the new procedure before it began, and then a system of escalating reminders and decentralized decision-making began. After a patient had been monitored for three days, a sticker was placed in his daily progress note. On the fourth day, the nurse caring for the patient would call the physician to verify appropriateness of telemetry orders. Upon repeated measurement of the median LOS in telemetry units, it had increased to 5 days. The hospital instituted an automatic discontinuation of telemetry past 72 hours, with the option of re-ordering if the patient was known to have arrhythmias. This cycle of designing a policy, intervening, measuring and correcting is termed the “plan-do-check-act” cycle. Eight months after the initial intervention, the median telemetry length of stay had not changed. After more P-D-C-A cycles over the course of two years, median LOS was reduced to 4.3 days.

There were several contributors to this net reduction in length of stay. One contributor was the effect of behavioral prompts at the point of physician ordering. The advent of electronic ordering systems created a natural experiment that recreated this effect in Leighton’s observational study of utilization patterns at a mid-size New York City hospital. In this study, implementation of a computerized order system (with dialogue box asking for reason to justify the order) increased the rate of appropriate telemetry admission from 65% to 81%. But by hospital day 2, that rate was actually worse than with the old order system. The authors explain this trend as a consequence of the electronic order system’s design; after entering the indication at admission, providers could continue monitor orders without offering further reasoning[25](#_ENREF_25).

Ironically, this new process resulted in an increase in unnecessary telemetry usage. However, the Toyota philosophy emphasizes the importance of reducing waste. Toyota’s Lean methods focus on micro-level process modifications to identify and reduce waste. Piggott*, et al* describe an intervention which used Lean methodology to reduce the time to assessment of emergency department patients’ heart rhythms[23](#_ENREF_23). By identifying instances where batching of patients and poor communication led to delays, the hospital was able to specify a process which would improve patient flow through the ED. The proportion of ECGs and physician assessments performed within the target time increased by 37% and 12%, respectively. Midway through the study period, the Lean quality improvement infrastructure was used for a new initiative to institute a color-coded risk stratification system for patients presenting to the ED with acute coronary syndrome. However, inpatient telemetry is different from the emergency department because it is affected by operational variables that introduce downstream complexity.

Should complexity occur, Toyota Production System allows for front-line employees to solve problems. This reflects its origin on the shop floor, where workers were thought to have the best knowledge of their own manufacturing process[26](#_ENREF_26). Though prior knowledge and heuristics are insufficient for the complex hospital environment, there are analytic techniques associated with Toyota Production System. Braaten describes a telemetry unit which used the “five whys,” pre-specified operational interconnections and dichotomous goals to evaluate the success of work processes[40](#_ENREF_40). In this qualitative study, a front-line staff empowered to analyze its work and describe an ideal “target condition” became more cognizant of potential problems. Thus, employees’ heightened awareness of the environment represents a stronger afferent loop of the learning process whereas leadership’s receptiveness to employees’ ideal condition is the efferent loop of double-loop learning[41](#_ENREF_41)

### Summary of Telemetry Quality Improvement Literature

The quality improvement programs discussed above differ in their philosophical approach but share many similarities. Most programs are formulated by a small group of hospital actors setting goals within the bounds of preexisting organizational value statements. Once that is done, hospital leaders use their power to enact new policies that change structures or processes of care. Lastly, these initiatives use longitudinal data to evaluate success. Then the program can cease when some numerical target is satisfied and the condition remains stable.

Achieving stability in telemetry is inherently difficult, and it is a challenge for healthcare organizations to design sustainable strategies. There are multiple noise sources that may be targeted by a quality improvement initiative. Each may have a peak in a different frequency range and the amplitude of noise it produces may have some diurnal variation. And even if the noise can be controlled, quantifying sound reduction is inadequate to understand the impact of the quality improvement initiative. The perceived level of noise and subjective stress resulting from noise depends not only on the character of noise (e.g. amplitude and frequency) but also the environment in which the noise is perceived and personal characteristics of the individuals perceiving it.

### The Sociology of Telemetry Improvement

The sustainable strategy falls somewhere on the spectrum between eliminating monitor noise because it is harmful and doing nothing because noise is to be expected. Though alarms are inherently stressful to employees and patients, monitors have become integral to caring for clinically unstable patients in the modern hospital. Electronic monitors remain central to patient care despite their ergonomic problems because they provide immediate information on the cardiac rate and rhythm. In that respect, monitor alarms serve as a useful structural adaptation for employees who have entered into an organization so as to find protection from some of the uncertainties of the external environment[42](#_ENREF_42). When those uncertainties pierce the organizational veil, structures gradually change and employee behavior adapts. These adaptations transform the prescribed processes so the idealized structures that once existed are adapted to the new reality[43](#_ENREF_43).

After the new reality has conflicted with the official rules for some time[44](#_ENREF_44), employees use cognitive processes to resolve the dissonance and communicate with each other to try to control disorder[45](#_ENREF_45). When that communication results in a mutually agreeable approach, it may become formally structuralized as an observable part of the organization. This cycle of forming organizations, adapting to changing organizational demands and creating policies is what Giddens’ structuration theory describes as the recreation of organizational structures within the processes of organizational actors who are reacting to the preexisting, physicalized form of the organization[46](#_ENREF_46). Though that process is largely unconscious, there are several conscious decisions that comprise organizational life.

