Cost of Poor Quality or Waste in Integrated Delivery System Settings

Final Report

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Contract No. 290-00-0018

RTI Project No. 0207897.011

September 2006

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Section 1. Overview and Background

1.1 Overview

On July 10, 2005, David Walker, head of the U.S. Government Accounting Office, testified before the Citizens' Health Care Working Group at its community hearing in Salt Lake City, Utah. As comptroller general of the United States, he noted that unfunded financial liability for the federal Medicare program for citizens currently alive totals $29.9 trillion, or about two-thirds of the $48.5 trillion total net worth, including home equity, of all U.S. citizens. In comparison, unfunded liabilities for FICA (Social Security) total only $5.7 trillion. At present rates of health care cost increases, the Medicare Trust Fund will be exhausted by 2018. However, the assets of the Medicare Trust Fund are stored in the form of U.S. treasury bonds. Redeeming those bonds will require significant tax increases or redirection of existing tax funds from other parts of the U.S. federal budget. By that measure, significant funding shortfalls for Medicare will appear by about 2011 or 2012.

Similar health care cost increases are burdening U.S. businesses, making them less competitive in international markets. As a result, an increasing number of companies are shifting health care costs to employees or dropping employment-related health benefits altogether. By any metric, continued growth in health care costs, well in excess of growth rates for the general economy, herald a looming cost crisis for health care. While the U.S. spends significantly more money per capita on health care than any other modern industrialized democracy, rates of increase in other countries are similar. Although starting from a lower base rate, many other countries regard health care cost increases in much the same light as does the United States.

While there is some question about the ability to contain health care costs by eliminating waste and inefficiency (e.g., Schwartz & Mendelson, 1994), documentation of waste/inefficiency in health care and the ability to reallocate these resources holds promise (Ovretveit, 2004b). According to Ovretveit (2004a, p. 7), "the absence of empirical studies and of strong evidence about costs and savings is surprising given the claims made about waste and the effectiveness of quality methods."

The primary purpose of this task was to collaboratively build a system that could be actively used to identify the costs of poor quality or waste in an effort to identify opportunities for improvement in hospital settings. The proposed identification strategy has been designed from a financial management perspective, recognizing that we are in the business of providing high-quality medical care. In doing so, our aim as an industry is to provide

> "All the right care, but only the right care."
> (Brent James)

The lead integrated delivery system (IDS) partners for this effort are Intermountain Healthcare and Providence Health System (PHS). We also solicited periodic input via in-person discussion throughout the task from our IDS partners—Baylor Health Care System, UNC Health Care, and UPMC Health System. Researchers at RTI International (RTI) supported and contributed to the investigative effort. A multidisciplinary team of clinical, quality improvement, finance, and management engineering research staff were engaged in this demand-driven, participatory research.

1.2 Background

Although there are many definitions of inefficiency in health care, we chose to adopt a broad definition that has been used in quality of care assessment: "…a wasteful use of resources for no (or very little) benefit, or a failure to use resources on clearly beneficial activities. Inefficiency may arise because of apparently inappropriate, irrational, or misinformed decisions by individuals or organizations" (Severens, 2003, p. 366). The cost of such waste is typically framed in terms of people and resources. It is recognized that there are different kinds of costs—developmental/acquisition, planning, implementation, and maintenance—that can be further categorized as one-time or recurring. However, no standard mechanism for capturing these costs and categorizing areas of waste/poor quality is available for health care. It has been argued that such guidance is necessary to make the business case for improvements and to prioritize such efforts across competing needs (Weeks & Bagian, 2003).

Clinical quality improvement (QI) provides a theory and a set of practical tools for measuring and managing health care delivery processes (Crosby, 1979; Donabedian, 1980; Deming, 1986). QI theory holds that all planned human work, including health care delivery, is accomplished through such processes. QI theory further posits that every such clinical work process produces parallel medical and cost outcomes, suggesting that medical outcomes are directly related to cost outcomes. Clinical QI describes three causal relationships that define this link. One of those relationships describes process changes that produce better medical outcomes, but only through higher resource investments. Reductions in the other two relationships—quality waste and inefficiency waste—generate lower costs by improving medical outcomes or while medical outcomes hold stable. We draw on this body of work as a core foundation to our thinking in this project (James, 1989).

Examples of poor quality and/or waste in health care are diverse and include clinician interruptions, duplicate or repeat testing/procedures, delays in care, inefficient use of clinician time, improper documentation/record keeping, iatrogenesis, and patient injuries. For example, a recent study funded by the Agency for Healthcare Research and Quality (AHRQ) (Zhan et al., 2003) demonstrated that medical injuries during hospitalization resulted in longer hospital stays, higher costs, and a higher risk of death. The study, "Excess Length of Stay, Charges, and Mortality Attributable to Medical Injuries During Hospitalization," was published in the October 8, 2003, issue of the *Journal of the American Medical Association*. Zhan et al. found that the impact of medical injuries varies substantially. Using data from the 2000 Nationwide Inpatient Sample, the study provides specific estimates for excess length of stay, charges, and risk of death for 18 of the 20 AHRQ Patient Safety Indicators. This study, and many like it, shows an association between cost and quality but does not pinpoint where or how this is occurring at the point of service—details required to address the problem.

An initial literature review conducted by research staff at Intermountain Healthcare resulted in the identification of actual markers that signify the cost of poor quality. More than 1,330 articles that showed cost improvements associated with clinical change were identified. This was not a systematic review of the literature. Even with our updated scan, we note that a wide net must be cast to identify such studies, which largely do not include terms such as "quality waste" or "inefficiency" as key words (see Appendix A).

Estimates suggest that health care quality waste and inefficiency waste may account for more than 50 percent of all American health care expenditures. The Midwest Business Group on Health has estimated that 30 percent of health care costs are for waste, and the average cost of poor quality care per patient per year is $1,500. Growing pressure on health care costs have generated an interest in quality and inefficiency waste as means to control costs and possibly expand health care access while maintaining high health care quality given waste projections such as these. However, theory and estimates do not always translate into practice.

As a first step, we examined the peer-reviewed medical literature, seeking instances showing quality waste and inefficiency waste mechanisms at work within current American health care delivery. Our aim was to see whether such phenomena exist in practice as well as theory and to get some preliminary sense of their possible scale and, hence, potential. The findings from this preliminary search suggested that there is good evidence that quality waste and inefficiency are common in health care delivery and that attacking them can produce significant cost savings (at least as illustrated by individual projects where this occurred; see, for example, Ovretveit, 2004a, b).

Key leaders from our partner IDSs affirmed the need to address this problem. The literature and leading researchers have spoken in an abstract sense for years about making health care more efficient and eliminating waste without giving clear direction on how to identify such improvement opportunities. Quotes from senior executives in our partner IDSs illustrate the situation:

> "Patient injuries are expensive. Any class of patient safety is going to be part of this."

> "This idea of leveraging waste elimination creates capacity. Because of growth in potentially avoidable medical admissions, you are canceling elective surgeries."

> "We own a health plan that covers over 10 percent of our admissions. The health plan is more profitable if the hospital has less waste. More admissions and shorter length of stay with higher quality. Waste has a negative correlation with quality items."

With this in mind, we set out to construct an organizing framework for considering quality waste and inefficiency in health care that builds on existing constructs. The end point of this effort is intended to produce a toolset for eliminating/mitigating quality waste and/or inefficiency in health care and to provide a more refined set of waste/poor quality estimates to guide efforts to extract underutilized resources in hospitals.

Section 2 presents our aims, the context for this work, and our resultant organizing framework. In Section 3, we illustrate how current approaches have addressed the problem of waste/poor quality and present specific examples of these estimates.

Section 2. Aims, Existing Constructs, and Organizing Framework

2.1 Aims

There were two primary aims for our work:

1. Estimate the amount of waste in current American hospital operations.
2. Provide a set of tools that hospital Chief Financial Officers (CFOs) can use to identify and eliminate said waste in their operations.

In considering these aims, it was important to set boundaries on our work. We limited our evaluation to hospital operations, without direct comment on outpatient care, long-term care, etc. One useful extension would be to examine episodes of care across these settings.

2.2 Overview of Existing Quality Constructs for Waste/Poor Quality

Chassin coined the useful terms “overuse” (providing a treatment when its risk of harm exceeds its potential benefit), “underuse” (failing to provide an effective treatment when it would have produced favorable outcomes), and “misuse” (avoidable complications of appropriate care) to describe common classes of quality failures in health care delivery (Chassin, 1991; Chassin et al., 1998). He recognized that all three represent process defects, and he linked them to quality improvement (QI) methods that have significantly reduced defect rates in settings outside of health care (Chassin, 1998). He also considered the relationship of defect reduction to health care costs, arguing that (1) most health care delivery is not positively cost-effective; (2) in a perfect system, any cost savings generated from reducing overuse and misuse likely would be consumed, correcting underuse; and (3) therefore, QI activities, broadly applied, will require active, long-term investment with expected returns primarily coming in the form of improved health, rather than better access to care through reduced costs.

Poor quality can produce waste. Industrial quality theory adds a complementary dimension to Chassin’s three categories, under which improvements in the quality of processes, products, and services can significantly decrease production costs (Crosby, 1979; Deming, 1986). When mapped into clinical practice, two specific mechanisms drive quality-based cost reduction. Both rely upon managing processes to reduce or eliminate process failures, or defects.