The following program is a method by which group decision making may be incorporated into quality improvement. In so doing, structures may be created to facilitate individual employees’ participation as the organization addresses internal uncertainties.

# Program

## Objective

The goals of this program are to increase and organize participation in quality improvement activities. An organized decision-making process can improve the assessment of the internal environment and widespread participation may limit the influence of the individual over organizational resources. If involving employees affects culture in a desirable way, organizations can perpetuate those changes by structuralizing the channels through which employees participate in quality improvement.

## Rationale

Employee involvement is desirable because the wholesale adoption of “best practices” will only address the intended outcomes via idealized processes. The peculiarities of the organization’s internal environment will not be addressed, which may then be an unintended source of uncertainty in the forecasts of a quality improvement initiative.

If this uncertainty is structuralized, processes may not occur as designed. This process uncertainty can create psychological stress for employees who are trying to fulfill the requirements of their jobs. In this case, stress arises from and is exacerbated by a lack of control over the environment. Superiors can mitigate stresses with the appropriate social support at the right time. If that does not occur, employees will experience stress. Then, colleagues may either maximize their own well-being at coworkers’ expense or sympathetic colleagues may provide a buffer against environmental stress[15](#_ENREF_15).

Telemetry services are so interconnected that employees’ interdependence creates a social environment in which there is implied support of colleagues who have different work roles. Employees’ superiors (i.e. hospital administration) can offer explicit social support by allocating resources[47](#_ENREF_47) to structures that facilitate achievement of the desired outcome, as in Donabedian’s model.

The institutional support and external conditions will establish a resource constraint that the delivery of care cannot exceed. Conversely, there are regulatory requirements for the minimum standard of care. These serve as the upper and lower bounds, respectively, for the provision of care. In the intervening space, there is a utility maximand along the aggregate utility[48](#_ENREF_48) function of the affected hospital employees and patients.

Theoretical utility cannot become real satisfaction without a decision about which outcome or implementation strategy to pursue. The decision-making process requires information flow and higher order cognitive processes. The healthcare organization which provides a structure for group cognitive processes improves the performance of the group by forcing it to modulate its attention, switching between the primary objective and decision-making process. Thus, structured decision-making processes forces participants to engage in meta-thinking where they are aware of the group cognitive-emotional process as it proceeds toward its eventual outcome[49](#_ENREF_49).

In this way, collaboration can help approximate an unobservable subjective quantity while reducing the impact of cognitive biases in the group’s objective estimate of a problem[50](#_ENREF_50).

## Content

However, the group must be capable of solving problems. Quality fields are taught inconsistently during training[51](#_ENREF_51), so educating employees will help an organization to standardize its employees’ level of understanding. These employees may then generate ideas for quality improvement at the unit or department level. Ideas will flow upward to the hospital level, where decision-making may occur. In the final stage of the process, employees interact with an administrative quality improvement department so the ideas can become modifications to the physical plant.

### Education

To begin with, an organization must determine the appropriate amount of resources to expend on educating its workforce in quality principles. Relevant variables are the age of the employees, professional diversity of the workforce and available media for education. Trends in academic medicine have led to the introduction of quality fields like systems theory[51](#_ENREF_51),[52](#_ENREF_52) during training, so younger clinicians will have more familiarity with these topics. A workforce which is composed of many different types of professionals may be more likely to benefit from systems theory, as it may have more opportunities to use the new understanding of its interconnections. And lastly, hospitals that have several established options for distributing didactic content to employees can distribute quality improvement educational materials efficiently.

The workforce will benefit from learning about healthcare quality if they gain enough declarative knowledge of its principles and understanding of operational concepts[53](#_ENREF_53),[54](#_ENREF_54) to maximize hospital performance. Shared decision-making requires a uniform lexicon to facilitate information flow throughout the quality improvement process. The use of standard terminology may serve as a check on the quality of front-line observations made by the employees who begin the quality improvement process. If shared decision-making occurs in fields that are less tightly coupled than telemetry, education may provide benefit by explicitly illustrating the complex relationships within the hospital.

#### Basic Quality Improvement Terms

Employee participation in quality improvement can be beneficial even if it does not result in substantive improvement[55](#_ENREF_55). However, substantive improvement is inherently beneficial and provides a psychological incentive for employees to reinvest effort in quality improvement. Though front-line employees do not need training in quality improvement to reap the psychological benefits of participating in improvement projects, the likelihood of success will be higher if they have some understanding of the field’s principles.

At the minimum, these principles consist of an organizing framework like the Donabedian model. The framework will be enriched by terms drawn from the quality improvement philosophy favored by the organization. Though there are different approaches to quality improvement and disagreement over which approach is most valid, the choice of quality improvement philosophy is the organization’s. The organization which is neutral in this matter may use the Institute for Healthcare Improvement’s Open School free online modules, as a means of increasing access and improving completion rates[52](#_ENREF_52). For the purposes of shared decision-making, in general, and this program, specifically, the important thing is that the language of quality improvement be mutually understood. Then, different entities within the organization may be compared and evaluated against each other.

#### Systems-thinking

Ostensibly unrelated entities are being compared because of the complexity of the modern hospital. Actors and targets are not always connected by linear actions with predictable consequences. The network of relationships is broad enough that an understanding of quality is difficult (if not impossible) if employees restrict their understanding to the microsystem.

The hospital which teaches employees about systems-thinking will convey this image of an interconnected web. Systems theory is a paradigm in which a deterministic model of causation is rarely used. In contrast to the determinist notion that the observed condition is the result of one agent’s action on the past condition, systems thinkers acknowledge the importance of several parallel causes. Complexity science is an outgrowth of systems theory[56](#_ENREF_56) which specifies that the interconnections are non-linear. That is, a change in one entity is unlikely to cause a predictable linear result.

For a complex service like telemetry with several relevant factors to consider, it may be helpful for the workforce to understand the complexity of the issue. Whether it is in the quality of the initial round of suggestions or employee participation in later rounds of the program, a clear understanding of the systems that deliver telemetry will probably improve overall performance of this quality improvement decision-making approach.

The relationships between systems may be less apparent in some of the other fields that can benefit from shared decision-making. In those situations, providers are consciously aware of an interdependence with coworkers who share their caregiving tasks. However the dependence on unseen colleagues is less obvious, even when they impact the patient outcomes for which providers receive feedback. And since that pattern of interdependence has implications for group and individual goals, it creates an incentive to expend energy[57](#_ENREF_57).

### Structured decision-making

In order to minimize the energy and time needed to allow employee participation in productive quality improvement, structured decision-making methods may be used. The nominal group technique can be used to collect data about the internal environment in the initial rounds, followed by a modified Delphi Technique to build consensus at the hospital level. If the Delphic panel is selected carefully, its recommendations may be widely accepted in a quality improvement initiative.

#### Panel Selection and Weighting

Telemetry is an instance in which the provision of direct patient care by clinicians must be supported by non-clinician professional fields. Engineering, facilities management and other staff may have valuable insights into telemetry quality improvement. Relevant clinical departments vary with the hospital’s composition but almost certainly include core clinical fields like cardiology and emergency medicine. The technical skill of the hospital is positively correlated with the number of possible departments for the panel; cardiothoracic surgeons and neurosurgeons are only found in academic medical centers and large community hospitals.

In these largest hospitals, there is a need for mechanisms to allow expanded participation without worsening the group estimate. But to do so, random error present in each individual participant’s forecast cannot correlate too strongly with the random error within his fellow participants’ forecasts[50](#_ENREF_50). Unfortunately, a systematic bias may arise in many ways. Because they tend to be more strongly associated and have more cognitive availability, repetitive events will be easier to recall[58](#_ENREF_58).

Since monitor alarm noise is a major component of the high-frequency hospital noises that affect patients’ and providers’ health, they are probably readily available for recall. This perceptual distortion could introduce a systematic bias into the results of the group decision-making process.

Therefore, the procedure must accommodate the introduction of new participants and a potential systematic bias while remaining representative of the environment. The best (most representative) estimate will be obtained when the aggregate error is smallest. If one makes the assumption that professional role correlates with the ability to apply quality principles in the hospital, it is desirable to rank by job title.

In the case of telemetry quality improvements, clinical providers may comprise core members of a panel to conduct the Delphi process. Cardiologists, nurses, intensivists, and emergency physicians are the clinicians most affected by telemetry services. A proportional system (e.g. each department’s vote has equal weight) can be used to apportion vote share. Non-clinician departments may be invited to participate, in the event that an issue touches upon some matter of their expertise. To maintain the discriminative performance of the decision-making process, the vote of these ancillary participants should be partially discounted. First, non-clinical departments should be ranked by their expected knowledge of the hospital’s telemetry services and then this ordinal ranking used to apportion vote share to each department (see Appendix B). However, the participants should be blinded to the weighting.

With the relevant functional groups chosen, they would return to their departments to conduct data gathering from the hospital’s front-line employees.

#### Nominal Group Technique

A nominal group technique is the mechanism by which most employees would have direct input into this quality improvement decision-making. At this point in the process, employees can contribute by entering suggestions or their observations. If these are entered in adequate quality and sufficient quantity, they will become the basis for the rest of the statistical decision-making to follow.

Each hospital department can conduct its own nominal group technique using face-to-face interaction, a real-time online[59](#_ENREF_59) platform or asynchronous online[60](#_ENREF_60) procedure. Regardless of method, the basic elements are the same; the nominal group technique includes silent time for respondents to write down ideas and a round-robin format in which each respondent submits his idea to the group for discussion. After discussion, respondents rank the ideas and the rankings are totaled.

The structure of the nominal group technique is conducive to an exploratory “problem-centeredness[61](#_ENREF_61)” rather than consideration of strategies to solve those problems. With that being said, the nominal group technique is different from traditional brainstorming because the designated discussion period results in a smaller, more focused list of problems[62](#_ENREF_62).