Quality waste. When a step in a clinical process fails, some proportion of those process failures will lead to outcome failures. There are only two choices for dealing with the resulting outcome failures, and both raise costs:

1. Invest additional resources to repair the initial failure (rework). For example, treating a medical complication consumes more health care resources than if the complication had never occurred.
2. Discard the defective output and start again (scrap). For example, repeating an X-ray when the initial image is unreadable or making multiple attempts to track down a missing

laboratory result, both produce scrap (i.e., wasted images and unnecessary telephone calls).

Quality waste is often a cost to the system, not a penalty to the service provider, under current payment policies. Quality waste also includes the often significant cost of detecting outcome failures (inspection costs), because such vigilance would not be necessary if the process produced no failures. A good example of this is the efforts hospitals across the country are dedicating to medication reconciliation.

Currently, the QI infrastructure in health care should not be considered waste but rather as a necessary conduit for high reliability service delivery. However, it is technically still quality waste.

Recognizing the forms and magnitude of quality waste provides a way to identify opportunities for improvement (i.e., watch for any instances of rework or scrap) and to respond to them (i.e., build and manage a process that does not fail in the first place). Quality waste strategies center on prevention, applied in a very broad way: for any defect, *move upstream* in the process, find the root causes of the failure, then *do it right the first time* for future cases. Under this theory, better clinical process design and management can produce better medical outcomes, eliminate quality waste, and reduce health care costs.

Inefficiency waste. Two processes accept identical inputs and produce identical outputs, but one process consumes more resources to do so (is less efficient). Which one should care providers use? With limited health care resources, an inefficient process wastes resources that could otherwise generate health benefits and thus reduces the total health benefit achieved for a population of patients.

Roberts and Zangwill (1993) define inefficiency waste as "any non-value adding work" (p. 2). They catalog an impressive list of specific mechanisms by which inefficiency wastes resources, including unnecessary redundancy (e.g., repetitive collection of patient histories); downtime and delays (e.g., time during which a piece of expensive equipment is not in active use); unnecessary complexity; failure to use all available resources, including knowledge, people, and equipment, to add value when there is good economic opportunity to do so; efforts spent improving processes that were useless to begin with; and consuming resources to produce products that see no use (e.g., some bureaucratic reports or mandatory quality reporting systems that produce no change).

One particularly interesting entry in Roberts and Zangwill's hierarchy of inefficiencies is *care design waste*. Over time, many processes improve through thoughtful experimentation and refinement. Steps initially thought to be essential shorten or disappear, producing efficiencies. In retrospect, those eliminated steps and their associated resources were waste.

For example, over the past several years, many U.S. cardiac surgery programs have reduced median post-surgical intubation times from more than 25 hours to less than 8 hours, producing major cost savings while maintaining excellent clinical outcomes (Cheng, 1998; Silbert et al., 1998). In retrospect, more than two-thirds of that initial thoracic intensive care unit (ICU) care process represented inefficiency waste, compared with what was eventually discovered. As care delivery teams change, refine, and eliminate process steps, new opportunities for further waste removal become obvious in continuing cycles of improvement. According to this bold framing, failure to innovate and failure to use proven innovations are both forms of waste.

Better clinical process design and management can eliminate inefficiency waste, causing health care costs to fall while medical outcomes remain stable. If health systems use those savings to extend effective care to other patients, costs hold stable while other medical outcomes, at a population level, can improve.

2.3 Planned Approach for Identifying a Typology of Waste/ Inefficiency

This task initially intended to identify a typology for waste/inefficiency in health care, drawing on the literature and abstraction of a set of projects completed at Intermountain Healthcare (i.e., Advanced Training Program [ATP] projects) and Providence Health System (PHS) (i.e., Six Sigma projects). When executed, this approach did not provide the expected, emergent typology. A primary limitation was that these projects were largely done for training purposes, there was variability over time, and they did not provide a representative cross-section of waste/inefficiency in health care. Nevertheless, we present a summary of findings from this assessment below to document our effort.

We reviewed 10 years of Intermountain Healthcare ATP projects and 3 years of PHS projects for these purposes. The ATP projects represent work by representatives of many U.S. health systems to target areas of waste and poor quality. The ATP projects span a number of years; 58 projects for which summary reports were available were used in the review. The Six Sigma projects were conducted over 3 years at PHS. Some initial projects were selected as training projects for the initial Six Sigma roll-out, but there is reason to believe that the projects are representative of the kinds of waste reduction efforts found nationally. The ATP and Six Sigma projects are summarized in Exhibits 1 and 2, respectively.

Even within the QI approach, differences were observed between the ATP targets and Six Sigma targets. The ATP projects tended to focus on overuse, whereas the Six Sigma projects concentrated on throughput. These differences reflect different internal organizational agendas and external, industry-wide forces and did not appear to be method related.

The three areas of problems that emerged from our abstractions that we believed would be most productive for drill down and waste elimination in hospitals were

1. throughput/unnecessary length of stay (LOS);
2. bottlenecks, such as those caused by delayed laboratory results; and
3. substitutions in role/function.

Throughput was determined to be the most productive focus for inquiry because of interest among financial analysts at partner health systems and as evidenced by reports on this topic in relevant trade journals. Bottlenecks and substitutions are causal elements and are observed at the point of service.

In addition to this review of independently produced analyses (i.e., ATP and Six Sigma projects), we conducted several directed analyses at Intermountain Healthcare and PHS:

- An incident analysis (Appendix B) that demonstrates extended LOS for patients where any type of voluntary incident report is submitted at PHS; and

Exhibit 1. Major categories targeted by ATP projects

Description	Number
Address underuse or overuse of treatment (often medications)	17
Devise better scheduling, information flow, and other types of coordination	15
Reduce delays	8
Reduce variation in how a condition is clinically treated (e.g., via guideline adherence, etc.)	7
Streamline administrative processes such as billing, Institutional Review Board (IRB), incident reporting system, etc.	5
Create methods for better diagnosis of patients' conditions	3
Reduce supply waste	3
Total	58

Exhibit 2. Major categories targeted by Six Sigma projects

Description	Number
Reduce delays	14
Devise better scheduling, information flow, and other types of coordination	4
Address underuse or overuse of treatment	2
Streamline administrative processes	2
Reduce supply waste	1
Create methods for better diagnosis of patients' conditions	1
Reduce variation in how a condition is clinically treated	0
Total	24

- TPS/Lean observations (Appendix C) that were completed as part of an operational initiative at Intermountain Healthcare and were validated with reliability testing and training at UNC Health System, depicting waste and inefficiency at the point of care.

Several more themes emerged from our QI, TPS, Lean, and incident analyses:

- throughput/delay
- errors/defects
- using resources that are more expensive than necessary (treatment, setting, provider, equipment) whereby initial choices determine subsequent ones, preventing cheaper alternatives (i.e., for the same choice of setting, there can be more or less expensive provider levels and more or less expensive supplies)
- reducing variation
- improving diagnosis

While these exploratory analyses produced a set of focal areas for further investigation of variances in health care delivery, they did not yield a constructive typology to guide our work. This initial work did, however, contribute to our ability to provide specific examples and demonstrate how to capture waste and inefficiency in health care. Drawing on available constructs from the literature, we identified an organizing framework to guide our subsequent efforts, which is presented in Section 2.4.

2.4 Selected Framework for Considering Cost of Waste/ Poor Quality

The Institute of Medicine defined quality of care as the extent to which health services increase the likelihood of desired health outcomes and are consistent with current professional knowledge (IOM, 1990). In a more recent report, *Crossing the Quality Chasm*, the Institute of Medicine (IOM) alleges that the quality of health care is inadequate and has called for improvements in six areas—safety, effectiveness, patient-centeredness, timeliness, efficiency, and equity—concluding that QI cannot be achieved given the constraints of the current system and processes of care (IOM, 2001; Detmer et al., 2001).

> "Perfect care may be a long way off, but much better care is within our grasp. The committee envisions a system that uses the best knowledge, that is focused intensely on patients, and that works across healthcare providers and settings. Taking advantage of new information technologies will be an important catalyst to moving us beyond where we are today. The committee believes that achieving such a system is both possible and necessary" (IOM 2001, p. 21).

In 2000, while serving on IOM's Committee on Quality of Healthcare in America (which produced *To Err Is Human* and *Crossing the Quality Chasm*), Dr. Donald Berwick introduced a useful hierarchy of health care delivery structures that he termed the *Chain of Effect for Quality*. The *Chain of Effect for Quality* provided a high-order structure that helped us organize examples of waste at a functional level and make sense of other waste classification systems (i.e., Chassin's overuse/underuse/misuse model and Deming's quality waste and inefficiency waste; Berwick, 2002) (see Exhibit 3).

Exhibit 3. The chain of effect for quality applied to waste analyses

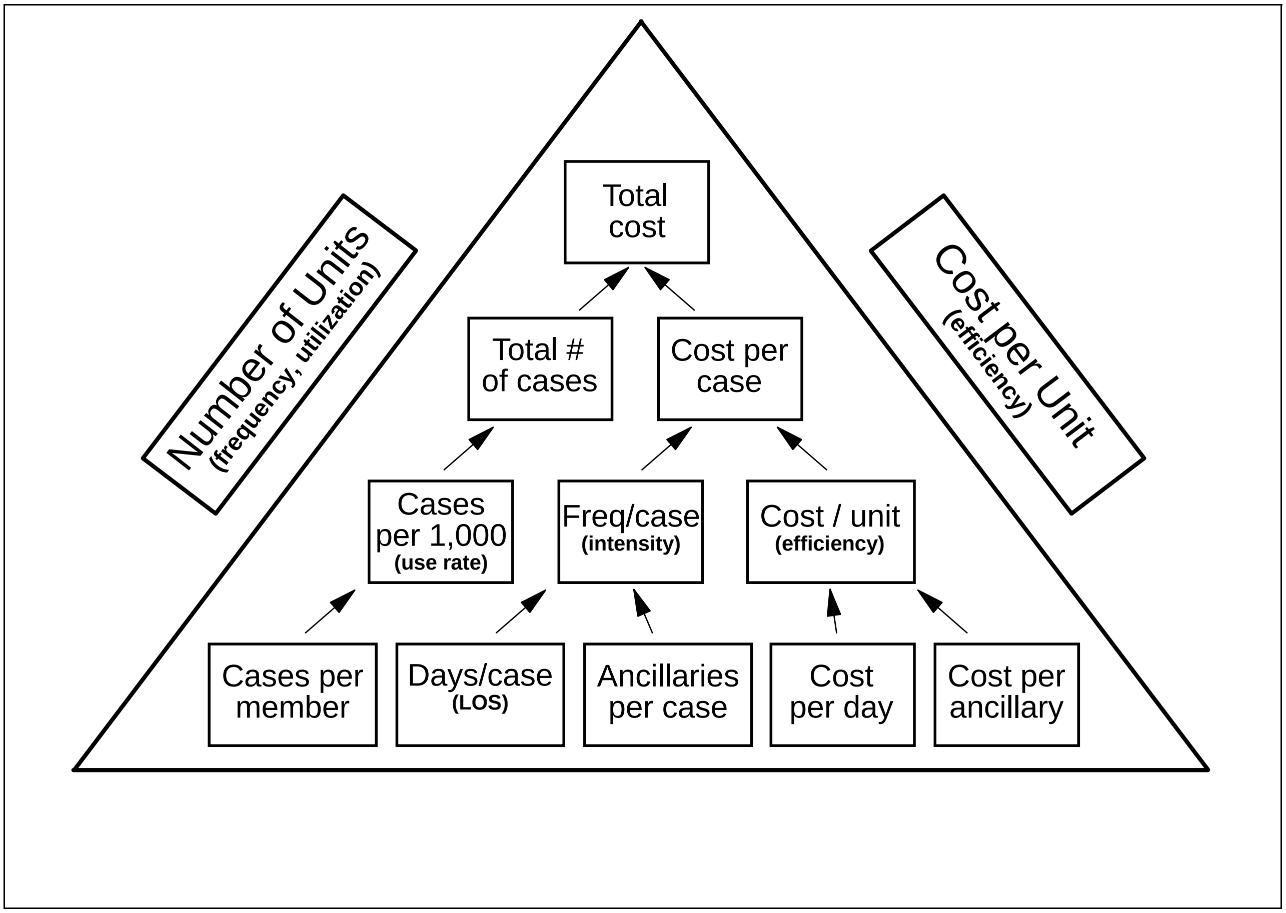
		The Chain of Effect for Quality		
	Waste Analysis Level	**Structural Care System Element**	**Organization/People**	**Activity**
1.	Population Level	Environmental context	Federal and state government; employers and insurers	Health policy and oversight; health finance
2.	Episode Level	Organizational context	Health care delivery organizations	Health system management
		Microsystems	Clinical teams (e.g., physicians, nurses)	Process management
3.	Patient Level	Patient and community	Patients and families	Seeking help and care

From a financial management perspective, the *Chain of Effect for Quality* corresponds, roughly, to a method for building up health care costs as follows (see Exhibit 4):

- Cost per unit (Patient Level): a "unit of care" is any single granular service that a hospital provides to a patient; for example, a single specific lab test (e.g., a CBC, an SMA-6, a c. deficile assay); a single dose of a particular drug, including route of delivery (1 gram of IV Ancef); a single imaging examination (a two-view chest radiograph); an acuity-adjusted minute in a procedure room; an acuity-adjusted hour of nursing services; or a particular disposable product (e.g., an emesis bowl, a meal, an incentive spirometer, the components of an artificial hip implant)

- Number of units per case (unit frequency; Episode Level): the number of "units of care" that are provided to make up a case.
- Number of cases per population (case frequency; Population Level)

Exhibit 4. The cost per unit versus number of units (frequency) triangle for understanding total care delivery costs



Source: Courtesy of Dr. David A. Burton, Intermountain Healthcare.

This method of thinking about the cost of care derives, in large part, from activity-based cost (ABC) accounting systems, which record individual units of care in a "transaction file" as they are provided across traditional cost/revenue silos (i.e., departments) (Emmett & Forget, 2005). ABC systems divide all care into detailed services and then track each service delivered to a patient by recording utilization in a transaction file. Such systems typically organize individual units of care into seven large categories:

1. Professional/room services (e.g., an acuity-adjusted hour of nursing service, a level 4 evaluation by a primary care physician, a 1-hour use of a private room)
2. Pharmacy (e.g., individual medications by amount and route, such as a 1-gram intravenous dose of cephtriaxone)

3. Laboratory tests (e.g., a complete blood count with differential [CBC with diff] or a basic metabolic panel [BMP])
4. Imaging/radiology (e.g., a two-view chest x-ray)
5. Operating and procedure rooms (e.g., acuity-adjusted minutes in an operating room with laminar airflow, a catheterization laboratory, or a labor and delivery suite)
6. Central supply (e.g., physical devices, such as an incentive spirometer or the components of a total hip arthroplasty implant)
7. Other

An ABC system centers around a cost master file (sometimes called a charger master) that contains an entry for every billable service. Ideally, individual unit of care entries within an ABC cost master file provide detailed breakouts of fixed and variable and direct and indirect costs, which are updated on a rotating basis by management engineers, using direct measurement. Some hospitals carefully maintain their cost masters to reflect true unit costs, applying a standard mark-up across all units of care. Others modify individual unit costs without a systematic approach, which can result in major cost disparities within their cost master (e.g., the $900 toilet seat), even though total costs superficially appear to be accurate. A typical inpatient cost master file might contain more than 20,000 unit of care entries.

The Patient Level roughly corresponds to the ABC systems used in some health care delivery organizations, in both inpatient (e.g., Intermountain Healthcare) and outpatient (e.g., the Marshfield Clinic) care settings. Fee-for-service payment schemes usually function at the Patient Level, identifying and paying for individual units of care on a cost-plus basis.

The Microsystem or Episode Level bundles together the individual units of care associated with a clinic visit or a hospitalization. In those circumstances where a particular type of episode uses a consistent set of units of care, the bundled services may themselves, as a group, be treated as a unit. For example, the Diagnosis-Related Group (DRG) Prospective Payment System identifies 477 patient treatment categories, then bundles payment for all underlying unit services into a single transaction. Similarly, per diem payment systems bundle all services contained within a hospital day. Within the Chain of Effect for Quality, the Episode Level also corresponds to care delivery process management, the major focus of clinical QI (note: we discussed labeling this the Process Level, but because process management theory applies at the other two levels as well, we decided that it might be confusing).

The Population Level extends care delivery episodes across the continuum of a patient’s life, addressing longitudinal disease entities from their prevention to their detection, treatment, and eventual conclusion. It corresponds to total lifetime costs for a particular disease or across a particular patient’s life. Most capitation payment systems function at the Population Level, at least to the limits of a single contracting cycle (e.g., an insurance company may renegotiate insurance premiums and care delivery payment contracts annually, but in most circumstances patients can continue their coverage over time, from year to year, even if they develop significant chronic diseases).

To identify and capture specific aspects of costs that could be reduced/eliminated at the Patient Level, several tool sets are now being embraced by the health care system and were integrally involved in our work. Most notable among these are

- application of Lean Thinking and Toyota Production System (TPS), and
- Six Sigma (Pande et al., 2000; see also http://www.isixsigma.com).

Overall, we found Six Sigma and Lean to be complementary approaches. Six Sigma, as applied at PHS, looks at the entire process, focusing on all delays. The speed of the process is controlled by (1) the way the work is organized, (2) the efficiency of individuals in implementing their role, and (3) defects that require extra processing (rework). Factor 1 is process centered, whereas Factor 2 is staff person centered. PHS Six Sigma targets Factor 1, whereas Lean targets Factors 2 and 3. Obviously, there is overlap between the two methods.

For our purposes, we relied heavily on TPS, which offers a problem-solving approach for process improvement and operational excellence. Growing interest in TPS and lean production thinking in health care, coupled with the relevance of its systematic and granular focus on waste/inefficiency, led us to explore this approach within our study.

We next introduce key concepts that depict how financial reimbursement influences our ability to capture waste/inefficiency in health care (see Section 2.5). In Section 3, we conclude our report with specific depictions of our examination of quality waste and inefficiency in health care.