#### Panel Voting

Once each department has identified an appropriately narrow list of problems, these may advance to the hospital level. There, other hospital departments will enter the decision-making arena with their own problems.

The modified Delphi process may begin with the problems from each department. The problems are analogous to the questionnaire in the traditional Delphi technique.[63](#_ENREF_63)

Thereon, the process is comprised of multiple rounds of anonymous voting. The vote may be conducted with paper ballots or through the hospital’s intranet, and those entries that receive the most votes advance on to the next round. Between rounds, the results feed back to respondents[64](#_ENREF_64). Then, when the planned number of rounds concludes or continued voting ceases to have any marginal benefit[65](#_ENREF_65), the Delphi technique ends.

#### Quality Improvement

The hospital’s front-line employees will have chosen the issues they perceive to be the best uses of quality improvement resources. Many of these issues are likely to be structural and even if they are not, Donabedian’s model implies that the quality of processes cannot be disentangled from the structural environment. Thus, administration should become involved in the process to maximize the efficiency of the improvement process.

If it is a novel problem, then a novel solution must be devised. Administration can aid in modifying the environment, overseeing the budget and coordinating multiple efforts[66](#_ENREF_66). At that time, the solution should be documented according to Proctor *et al.*’s implementation strategy template[67](#_ENREF_67). If it proves successful, the solution may be added to the organization’s fund of knowledge[68](#_ENREF_68) so it can be replicated.

If, however, the employees have specified an issue that has previously been addressed in the organization’s fund of knowledge, the approach will be different. Administration’s role is to delineate the resource constraints and regulatory requirements. Then, the employees of a clinical department may select an appropriate combination of quality improvements which remains within these constraints.

Even with another round of voting and several levels at which an employee can participate, a dissenter invariably arises. In that case, there should be a mechanism which allows for departure from clinical protocols but affords the opportunity to explain why the departure was medically necessary and how the protocol may be improved[69](#_ENREF_69). Preserving individual autonomy within the spirit of a shared purpose should help to preserve the cultural dynamics necessary for future cycles of quality improvement.

# Conclusion

The program described here is a decision-making method that may be used in quality improvement. The delineation of formal boundaries by hospital administration creates a space in which front-line employees can combine knowledge of their respective work processes to solve problems. Using a structured method within this decision space will have short-term and long-term effects. Individual employees’ *ad hoc* solutions at the point of care will be replaced by collaborative problem solving that may help to avoid redundant improvements. Still, a collaboration which consists of a well-designed, predictable set of interactions can approach the goal of considering each actor’s preference during the problem solving process. As this occurs within the bounds of organizational infrastructure, informal problem-solving relationships with laterally-related structures[66](#_ENREF_66),[70](#_ENREF_70) are being strengthened.

The solutions devised by employees are an aggregate of individual wishes, made mutually agreeable and relevant to the problem at hand. Because they are an expression of employees’ wishes, these new processes may decay more slowly than if they were to have originated from outside. This may extend the time between quality improvement initiatives, but improvement is an inevitability of organizational life. When that time comes, communication channels will make decision-making more efficient. Thus, employees’ perceptions may be structuralized in quality measures and operationalized in quality improvement. Taken together, these two things comprise a culture of safety.

The culture of safety does not shape employees’ beliefs, so much as reflect a collective need. And as they pull the quality improvement chain, employees will allocate resources to reflect their mutual values. However, these values are constantly shifting. In the era of pay-for-performance and frequent employee turnover, hospital quality improvement provides an occasion for organizational values to be made tangible at a spatial location and a moment in time. In addition to productive work processes, the organizational environment includes a set of emotional processes that may be perceived in the structures on which employees tacitly agree[71](#_ENREF_71).

Thus, the culture and physical structure of the hospital are mutually reinforcing characteristics that serve to perpetuate one another with the goal of establishing control over the environment. A cyclic decision-making process may help to include each new member of the organization, even as the internal and external environment changes. As such, the dynamic evolution of the hospital may be subsumed within the cognitive processes of repeated collaborative decisions. By reducing the influence of any single participant, these collaborations can also generate decisions that require fewer conscious adaptations than are observed with periodic top-down quality improvement programs.

## real-world application

The growth of the healthcare sector has coincided with social trends emphasizing transparency and sustainability[72](#_ENREF_72). Governmental policy responses have consisted of information dissemination and economic incentives. Organizations reacting to these policies undertake quality improvement initiatives to address the targets.

When the incentive is large enough and an acceptable solution already exists in the literature, a hospital’s most efficacious short term decision is to allocate resources to these targets. But there may be situations when subsidies are unavailable to guide behavior or there is insufficient data applicable to the organization’s specific question. In that case, a hospital’s allocation decision should reflect its aggregate preferences. The environmental constraints delineate an optimal path for implementation of that decision.

## Public Health Relevance

Communities retain a financial and social interest in the non-profit institutions that render integral services like healthcare. Hence, healthcare organizations should aspire to the sustainable delivery of health services which reflect local needs. And yet, it is difficult to identify the intangible components of those needs. Since healthcare workers comprise part of the community, they may be a proxy for the desires of the whole community.

This is particularly salient when there are significant resource constraints and a large number of patients. Then, overprovision is not a feasible strategy for the health services delivery system to satisfy multiple stakeholders’ wishes. A community in this situation may be more satisfied if its choices are directly addressed via healthcare worker participation in quality initiatives, rather than through the satisficing of economic demand[27](#_ENREF_27). And because the process is self-organizing, resource costs need not be prohibitive.

Thus, we conclude this discussion of a framework for collaborative decision-making. Though the framework was designed to apply to any organizational decision, it is best applied to non-economic outcomes with significant observable interdependence (see Appendix C.) The method performs best with large numbers of participants who are part of the same organizational culture, but it also may be used to incorporate new participants into that culture. In so doing, it may be part of a multi-level approach to increase emphasis on mutually agreeable outcomes like patient safety.

* + - * 1. **: AMERICAN HEART ASSOCIATION INDICATIONS FOR TELEMETRY**

|  |  |
| --- | --- |
| Class I Indications | Class II Indications |
| Patients with Unstable Coronary Syndromes    This includes new critical left main CAD amenable to revascularization | Patients with Chest Pain Syndromes at low risk of MI    This includes: acute chest pain of unknown etiology |
| Patients in the Early Phase of Acute Myocardial Infarction  This includes: STEMI, NSTEMI, unstable angina | Patients with post-Acute Myocardial Infarction  This includes: patients 24 to 48 hours status-post  STEMI, NSTEMI or unstable angina |
| Patients who have been resuscitated from cardiac arrest    Should be: monitored in an ICU while being evaluated and have an ICD placed unless an obvious, transient etiology was present | Patients with Subacute Heart Failure    May have: treatment plans monitored and manipulated with the aid of telemetry |
| Patients Who Have Undergone Cardiac  Surgery    This includes: Both Adult and Pediatric Patients | Patients Undergoing Routine Coronary  Angiography    This includes: The period immediately after the procedure, but may be discontinued after that |
| Patients Who Have Undergone Non-urgent  Percutaneous Coronary Intervention with  Complications    Should: Begin immediately post-procedure and last 24 hours or longer if there is evidence of ischemia | Patients Undergoing non-Urgent  Percutaneous Coronary Intervention without  Complications    Should: Begin post-procedure and discontinue 6-8 hours later |

**Adapted from Drew et al**[**19**](#_ENREF_19)

**Figure 1. 2004 Electrocardiography Guidelines**

* + - * 1. **: FORMULAS FOR VOTE WEIGHTING**

With Only Clinician Departments Participating

Where,

C= number of clinician departments

When non-clinician department opts in,

# appendix c: examples of program applications

*Example: Expansion of telemetry services, large academic center undergoing horizontal integration*

**Round I (Participant Selection)**

Relevant departments are selected to participate. These include nursing, cardiology and emergency medicine.

**Round II (Nominal Group Technique)**

Because of non-overlapping shifts, most departments choose to conduct an asynchronous NGT. The extensive hospital intranet provides the infrastructure for this.

**Round III (Delphi Technique)**

The hospital’s preexisting infrastructure may be used to support a variant Delphi technique. Since the ramifications of this decision are primarily economic, the hospital believes individuals might skew the decision to their self-interest. Thus, each department’s Dephi “panelist” is comprised of that department’s aggregate voting via the intranet.

The decision-making process identifies the lack of formal care coordination for future telemetry patients as the major concern. As of now, inter-hospital transfers and follow-up care are arranged through informal channels and relationships.

**Round IV (Implementation)**

Social workers and nurses offer input on the regulatory requirements for care coordination. Business administration communicates a break-even budget constraint. Some improvements from the organizational fund of knowledge fall within the intervening space. Care coordination technologies that satisfy these requirements are added to this list and sent to participants for voting.

*Example: Planned collaborative decision-making as part of continuous quality improvement, mid-size hospital*

**Round I (Participant Selection)**

The hospital chooses to limit the size of functional groups to facilitate decision-making. But by grouping departments with interrelated clinical functions together, interdependence is preserved. We follow the telemetry subset.

**Round II (Nominal Group Technique)**

Quality improvement is already a widely-valued part of hospital culture. Hence, many departments set aside time for face-to-face nominal group discussions.

**Round III (Delphi Technique)**

A questionnaire is constructed from the results of the nominal group rounds. Then, the telemetry Delphi panel conducts anonymous voting on the questionnaire. An allocation decision has been made after several rounds.

The panel identifies the inconsistent availability of monitors for patients arriving at a new unit.

**Round IV (Implementation)**

The relevant regulations pertain to unmonitored time, staffing levels and emergency department response time. The budget constraint is communicated by administrators.

Three feasible options exist. Patient and monitor flow can increase with supply chain improvements. Alternately, the hospital may buy enough new monitors to solve the problem under the current system. Thirdly, a hybrid of the two solutions may be used.