2.5 Financial Reimbursement Influences on Capturing Waste/ Inefficiency

In examining the U.S. health care system, we classified expenditures as waste if they demonstrably consumed health care resources, without producing a health benefit or contributing value to health care operations, at the Population Level. This viewpoint highlights two forms of suboptimization. Many factors that represent waste at the population level represent business profit at lower levels in the system. In counterpoint, changes that generate cost savings for the system as a whole may financially punish those who must implement the changes that drive the savings.

2.5.1 Increases in Waste that Enhance Health Care Providers' Profits (Unit Costs versus Frequency)

For many disease-treatment entities, the number of units of care necessary to achieve a good result for a patient is not empirically known. Faced with rapidly escalating health care costs, governmental and private payers usually try to control their expenditures by reducing unit costs. Health care providers often respond by relaxing indications criteria and thus increasing the number of units of care used to treat a patient (for example, imaging examinations, clinic visits, or hospitalizations). As a result, even while unit payments drop, total costs (and income for health care providers) rise (Exhibit 4). Providers may also "unbundle" services by breaking a bundled package of services into more granular underlying units of care and then move those units of care outside of the negotiated payments for the bundled service, exposing higher unit prices than were hidden within the negotiated bundled service. Care providers may also unilaterally redefine the content of a bundled service. For example, faced with relative reductions in payment rates within DRG categories for per case (bundled) payment, acute care hospitals now often quickly transfer those patients to long-term care facilities. That has the effect of reducing the acute care hospital's LOS and associated frequency of underlying units of care, so that the hospital has lower costs while receiving the same fixed payment. Meanwhile, the governmental or private insurer is faced with additional payments to a second entity (the long-term care facility), greatly increasing its total payment for the same care episode.

The frequency effect is exacerbated by the introduction of new technology, which introduces completely new units of care for consumption and payment. In addition, even though the unit cost of a particular technology drops over time, as economies of scale and other efficiencies associated with the technology come into play, many care providers may supplement, rather than replace, the old technology with later technologies for a single case. For example, instead of moving directly to a nuclear stress test heart scan, a cardiologist may first order a plain stress test (relatively inexpensive today), followed by an ultrasound stress test (moderately expensive), and finally a nuclear stress test (much more expensive). Again, frequency increases, driving up total costs even though cost per unit drops.

Woolhandler, Campbell, and Himmelstein (2003) compared the administrative costs of health care delivery in the United States and Canada. They concluded that administrative costs in the United States ($1,059 per capita) were much higher than costs in Canada ($307 per capita) and that costs were increasing more rapidly in the United States than in Canada. They also showed that administrative costs were not evenly distributed among the various elements of the care delivery system. In particular, administrative personnel and costs for health care providers, as opposed to insurers, were much higher in the United States than in Canada.

Arguably, much of the higher administrative costs in the United States arose directly from mechanisms implemented to prevent increases in unit frequency by care providers, such as preauthorization systems. Related administrative mechanisms focused on fraud and abuse—another name for particularly egregious cases of frequency increases. Canada's national health care system achieves the same end more efficiently. Canada limits hospital beds and specialty physician practices through national health policy. Canada also uses provincial budgets to match primary care resource consumption to available resources, by automatically changing unit payments. Both of these mechanisms provide strong disincentives against case frequency. Many economists argue that administrative expenses undertaken to prevent frequency overuse still represent a net gain for the U.S. system. They also note that the Woolhandler et al. analysis categorized for-profit insurance companies' return on investment profit margins as administrative expense. As with inspection costs, this once again illustrates how systems designed to control costs or quality can themselves introduce inefficiency waste compared with more efficient alternatives.

2.5.2 Reductions in Waste that Damage Health Care Providers' Bottom-Line Financial Performance

A health care provider's long-term financial viability rests on net operating income (NOI, or margin), calculated by subtracting total operating expenses (cost of operations) from total revenues received. Most care providers explicitly track NOI by individual types of service (bundled episodes). If sustained NOI margins fall below about 2 to 3 percent of total operating costs over time, then the health care provider will fail financially. A minimum level of retained earnings is essential to replace aging buildings and equipment and for growth into new areas of care delivery as the science and technology of medicine advances over time. For-profit health care providers, including private practice physicians, must also build a profit margin (return on investment) and tax payments into their NOI margins.

Health care providers divide their costs of operations into two broad categories: fixed costs and variable costs. Fixed costs are expenses that a physician, clinic, hospital, or delivery system must pay regardless of the number of patients they treat. Fixed costs include such elements as payments for buildings, equipment, licensing and regulatory fees, malpractice insurance, and minimum levels of staffing required by regulation. Variable costs are those expenses that fluctuate directly with patient volumes, such as medications, disposable equipment, other supplies, and short-term staffing levels. The mix of fixed versus variable costs varies with the type of care being given; however, across most care delivery settings, 60 to 75 percent of all expenses fall in the fixed cost category (Roberts et al., 1999). Thus, only about 25 to 40 percent of the savings generated by quality-based waste reduction—representing the variable cost proportion—immediately appears on a health care deliverer's financial balance sheet as NOI margin. Sixty to 75 percent of the potential savings, representing the fixed cost proportion, appears as unused ("excess") capacity.

If a care provider can recruit additional, clinically appropriate patients to use the newly freed capacity, then fixed cost savings arising from waste reduction efforts will quickly drop to the care provider's bottom line, especially if the service episodes represented by the new patients have larger NOI margins than the episodes that were eliminated by waste reduction (Maureen Bisognano at IHI calls this "converting light green dollars into dark green dollars"). With higher patient volumes, the care provider's fixed costs will spread across a larger patient population (all of the former patients, plus the additional new ones) so that the effective fixed cost per patient falls, producing a larger NOI margin for each patient treated. If a care provider cannot increase patient volumes, then it must "manage out" the excess fixed capacity to recover the associated costs—an activity that can easily take several years; involve significant transition costs; and involve wrenching human decisions, such as eliminating jobs and releasing long-term employees. These management costs usually make it impossible to recover the entire excess capacity and realize related potential fixed-cost savings.

Different care delivery episode types have different levels of NOI margins. In particular, in the current U.S. health care system, some episode types have negative margins—providing a needed service means that the care provider will loss money, on average, for each patient treated. To survive financially, care providers who provide such services must counterbalance negative margin services with positive margin services. "Contribution to margin" (or "contribution") combines the concept of episode-level NOI margin with fixed versus variable cost accounting. A health care provider will insist that an episode type generate at least enough revenue to cover its associated variable costs. Any revenues in excess of variable costs then "contribute" to paying the care provider's fixed costs. The task of administrative financial management then becomes finding enough "contribution" to cover all of a provider's fixed costs, plus some level of retained earnings for capital replacement, growth, and return on investment (for for-profit providers).

"Contribution" also explains a set of business strategies that some health care providers bring to the health marketplace. "Cherry picking" describes a strategy of selectively providing only services with a high NOI margin. When unit costs are bundled to a case level (i.e., the DRG case-level payment system), "skimming" refers to the practice of selecting individual cases that have a high NOI margin, while refusing negative margin cases of the same episode type. The most common form of skimming involves physicians with practice privileges at two competing organizations, who have a direct or indirect financial return at one of the organizations. In such a circumstance, a physician will selectively route positive margin cases to the organization that generates higher personal income, while routing negative margin cases to the other organization.

Exhibit 5 diagrams the interaction between waste recovery levels and payment mechanisms currently used in the United States, from the NOI margin perspective of a health care provider (the level where waste recovery efforts necessarily reside). Only waste recovery at the Patient Level uniformly results in financial benefit under current payment mechanisms. As a result, in the past, almost all administrative efforts for cost control have focused at the Patient Level, where all successful activities provide financial benefit to the administrative team that initiates action to save costs. Given their long history and a high degree of understanding of these mechanisms within health care delivery, within this project we chose to ignore many traditional cost reduction strategies, such as negotiating better prices for supplies, replacing amortized equipment with more efficient models, or shifting staff mix to reduce seniority levels (more senior staff means higher pay for the same position) or staffing mix. We instead focused our Patient-Level efforts on TPS tools, an area largely unexplored in current health system management.

Exhibit 5. Effect of cost reduction strategies on a health care delivery organization's net operating income (NOI), based on common payment mechanisms

	Payment Mechanism			
Cost Reduction Strategy	**Discounted Fee For Service**	**Per Case**	**Per Diem**	**Shared Risk**
1. Decrease the cost of a unit of care (Patient Level)	⇧	⇧	⇧	⇧
2. Decrease the number of units of (Episode Level) care per case:				
a. decrease the number of nursing hours per case	⬇	⇧	⬇	⇧
b. decrease the number of any other unit of case per case	⬇	⇧	⇧	⇧
c. avoid complications in ways that decrease units, but reclassify the case	⬇	⬇	⬇	⇧
3. Decrease the number of cases (Population Level)	⬇	⬇	⬇	⇧

Notes:

A "unit of care" is any single diagnostic, treatment, or support activity performed on a patient's behalf, such as any single laboratory test, an imaging examination, a dose of a drug, or an hour of nursing care. For example, if a hospital is paid discounted fee-for-service for a particular case and successfully reduces the number of hours of nursing care services required to treat that case, then the hospital will lose reimbursement for those hours of service (column 1, row 2 above). If the hospital's administration had built a small margin of NOI into each hour of nursing care services, then the hospital will lose that NOI.