Because there are three acceptable solutions within the decision space, participants will select whichever they prefer.

# bibliography

1. Konkani A, Oakley B. Noise in hospital intensive care units--a critical review of a critical topic: 1. *Journal of critical care.* 2012;27(5):522.e521.

2. Medical device alarm safety in hospitals. *Sentinel event alert / Joint Commission on Accreditation of Healthcare Organizations.* Apr 8 2013(50):1-3.

3. Basner M, Babisch W, Davis A, et al. Auditory and non-auditory effects of noise on health. *Lancet.* 2014;383(9925):1325-1332.

4. Buxton OM, Ellenbogen JM, Wei W, et al. Sleep Disruption due to Hospital Noises. *Annals of Internal Medicine.* 2012;157(3):170-179.

5. Topf M, Bookman M, Arand D. Effects of critical care unit noise on the subjective quality of sleep. *Journal of Advanced Nursing.* 1996;24(3):545-551.

6. U L, A K, M B. Acceptable levels of tonal and broad-band repetitive and continuous sounds during the performance of nonauditory tasks. *Perceptual and motor skills.* 1995;81(3 Pt 1):803-816.

7. Topf M. Personal and environmental predictors of patient disturbance due to hospital noise. *Journal of Applied Psychology.* 2015-02-03 1985;70(1):22-28.

8. J TG, C LA. Effect of intermittent truck noise on percentage of deep sleep. *The Journal of the Acoustical Society of America.* 1978;64(4):1078-1080.

9. Minckley BB. A STUDY OF NOISE AND ITS RELATIONSHIP TO PATIENT DISCOMFORT IN THE RECOVERY ROOM. *Nursing research.* 1968;17(3):247-249.

10. Fife D, Rappaport E. Noise and hospital stay. *American Journal of Public Health.* 1976;66(7):680-681.

11. Blomkvist V, Eriksen CA, Theorell T, et al. Acoustics and psychosocial environment in intensive coronary care. *Occupational and environmental medicine.* 2005;62(3):e1-e1.

12. Topf M. Hospital noise pollution: an environmental stress model to guide research and clinical interventions. *Journal of advanced nursing.* 2000;31(3):520-528.

13. Topf M, Dillon E. Noise-induced stress as a predictor of burnout in critical care nurses. *Heart & lung : the journal of critical care.* Sep 1988;17(5):567-574.

14. Van Servellen G, Topf M. Personality hardiness, work-related stress, and health in hospital nurses. *Hospital Topics.* Spring1994 1994;72(2):34.

15. Van der Doef M, Maes S. The Job Demand-Control (-Support) Model and psychological well-being: A review of 20 years of empirical research. *Work & Stress.* 1999;13(2):87-114.

16. Institute of Medicine . Committee on Quality of Health Care in A. *Crossing the quality chasm: a new health system for the 21st century.* Washington, D.C: National Academy Press; 2001.

17. Donabedian A. Evaluating the Quality of Medical Care. *The Milbank Memorial Fund quarterly.* 1966;44(3):166-206.

18. Emergency Cardiac Care Committee M, Jaffe AS, Atkins JM, et al. Recommended guidelines for in-hospital cardiac monitoring of adults for detection of arrhythmia. *Journal of the American College of Cardiology.* 1991;18(6):1431-1433.

19. Drew BJ, Califf RM, Funk M, et al. Practice standards for electrocardiographic monitoring in hospital settings: an American Heart Association scientific statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young: endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses. *Circulation.* Oct 26 2004;110(17):2721-2746.

20. Brady WJ, Gurka KK, Mehring B, Peberdy MA, O’Connor RE, American Heart Association's Get with the Guidelines I. In-hospital cardiac arrest: Impact of monitoring and witnessed event on patient survival and neurologic status at hospital discharge. *Resuscitation.* 2011;82(7):845-852.

21. Graham KC, Cvach M. Monitor Alarm Fatigue: Standardizing Use of Physiological Monitors and Decreasing Nuisance Alarms. *American Journal of Critical Care.* 2010;19(1):28-34.

22. Funk M, Clark JT, Bauld TJ, Ott JC, Coss P. Attitudes and practices related to clinical alarms. *American Journal of Critical Care : An Official Publication, American Association of Critical-Care Nurses.* 2014;23(3):e9-e18.

23. Piggott Z, Weldon E, Strome T, Chochinov A. Application of Lean principles to improve early cardiac care in the emergency department. *CJEM.* 2011;13(5):325.

24. Gazarian PK, Carrier N, Cohen R, Schram H, Shiromani S. A description of nurses' decision-making in managing electrocardiographic monitor alarms. *Journal of Clinical Nursing.* 2015;24(1-2):151-159.

25. Leighton H, Kianfar H, Serynek S, Kerwin T. Effect Of An Electronic Ordering System On Adherence To American College Of Cardiology Guidelines For Cardiac Monitoring. *Journal of the American College of Cardiology.* 2012;59(13):E1870.