Successful waste elimination always reduces costs, but some payment mechanisms may deliver those savings exclusively to a health care payer (e.g., the federal Medicare program, an HMO, or a self-insured employer), leaving the health care delivery group to cover the costs of the waste elimination activity and, at the same time, find other funds to cover the lost NOI.

The fact that waste elimination at the Episode and Population Levels often damages care providers' financial viability, while care providers are the only group that can change care delivery practices to eliminate the waste, is the foundation for the recent Pay for Performance (P4P) movement. P4P aims to redesign health care delivery payment so that care providers share in the savings generated by waste reduction, both as a financial incentive to eliminate waste and to provide the financial resources necessary to undertake waste reduction efforts. In particular, under current payment mechanisms and given health care's high proportion of fixed expenses, successful waste reduction efforts can greatly increase care providers' incentives to increase their "unit of care" frequency

As item 2(c) in Exhibit 5 notes, successful waste reduction efforts at the Episode Level can also damage care providers' NOI margin by changing the episode type. To illustrate, in 1995, Dr. Kim Bateman, a physician medical director managing nine rural facilities within Intermountain Healthcare, successfully introduced an evidence-based best practice guideline for community-acquired pneumonia (CAP). Intermountain tracked the impact of the guideline by comparing its effect in the 9 rural facilities with CAP results in 12 other adult hospitals within the Intermountain Healthcare system where the practice guideline was not introduced (a prospective non-randomized controlled trial, or quasi-experiment). There were 1,179 CAP cases treated from 1994 through 1996 in the 9 rural hospitals using the new CAP protocol, compared with 3,455 CAP cases treated without the protocol in those same 9 hospitals (pre-protocol period) plus the 12 Intermountain control hospitals (both pre- and post-protocol periods, to establish secular trend). All cases were fully risk-adjusted based on 3M APR-DRG severity of illness (a commercial risk adjustment system that predicts cost based on patient presentation), patient age, gender, location (urban versus rural), specific hospital, and calendar month of treatment (to pick up medical inflation over time, as well as general changes in pneumonia care that affected the entire community).

One major effect of the Care Process Model (CPM) was to change physicians' initial choice of antibiotics. Use of recommended "ideal" antibiotics increased from 22 percent to 40 percent in test hospitals following introduction of the practice guideline. As appropriate choice of ideal antibiotics increased, complication rates decreased (from 15.3 percent to 11.6 percent of patients suffering a major complication while hospitalized) and mortality rates decreased (from 7.2 percent to 5.3 percent, representing about 70 lives per year). With fewer complications to treat, costs under the CPM fell by an average of $572 per case (from a baseline average of $4,851 per case), an 11.9 percent drop in cost per case. Across the 1,179 patients in the test group, costs fell by a total of $674,329.

At the same time, payments dropped by $894 (16.9%) per case against straight-line projections of expected revenues (initial average across all payers: $5,306). The total loss in expected payments totaled $948,317. Intermountain suffered a net loss of $273,988, or about 5 percent of the total cost of care (Exhibit 6). In other words, all of the savings flowed back to payers and pulled additional NOI operating margin as well. The reason for the payment reduction was changes in DRG categories that resulted from fewer complications. For example, pneumonia-associated complications often result in a patient requiring support from a mechanical ventilator. Such ventilator support shifts the patient's DRG assignment from DRG 89—CAP to DRG 475—Long-Term Ventilator Support. At the time of this study, DRG 475 paid about $16,400 and provided a positive NOI margin of about $800. DRG 89, on the other hand, had a negative NOI margin of about $400 (Intermountain received about $400 less per case than the true costs of operations).

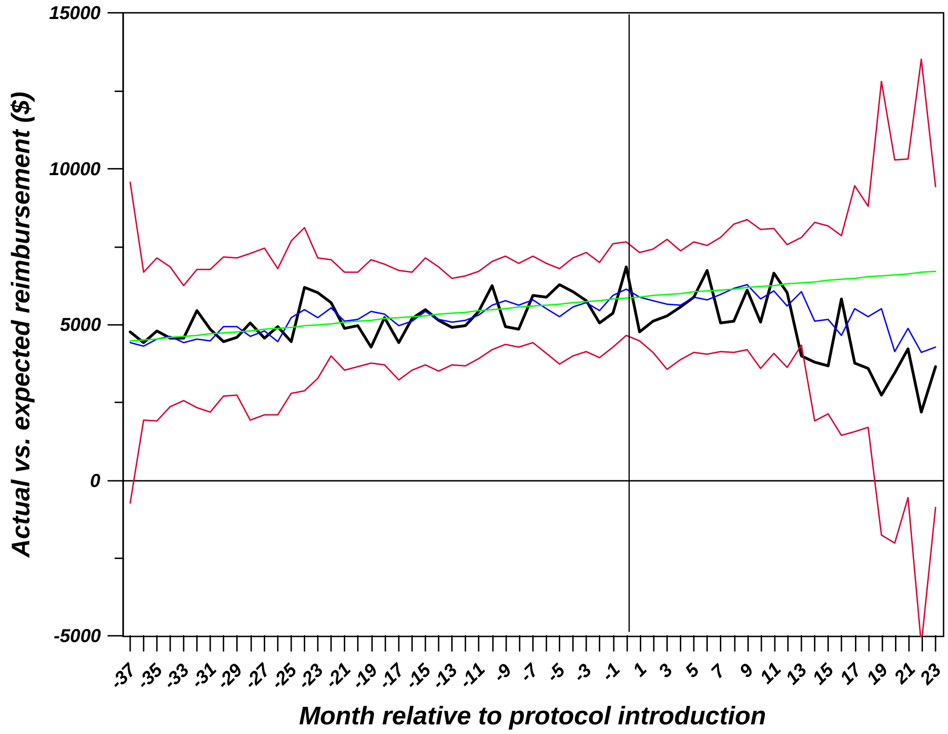
2.5.3 Intermediate Financial Conclusions that Affect Waste Estimation and Reduction

One man's waste is another man's profit. Whether an expenditure appears to be waste or profit depends on one's level in the C*hain of Effect for Quality*, as reflected through the four listed payment mechanisms. For example, when confronted with cost controls that reduce the amount a physician receives per patient visit, or that a hospital receives per case, physicians and hospitals routinely respond by increasing the number of visits or the number of hospitalizations.

Paid for waste. Another anomaly of current payment policies is that health care providers are paid for quality waste. Dr. R. Burney (2004) observed that the health care system tolerates poor quality and pays the same for poor and high quality care." Current reimbursement policies actually provide financial incentives for poor quality care. Examples include payment for treatments for complications due to adverse events, which are technically defects of the system. The industry has clearly recognized this problem.

Margins matter most. NOI margins, not total cost or savings, are the key measure for return on waste reduction investments at the care provider level.

Exhibit 6. Financial results of quality waste reduction in CAP



Notes:

- Actual costs (blue dashed line) versus expected costs (green line) for the cases managed under the guideline. The guideline was introduced at time point 0 on the x-axis (at the vertical line). Note that average actual costs tracked very closely to expected costs in the "before" period but that there is a net accumulation of lower costs after the intervention.
- The upper and lower dotted red lines are statistical process control limits—a method of showing statistical significance (p = 0.001) graphically, for single points.
- The black line is reimbursement, which fell further than costs.
- All of the data are fully risk-adjusted.
- Further to the right in the graph, case numbers decline, as reflected in the widening control limits (the red lines). That is because hospitals joined the study one at a time, usually one per month ("staggered implementation," which strengthens the statistical validity of the study design).
- The green line (expected costs) rises over time, reflecting actual medical inflation over the life of the study.

Throughput. CFOs are interested in throughput because of inefficient use of physical and human capital. In one sense, throughput rests on the idea of continuum of care; by breaking up the continuum of care, health care providers can increase the number of episodes while reducing their internal cost per episode. Alternatively, throughput is the key to more efficient use of facilities and labor. Throughput, or its opposite (delay), has immediate and second-order impacts. The primary impact is on the inefficient use of capital—human and material. Each additional day in the hospital requires additional nursing hours, blood draws, meals, medical consults, and so on. Typically, these costs are in proportion to the additional time spent. Second-order impact is that each additional day involves new staff who must be oriented to the patient, with attendant hand-off problems and costs. Also, more days means additional chances for infections or other adverse events. Third-order delay is administrative (e.g., more complex staffing and scheduling plans, added facility space for holding areas), including the need to house patients sometimes in inappropriate beds (e.g., use of an ICU bed versus a telemetry bed, a psych bed, or an ED holding area). Complex staffing and scheduling can also increase patient transport and reconciliation costs. Managing throughput is a more efficient way of continuously managing fixed cost inputs, by spreading them over larger numbers of cases, rather than conducting a waste reduction project, creating excess capacity, then reacting to “manage out” the excess capacity.

Section 3. Examining Waste/Poor Quality

Our examination of waste/poor quality in health care is guided by the *Chain of Effect for Quality* as described in Section 2.4 and depicted in Exhibit 3. Specifically, we focus on three distinct levels to exemplify approaches for culling out waste/poor quality in health care: the Population Level, the Microsystem/Episode Level, and the Patient (care delivery) Level (Exhibit 7). These approaches for examining waste are linked to our analytic approach in Exhibit 8. For these three areas, we provide a more detailed description of the approach together with specific examples of how these approaches can be applied (and estimates when appropriate).