26. Spear S, Bowen HK. *Decoding the DNA of the Toyota Production System.* Vol 77: Harvard Business School Press; 1999.

27. Tiebout CM. A Pure Theory of Local Expenditures. *Journal of Political Economy.* 1956;64(5):416-424.

28. Goh SC, Chan C, Kuziemsky C. Teamwork, organizational learning, patient safety and job outcomes. *International journal of health care quality assurance.* 2013;26(5):420-432.

29. Dandoy CE, Davies SM, Flesch L, et al. A team-based approach to reducing cardiac monitor alarms. *Pediatrics.* Dec 2014;134(6):e1686-1694.

30. Coleman KM, Davies SM, Flesch L, et al. Sustaining a Standardized Cardiac Monitor Care Process to Reduce Nuisance Alarms. *Biology of Blood and Marrow Transplantation.* 2// 2015;21(2, Supplement):S375-S377.

31. Crimlisk JT, Johnstone DJ, Winter MR. Cardiac Monitoring: Hospital-wide Education and Staff Competence. *Dimensions of Critical Care Nursing.* 2015;34(3):170-175.

32. Taylor-Ford R, Catlin A, LaPlante M, Weinke C. Effect of a noise reduction program on a medical- surgical unit. *Clinical Nursing Research.* 2008;17(2):74-88.

33. Whalen DA, Covelle PM, Piepenbrink JC, Villanova KL, Cuneo CL, Awtry EH. Novel Approach to Cardiac Alarm Management on Telemetry Units. *The Journal of cardiovascular nursing.* 2014;29(5):E13-E22.

34. Diamond GA, Denton TA, Berman DS, Cohen I. Prior Restraint: A Bayesian Perspective on the Optimization of Technology Utilization for Diagnosis of Coronary Artery Disease. *The American Journal of Cardiology.* 7// 1995;76(1–2):82-86.

35. Denis J-L, Hébert Y, Langley A, Lozeau D, Trottier L-H. Explaining diffusion patterns for complex health care innovations. *Health care management review.* 2002;27(3):60.

36. Huesch MD. Is blood thicker than water? Peer effects in stent utilization among Floridian cardiologists. *Social science & medicine.* 2011;73(12):1756-1765.

37. Crites GE, McNamara MC, Akl EA, Richardson WS, Umscheid CA, Nishikawa J. Evidence in the learning organization. *Health research policy and systems / BioMed Central.* 2009;7(1):4-4.

38. Smith AD, Offodile OF. Data collection automation and total quality management: case studies in the health-service industry. *Health marketing quarterly.* 2008;25(3):217-240.

39. Hanna LA. Managing a cardiac monitoring problem. *Nursing management.* 1997;28(7):32D.

40. Braaten JS, Bellhouse DE. Improving patient care by making small sustainable changes: a cardiac telemetry unit's experience. *Nursing economic.* 2007;25(3):162.

41. Nutley SM, Davies HTO. Developing organizational learning in the NHS. *Medical Education.* 2001;35(1):35-42.

42. Berends H, Boersma K, Weggeman M. The structuration of organizational learning. *Human Relations.* Sep 2003; 2014-05-23 2003;56(9):1035-1056.

43. DeSanctis G, Poole MS. Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. *Organization Science.* 1994;5(2):121-147.

44. Amalberti R, Vincent C, Auroy Y, De Saint Maurice G. Violations and migrations in health care: A framework for understanding and management. *Quality and Safety in Health Care.* 2006;15(1):i66-i71.

45. Weick KE, Sutcliffe KM, Obstfeld D. Organizing and the Process of Sensemaking. *Organization Science.* 2005;16(4):409-421.

46. Giddens A. *The constitution of society: outline of the theory of structuration.* Cambridge [Cambridgeshire] U6 - ctx\_ver=Z39.88-2004&ctx\_enc=info%3Aofi%2Fenc%3AUTF-8&rfr\_id=info:sid/summon.serialssolutions.com&rft\_val\_fmt=info:ofi/fmt:kev:mtx:book&rft.genre=book&rft.title=The+constitution+of+society&rft.au=Giddens%2C+Anthony&rft.series=Social+theory+%28Alexander+Street+Press%29&rft.date=1984-01-01&rft.pub=Polity+Press&rft.externalDocID=7266304&paramdict=en-US U7 - eBook: Polity Press; 1984.

47. Kirk WR. *Your future in hospital administration.* United States U6 - ctx\_ver=Z39.88-2004&ctx\_enc=info%3Aofi%2Fenc%3AUTF-8&rfr\_id=info:sid/summon.serialssolutions.com&rft\_val\_fmt=info:ofi/fmt:kev:mtx:book&rft.genre=book&rft.title=Your+future+in+hospital+administration&rft.au=Kirk%2C+W.+Richard+%28Weir+Richard%29&rft.date=1963-01-01&rft.externalDBID=hathitrust%3Apd&rft.externalDocID=oai\_quod\_lib\_umich\_edu\_MIU01\_001560051&paramdict=en-US U7 - eBook1963.

48. Ali Mohammad M. Healthcare service quality: towards a broad definition. *International journal of health care quality assurance.* 2013/03/15 2013;26(3):203-219.