Exhibit 7. Identifying waste by levels

Approach	Level to Address Waste
National rates of potential overuse and underuse	Population Level
Analysis of waste represented by overuse, as reflected in regional variability	Population Level
Analysis of the cost of errors and adverse events	Microsystem/Episode Level (health delivery organizations)
Analysis of ATP, Six Sigma target areas	Microsystem/Episode Level (health care delivery organizations, microsystems)
Lean™ Observations	Patient Level (microsystems, individuals)

Exhibit 8. Efficiency/waste metric and analytic approach

	Analytical Approach			
Inefficiency/Waste Metric	**Dartmouth Atlas**	**Six Sigma, ATP**	**TPS**	**Cost of Unusual Occurrences**
Cost per unit	No	Yes	Yes	No
Units per case	No	Yes	Yes	Yes
Number of cases	Yes	No	No	No

3.1 Estimating Waste at the Population Level—the Dartmouth Atlas

In 1973, Wennberg and Gittelsohn published a seminal paper documenting massive geographic variation in the rates at which Americans are hospitalized. He later organized the Center for the Evaluative Clinical Sciences (CECS), based at Dartmouth University in Hanover, New Hampshire. In 1999, CECS first published the *Dartmouth Atlas*, which documents ongoing, massive variation in care delivery across the United States, as reflected in hospital admission rates. The CECS group has updated the *Dartmouth Atlas* on a 2- to 3-year schedule ever since.

Several years ago, Wennberg and the CECS group shifted the focus of their variation research to Medicare patients at the end of life (Wennberg et al., 2002). They have shown that (1) Medicare patients exhibit a very high degree of loyalty to a particular hospital and the physicians associated with that hospital, with about 90 percent of all services to a particular patient, on average, delivered through a single facility; and (2) care within a particular facility is consistent over time, despite major geographic variation among facilities. For example, health resource consumption in the last 2 months before death, which accounts for more than 20 percent of all Medicare expenditures, accurately predicts care resource consumption during the last 6 months of life, and accurately predicts health resource consumption during the last 2 years of life, well beyond the period associated with a final terminal illness. The CECS approach thus provides a unique method to account for and remove patient factors when measuring differences in clinical or cost outcomes. It directly adjusts for age, gender, ethnicity, and chronic disease burden, but then centers on patients who all are at an equivalent health outcome—all patients in this class have died. It then demonstrates that resource consumption at a particular hospital for this class of patients accurately predicts resource consumption at the same facility in other time periods before terminal illness (Wennberg, 2005; Wennberg et al., 2002).

The CECS analysis identified three classes of care: effective care, supply-sensitive care, and preferences-sensitive care. “Effective care” refers to disease entities with good evidence for effective treatment, such as total hip arthoplasty following hip fracture. Effective care tends to be generally underutilized, but shows very little geographic variation. “Supply-sensitive care” centers on 13 chronic conditions, accounting for more than 50 percent of all Medicare expenditures (Exhibit 9). “Preference-sensitive care” centers on an additional 10 elective surgical procedures (Exhibit 10), where patients have legitimate choices among surgical, medical, or “watchful waiting” options. Together, supply-sensitive and preference-sensitive care account for almost 80 percent of all hospital-associated Medicare expenditures and explain the high rates of cost variation that the CECS group has documented. High resource utilization directly and significantly correlates with high rates of patient visits to specialists, with higher testing rates, higher hospital use rates, and more days spent in intensive care units. In turn, utilization of each of those resources was very strongly correlated with their availability in the geographic community. Fisher et al. (2003) demonstrated that high utilization for supply-sensitive conditions is associated with worse medical outcomes (mortality rates about 2 percent higher than expected).

Exhibit 9. Supply-sensitive chronic conditions (as identified by the Dartmouth CECS group)

Supply Sensitive Chronic Conditions	Percentage of Medicare Patients Exhibiting Each Condition at the End of Life
Congestive heart failure	32.7%
Cancer: solid tumors	27.6%
Chronic pulmonary disease	22.5%
Dementia	14.8%
Nutritional deficiencies	10.5%
Coronary artery disease	8.6%
Chronic renal failure	5.9%
Cancer: lymphomas and leukemias	5.5%
Peripheral vascular disease	5.2%
Functional impairment	2.6%
Diabetes with end organ damage	2.5%
Severe chronic liver disease	2.0%
AIDS	0.1%

Exhibit 10. Preference-sensitive conditions associated with elective surgical procedures (as identified by the Dartmouth CECS group)

1. Benign prostatic hypertrophy
2. Abnormal uterine bleeding/uterine fibroids (hysterectomy)
3. Breast cancer
   – early breast cancer: chemotherapy and hormone therapy
   – early breast cancer: breast-sparing surgery
   – breast cancer: breast reconstruction
   – breast cancer: DCIS
   – breast cancer: metastatic phase
4. Coronary artery disease
   – treatment choices
   – chronic care
5. Colorectal cancer screening
6. Low back pain
   – acute management
   – chronic low back pain: treatment choices
   – herniated disc
   – spinal stenosis
7. Hip osteoarthritis
8. Knee osteoarthritis
9. Prostate cancer/PSA testing
10. Bariatric weight-loss surgery

In the latest release of the *Dartmouth Atlas* (Wennberg et al., 2006), the CECS group identified two integrated delivery systems—the Mayo Clinic hospitals and Intermountain Healthcare—as having the most efficient care delivery in the nation and excellent associated clinical outcomes. While their analysis focused exclusively on supply-sensitive conditions, they estimated that total Medicare costs to the nation (Part A and Part B) would fall by 32 percent if all other hospitals were to adopt similar care patterns. Preference-sensitive conditions offer even more savings. Internal CECS data suggest that, when patients are offered complete, fair, and unbiased choices around preference-sensitive conditions, procedure utilization rates fall by 20 percent to 60 percent.

We classified *Dartmouth Atlas* estimates of supply-induced demand as Population Level waste: health services that consumed resources but did not improve patients' clinical outcomes. To the extent that care practices for Medicare patients represent general patterns of care delivery and resource consumption, as the CECS analysis suggests, Medicare-associated waste levels would apply to total health care costs for the country. Supply-induced demand represents Chassin's "overuse" category. In Deming's scheme, it is inefficiency waste. It results from increased frequency of unit and bundled services, as described above.

The same *Dartmouth Atlas* report extended the CECS supply-sensitive variation measurement methodology to the level of individual hospitals (Wennberg et al., 2002). The Dartmouth Atlas Web site (http://www.dartmouthatlas.org) allows hospitals to estimate their rates of supply-induced overuse waste. The focus of our report is hospital care alone, so we excluded potential waste in Medicare Part B physician visits. On the basis of hospital costs alone, if the entire Medicare program achieved the blended Mayo Clinic/Intermountain Healthcare utilization rates, then Medicare Part A costs would fall by 14 percent.

Exhibit 11 presents the CECS methodology and provides blended base utilization rates for the combined Mayo Foundation and Intermountain Healthcare systems, compared with national averages. Exhibit 12 applies the Mayo-Intermountain baseline to the Medicare total hospital reimbursements for Providence Health System facilities to demonstrate how the method could be

Exhibit 11. Medicare hospital reimbursements at Mayo Foundation and Intermountain Healthcare Hospitals (1999–2003 data)