49. Okhuysen GA, Eisenhardt KM. Integrating Knowledge in Groups: How Formal Interventions Enable Flexibility. *Organization Science.* 2002;13(4):370-386.

50. Einhorn HJ, Hogarth RM, Klempner E. Quality of group judgment. *Psychological bulletin.* 1977;84(1):158-172.

51. Batalden P, Leach D, Swing S, Dreyfus H, Dreyfus S. General Competencies And Accreditation In Graduate Medical Education. *Health affairs.* 2002;21(5):103-111.

52. Zenlea IS, Billett A, Hazen M, et al. Trainee and Program Director Perceptions of Quality Improvement and Patient Safety Education: Preparing for the Next Accreditation System. *Clinical pediatrics.* 2014;53(13):1248-1254.

53. Berg GM, Acuna D, Lee F, Clark D, Lippoldt D. Trauma performance improvement and patient safety committee: fostering an effective team. *Journal of trauma nursing : the official journal of the Society of Trauma Nurses.* 2011;18(4):213.

54. David Y, Clark JT, Ott J, et al. Improving Patient Safety Through Clinical Alarms Management. Vol 16. Berlin, Heidelberg: Springer Berlin Heidelberg; 2007:1051-1054.

55. Mohr JJ, Batalden PB. Improving safety on the front lines: the role of clinical microsystems. *Quality & safety in health care.* 2002;11(1):45-50.

56. Gare A. Systems Theory and Complexity: Introduction. *Democracy & Nature.* 2000;6(3):327-339.

57. Saavedra R, Earley PC, Van Dyne L. Complex Interdependence in Task-Performing Groups. *Journal of Applied Psychology.* 1993;78(1):61-72.

58. Tversky A, Kahneman D. Availability: A heuristic for judging frequency and probability. *Cognitive psychology.* 1973;5(2):207-232.

59. Tseng K-H, Lou S-J, Diez CR, Yang H-J. Using Online Nominal Group Technique to Implement Knowledge Transfer. *Journal of Engineering Education.* 2006;95(4):335.

60. Dowling KL, St. Louis RD. Asynchronous implementation of the nominal group technique: is it effective? *Decision Support Systems.* 2000;29(3):229-248.

61. Ven A, Delbecq AL. Nominal versus interactinf group processes for committee decision-making effectiveness. *Academy of Management journal.* 1971;14(2):203-212.

62. Harvey N, Holmes CA. Nominal group technique: An effective method for obtaining group consensus. *International journal of nursing practice.* 2012;18(2):188-194.

63. Williams PL, Webb C. The Delphi technique: a methodological discussion. *Journal of advanced nursing.* 1994;19(1):180-186.

64. Brook RH, Chassin MR, Fink A, et al. *A method for the detailed assessment of the appropriateness of medical technologies.* Vol 3376; 3376. Santa Monica, CA: RAND; 1991.

65. Dalkey N. An experimental study of group opinion: The Delphi method. *Futures.* 9// 1969;1(5):408-426.

66. Holmberg L. Task uncertainty and rationality in medical problem solving. *International Journal for Quality in Health Care.* 2006;18(6):458-462.

67. Proctor EK, Powell BJ, McMillen JC. Implementation strategies: recommendations for specifying and reporting. *Implementation science : IS.* 2013;8(1):139-139.

68. Hulse NC, Galland J, Borsato EP. Evolution in clinical knowledge management strategy at Intermountain Healthcare. *AMIA ...Annual Symposium proceedings / AMIA Symposium.AMIA Symposium U6 - ctx\_ver=Z39.88-2004&ctx\_enc=info%3Aofi%2Fenc%3AUTF-8&rfr\_id=info:sid/summon.serialssolutions.com&rft\_val\_fmt=info:ofi/fmt:kev:mtx:journal&rft.genre=article&rft.atitle=Evolution+in+clinical+knowledge+management+strategy+at+Intermountain+Healthcare&rft.jtitle=AMIA+...+Annual+Symposium+proceedings+%2F+AMIA+Symposium.+AMIA+Symposium&rft.au=Hulse%2C+Nathan+C&rft.au=Galland%2C+Joel&rft.au=Borsato%2C+Emerson+P&rft.date=2012&rft.eissn=1559-4076&rft.volume=2012&rft.spage=390&rft\_id=info:pmid/23304309&rft.externalDocID=23304309&paramdict=en-US U7 - Journal Article.* 2012;2012:390.

69. Clemmer TP, Spuhler VJ, Berwick DM, Nolan TW. Cooperation: The Foundation of Improvement. *Annals of Internal Medicine.* 1998;128(12 Part 1):1004.

70. Galbraith JR. Organization Design: An Information Processing View. *Interfaces.* 1974;4(3):28-36.

71. Callahan JL. Reversing a conspicuous absence: Mindful inclusion of emotion in structuration theory. *Human Relations.* 2004;57(11):1427.

72. Fischer M. Fit for the Future? A New Approach in the Debate about What Makes Healthcare Systems Really Sustainable. *Sustainability.* 2014;7(1):294-312.