				Per Decedent			Ratio to U.S. Average				
Hospital/System	**Location**	**Loyalty**	**Deaths**	**Total Reimbursement**	**Hospital Days**	**Reimbursement Per Hospital Day**	**$**		**Days**		**$/Day**
Rochester Methodist Hospital	Rochester, MN	79.4	889	37,233	27.0	1,377	1.52	=	1.13	x	1.35
St. Luke's Hospital	Jacksonville, FL	88.0	2204	24,906	20.9	1,193	1.02	=	0.87	x	1.17
St. Mary's Hospital-Rochester	Rochester, MN	86.7	4314	29,733	22.9	1,299	1.21	=	0.96	x	1.27
Mayo Clinic Hospital	Phoenix, AZ	84.6	1484	24,240	18.6	1,304	0.99	=	0.78	x	1.27
Austin Medical Center	Austin, MN	89.6	953	21,845	19.9	1,097	0.89	=	0.83	x	1.07
Luther Hospital	Eau Claire, WI	93.1	1690	19,001	17.2	1,106	0.78	=	0.72	x	1.08
Franciscan Skemp-La Crosse	La Crosse, WI	95.1	1326	19,345	17.6	1,098	0.79	=	0.74	x	1.07
Fairmont Community Hospital	Fairmont, MN	91.7	584	18,249	17.8	1,027	0.75	=	0.74	x	1.00
Immanuel-St. Joseph's	Mankato, MN	92.8	1485	18,408	20.1	917	0.75	=	0.84	x	0.90
Naeve Hospital	Albert Lea, MN	92.5	920	18,129	16.3	1,110	0.74	=	0.68	x	1.09
Myrtle Werth Hospital	Menomonie, WI	91.3	510	17,429	15.4	1,133	0.71	=	0.64	x	1.11
Lake City Medical Center	Lake City, MN	89.8	161	20,383	17.0	1,198	0.83	=	0.71	x	1.17
Waseca Medical Center	Waseca, MN	82.1	207	18,733	14.0	1,342	0.76	=	0.59	x	1.31
Bloomer Medical Center	Bloomer, WI	85.3	172	18,218	16.4	1,113	0.74	=	0.69	x	1.09
Floyd County Memorial Hospital	Charles City, IA	87.9	337	17,633	16.5	1,068	0.72	=	0.69	x	1.04
Barron Memorial Medical Center	Barron, WI	88.3	315	16,456	14.6	1,127	0.67	=	0.61	x	1.10
Springfield Medical Center	Springfield, MN	92.7	234	16,344	14.5	1,126	0.67	=	0.61	x	1.10
St. James Health Services	St. James, MN	90.9	140	15,961	15.9	1,006	0.65	=	0.67	x	0.98
Franciscan Skemp-Sparta	Sparta, WI	84.2	192	13,721	12.4	1,107	0.56	=	0.52	x	1.08
Mayo Foundation Totals		**88.9**	**18117**	**23,430**	**19.7**	**1,188**	**0.96**	**=**	**0.82**	**x**	**1.16**
LDS Hospital	Salt Lake City, UT	90.1	1863	22,326	18.0	1,238	0.91	=	0.75	x	1.21
Dixie Regional Medical Center	St. George, UT	94.0	1665	20,135	17.2	1,173	0.82	=	0.72	x	1.15
Utah Valley Regional Med Center	Provo, UT	93.4	1647	20,392	19.2	1,062	0.83	=	0.80	x	1.04
Alta View Hospital	Sandy, UT	86.9	734	18,642	15.8	1,183	0.76	=	0.66	x	1.16
McKay-Dee Hospital Center	Ogden, UT	94.8	1726	18,796	15.5	1,214	0.77	=	0.65	x	1.19
Cottonwood Hospital	Murray, UT	90.2	1263	18,037	16.8	1,074	0.74	=	0.70	x	1.05
Logan Regional Hospital	Logan, UT	93.1	741	18,008	15.5	1,164	0.74	=	0.65	x	1.14
American Fork Hospital	American Fork, UT	91.4	547	16,429	12.0	1,365	0.67	=	0.50	x	1.33
Cassia Regional Medical Center	Burley, ID	92.7	482	17,301	19.4	893	0.71	=	0.81	x	0.87
Valley View Medical Center	Cedar City, UT	91.8	287	17,483	11.9	1,475	0.71	=	0.50	x	1.44
Garfield Memorial Hospital	Panguitch, UT	92.0	103	17,207	13.2	1,308	0.70	=	0.55	x	1.28

Exhibit 11. Medicare hospital reimbursements at Mayo Foundation and Intermountain Healthcare Hospitals (1999–2003 data) (continued)

				Per Decedent			Ratio to U.S. Average				
Hospital/System	**Location**	**Loyalty**	**Deaths**	**Total Reimbursement**	**Hospital Days**	**Reimbursement Per Hospital Day**	**$**		**Days**		**$/Day**
Heber Valley Medical Center	Heber City, UT	88.2	88	16,974	11.9	1,424	0.69	=	0.50	x	1.39
Delta Community Medical Center	Delta, UT	89.1	95	16,910	13.6	1,246	0.69	=	0.57	x	1.22
Sanpete Valley Hospital	Mt Pleasant, UT	89.3	117	15,685	12.5	1,255	0.64	=	0.52	x	1.23
Sevier Valley Hospital	Richfield, UT	90.6	263	14,255	12.2	1,166	0.58	=	0.51	x	1.14
Intermountain Healthcare Totals		**92.0**	**11621**	**19,254**	**16.6**	**1,163**	**0.79**	**=**	**0.69**	**x**	**1.14**
Combined Mayo/Intermountain		**90.1**	**29738**	**21,798**	**18.5**	**1,178**	**0.89**	**=**	**0.77**	**x**	**1.15**
U.S. Average				**24,491**	**23.9**	**1,023**	**1.00**	**=**	**1.00**	**x**	**1.00**

Exhibit 12. Medicare total hospital reimbursements for Providence Health System facilities, using the Mayo Clinic/Intermountain merged baseline to estimate potential Population Level waste (1999–2003 data)

				Per Decedent			Ratio to Mayo/Intermountain					
Hospital	**Location**	**Loyalty**	**Deaths**	**Total Reimbursement**	**Hospital Days**	**Reimbursement Per Hospital Day**	**$**		**Days**		**$/Day**	**Proportion waste**
Providence Holy Cross Med Center	Mission Hills, CA	85.9	996	35,180	29.4	1,198	1.61	=	1.59	x	1.02	0.38
Providence St. Joseph Med Center	Burbank, CA	91.6	2587	34,542	28.9	1,196	1.58	=	1.56	x	1.02	0.37
Little Company of Mary Hospital	Torrance, CA	87.3	1770	31,238	25.9	1,204	1.43	=	1.40	x	1.02	0.30
San Pedro Peninsula Hospital	San Pedro, CA	89.9	878	33,472	29.5	1,135	1.54	=	1.60	x	0.96	0.35
Providence Alaska Medical Center	Anchorage, AK	93.1	1229	27,390	23.3	1,177	1.26	=	1.26	x	1.00	0.20
Providence St. Vincent Med Center	Portland, OR	90.9	1645	21,229	17.2	1,235	0.97	=	0.93	x	1.05	-0.03
Providence Everett Medical Center	Everett, WA	92.2	2097	21,615	14.9	1,452	0.99	=	0.81	x	1.23	-0.01
Providence Portland Medical Center	Portland, OR	90.2	1622	20,403	16.1	1,266	0.94	=	0.87	x	1.07	-0.07
Providence St. Peter Hospital	Olympia, WA	92.6	1865	19,225	13.3	1,447	0.88	=	0.72	x	1.23	-0.13
Providence Centralia Hospital	Centralia, WA	93.3	1091	19,080	15.5	1,235	0.88	=	0.84	x	1.05	-0.14
Providence Medford Medical Center	Medford, OR	92.3	1214	17,788	15.0	1,185	0.82	=	0.81	x	1.01	-0.23
Providence Seaside Hospital	Seaside, OR	87.9	262	22,579	16.4	1,378	1.04	=	0.89	x	1.17	0.03
Providence Newberg Hospital	Newberg, OR	90.1	173	19,798	13.8	1,438	0.91	=	0.75	x	1.22	-0.10
Providence Milwaukie Hospital	Milwaukie, OR	85.3	274	18,116	11.9	1,516	0.83	=	0.64	x	1.29	-0.20
Providence Health System		90.8	17703	25,343	20.3	1,247	1.16	=	1.10	x	1.06	0.14

used to estimate Population Level waste for any U.S. hospital. These estimates are conservative, in that they exclude Medicare Part B payments, where the effect is larger; and they do not (yet) include estimates of overuse associated with preference-induced demand.

3.2 Estimating Waste at the Microsystem/Episode Level—Quality Improvement Analysis

The ATP projects represent work by representatives of many U.S. health systems to target areas of waste and poor quality. The ATP projects span a number of years; our analysis used 58 projects for which summary reports were available. Each project was categorized by its major area of focus, based on the project summary report. The Six Sigma projects were conducted over 3 years at Providence Health System. Some projects were selected as "training" projects for the initial Six Sigma roll-out, but there is reason to believe that the projects are representative of the kinds of waste reduction efforts found. Each project was categorized by its major area of focus based on materials presented at hospital briefing sessions attended by the author (BB) and shared with the other authors.

A major goal of the Six Sigma projects has been reduced delays (improved throughput). Throughput is the key to more efficient use of facilities and labor, both high cost factors in health care. Each additional day in the hospital requires additional nursing hours, blood draws, meals, medical consults, and so on. Typically these units per case are in proportion to the additional time spent.

Increased throughput can also be said to lower a facility's cost per unit by spreading fixed cost components (e.g., the cost of new equipment, the cost of hiring and training staff) over a larger volume. The amount of unit cost savings will depend on whether the cost of a lab test or a fully delivered medication is lower when the lab or the nursing floor is running at higher capacity.

Throughput also has second-order effects. Each additional day involves new staff that must be oriented to the patient, with attendant hand-off problems and costs. Several projects targeted redundant information gathering that was the result of delays. Longer stays also mean additional chances for infections or other adverse events.

Third-order effects involve the administrative layers necessary to address the many forms of delay. There are often more complex staffing and scheduling plans, added facility space for holding areas, the need to sometimes house patients in inappropriate floors, and additional patient transport.

Caveat. The method of cost per unit reduction by substituting less expensive resources (e.g., labor) for more expensive ones was not exemplified by either ATP or Six Sigma to any great extent. As previously stated, these projects did not represent a cross-section of all situations because they were selected for training purposes without an underlying framework to guide distribution of what was exemplified.

Quantifying Waste. The ATP and Six Sigma projects suggest huge opportunities for savings, but we cannot be sure of the total available savings via synthetic estimate. These projects are early attempts used for training purposes and only reflect targeted opportunities for investigation that may not be likely to other clinical areas. Nevertheless, they do provide examples that demonstrate how such tools (i.e., Six Sigma) can be used to excavate waste/ inefficiency. Some examples include the following:

- *A nutrition services project to address waste in snacks provided to patients*: At one hospital, 29,700 between-meal snacks are ordered and produced annually for patients. Only 56 percent ever reached patients. Of the nourishments delivered, 70 percent were consumed. Overall, only 39 percent of all nourishments produced were consumed by patients. Annualized cost associated with current waste is $32,000.
- *A project to reduce length of stay (LOS) for hip fracture patients who are discharged to skilled nursing facilities*: This project reduced LOS from 120 hours to 94 hours (21% reduction) by addressing delays in the assignment of an acute care manager and the timely removal of urinary catheters.
- *A project to reduce LOS for stroke patients*: Patients were discharged on average 20 hours sooner if stroke pre-printed orders were used AND an ACM reviewed their chart within 24 hours. The reduction from 78.9 to 58.6 hours constituted a 25 percent decrease in LOS.

Do these LOS reductions represent real cost savings to the hospital? Depending on the payment method, a hospital might see a loss in revenue. However, Providence and others are using a *backfill approach* (Cowan et al., 2006) to estimate the gain in net revenues attributable to a hospital's ability to admit more patients. With this approach, we assume that hospitals/units are admitting to capacity (typically, maximum capacity is an 80 percent to 85 percent census, to allow patient flow through the unit). Savings are then calculated as follows:

> Marginal Cost Savings = backfill profit – loss in net revenues for early discharge (where backfill profit = revenues – variable costs/day)

This further assumes that the earlier days bring in more revenue than later days in a LOS (i.e., not per diem–based reimbursement) and that the freed bed can be readily filled by a new case.

Application of this method is illustrated by Cowan et al. (2006). In their study of staff substitution leading to improved care management, they found a marginal cost savings of $1,591 (average value of backfill profit = $1,707 per case less marginal loss of eliminated additional days of $116). The authors note that Ettner et al. (2006) analyzed the cost offset and net costs savings using the same dataset but a different methodology and found similar results. Thus, the stability of this approach seems reliable.

A second observation on LOS efficiency improvements must be made, however. Shortening LOS can sometimes result in very sick patients being discharged from acute care hospitals to other sites, such as long-term care hospitals. This is important at the Population Level. The care efficiency efforts on the part of acute care hospitals is driving a new level of care for high acuity patients. The question is would the patient have been better off (in terms of quality of life and overall admission time and cost to CMS) if these patients were not discharged so quickly from an acute care facility? Conversely, are these patients better off in these specialized facilities? The key question here is *have we taken a systems perspective to understand unintended consequences of fragmented facility/reimbursement decisions?*

Finally, there is concern that too-short LOS may have an impact on readmission rates. For example, the Leapfrog Group is rating hospitals as to their LOS, taking readmission rates into account.

ATP projects and Six Sigma projects address waste in similar ways. Both have a set of QI principles and tools at their core. Terminology and project structure differ. Six Sigma projects appear to be successful in reducing waste, although the experience of Providence is that many

Six Sigma projects are taking longer than anticipated. Providence and Intermountain Healthcare have both adopted TPS methods as a tool for capturing "low hanging fruit" by involving frontline workers in short-term, Kaizen efforts.

Possible next steps at the Episode Level. While not able to estimate total health care waste at the Episode Level, our final efforts did produce a hypothetical analytic structure for possible use in the future. Several health care delivery systems are beginning to organize their operations around Deming's "key process" concept. Using a Baldrige quality award model, these institutions identify and then prioritize clinical work processes, with an aim to organize a relatively small list of processes (typically, about 10 percent of all clinical work processes in the organization) that produce the vast majority of clinical and financial results (typically, more than 90 percent of all clinical outcomes and costs), as suggested in *Crossing the Quality Chasm* (IOM, 2001). One such effort, which has been under development at Intermountain Healthcare for almost 10 years, has led to a "key process" list (this list is incomplete but illustrates the concept):

1. Patient Safety
    - Adverse drug events (medication selection, preparation, and delivery)
    - Hospital-acquired infections (especially post-operative deep wound infection)
    - Pressure injuries
    - Mechanical device failures
    - Complications of central and peripheral venous lines
    - Venous thromboembolism
    - Patient falls and injuries (strength, agility, and cognition)
    - Blood product transfusions
    - Patient transitions

2. Clinical Programs (condition-related clinical processes)
    - Cardiovascular
        - Ischemic heart disease
            - Chest pain/r/o myocardial infarction
            - Diagnostic and interventional cardiac catheterization
            - CABG surgery
        - Congestive heart failure
            - Medical management of congestive heart failure
            - Valve surgery
            - Heart transplant
        - Rhythm disorders
    - Neuromusculoskeletal
    - Surgical specialties
    - Women and Newborn
    - Intensive (inpatient) medicine
    - Intensive (inpatient) pediatrics
    - Intensive (inpatient) behavioral
    - Oncology
    - Primary care (outpatient clinics)

- Health maintenance and latent risk prevention (preventive medicine)

3. Clinical Support Services
   - Pharmacy
   - Imaging
   - Pathology (lab, microbiology, blood bank, and surgical pathology)
   - Central supply
   - Procedure rooms (anaesthesiology)
   - Intensive care units
   - Nursing units
   - Therapy (e.g., physical, respiratory)
   - Other (e.g., dietary)

4. Other
   - Office of Research
   - etc.

5. Service Quality

6. Administration processes

Such a list anticipates the creation of quality control measurement and management systems for each key process, which would create the ability to directly estimate waste and then manage it out. Essentially, all of the ATP and Six Sigma projects examined can be regarded as falling within this general structure, at either the Episode Level or the Patient Care Level.

Our work to date indicates that such an approach could have very high potential for identifying and managing waste, perhaps on the same order of magnitude as that found by the Dartmouth CECS group at the Population Level.

3.3 Estimating Waste at the Patient Care Level—TPS and Lean Analysis

The Toyota Production System (TPS) offers a problem solving approach for process improvement and operational excellence. Growing interest in TPS and lean production thinking in health care, coupled with the relevance of its direct focus on waste/inefficiency, led us to explore this approach for our study.

Eiji Toyoda and Taiichi Ohno of Toyota Motors developed TPS as part of a lean production approach when Japan faced critical threats to production (Womack et al., 1991). The underlying premise of lean production is to make things flow as close as possible to ideal manufacturing conditions, where there is no waste of any kind. Waste, therefore, is ideally eliminated between machine, equipment, and personnel such that these factors can work together to produce added value. Three key components are as follows:

- a just-in-time system that provides all needed materials (i.e., inventory)
- kanban, a method for process control

- kaizen, or continuous improvement, via trained workers who build quality into the production process to increase the reliability of product

Lean production combines the best features of craft and mass production and has amassed nearly 70 years of trial and error experience across multiple industrial sectors. Researchers have empirically examined the relationship between lean production and performance in the automobile industry, ending the debate over relative value added by lean production and TPS principles where significant process discipline and control have been observed (Oliver et al., 1994, 1996). Although no systematic validation and/or evaluation of lean production and TPS principles have been conducted to date in health care, substantial value added experience is documented for a growing number of health care facilities (Spear, 2004). Most notably, a large-scale effort by the Pittsburgh Regional Health Initiative to implement TPS principles across health care facilities in Southwestern Pennsylvania has been a success (Thompson et al., 2003). AHRQ has recently supported an exploratory demonstration of lean production as part of a larger health care redesign study DenverHealth through the Integrated Delivery System Research Network (Gabow, 2006).

As previously stated, trained workers accountable for continuous QI are a core feature of lean production and TPS principles. The ability to embed problem-solving techniques at the point of care by enabled staff offers high operational utility in health care. For this reason, we embraced this approach to examine waste/inefficiency at the Patient Care Level, with potential extension to the Episode Level, and we developed a set of data collection tools that are based on lean production and TPS concepts (see Appendix D). We note that structured observations incorporate a traditional, operations research, time-motion study approach. Developed tools were used by a trained observer at Intermountain Healthcare, with reliability testing of waste estimates at UNC Health Care. This allowed us to crudely validate the generalizability of waste estimates (a more detailed description of our approach and waste estimates are reported in a manuscript that has been submitted for publication; see Appendix C). Overall, these efforts were shown to produce actionable results that could be used by hospital management within current financial/ operational structures.

We adopted six classification categories from the manufacturing literature: operations, clarifying, defect/error management, processing, motion, and other. Twelve new subcategory clarifications emerged from our data, as well as “interruptions” and “location changes” as new categories to describe workflow fragmentation. Definitions, intended to create mutually exclusive activity categories and explicit measurement rules, are documented in Exhibit 13. Activity categories were reviewed with the observed workers. Three clinicians with research experience reviewed the definitions for language clarity.

Exhibit 13. Activity categories and definitions for TPS observation

Category	Definition/Description/Examples
1. Operations	Bedside caregivers: Caregiver is with the patient or family performing physical, mental, or emotional care. Non-bedside staff: Worker is engaged in operations specific to their job (e.g., phlebotomist drawing blood, scrub tech assisting surgeon).
2. Clarifying	Discussion (direct or by telephone) of day-to-day operations, workload, staffing, work processes. Meetings, report, rounds, teaching, “huddles”, looking through medical records, locating information, paging.
3. Defect/Error	Mistakes or interruptions in work that require a corrective response
Defect	Equipment, computer, or supply-related problem that requires time to correct (e.g., missing supplies)
Error†	Failure of a planned action to be completed as intended (e.g., mislabeled lab specimen). A wrong action is taken or a wrong plan is used to achieve an aim (deviation from policy, procedure, orders, or accepted standards). Medication error: A preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional (prescribing, order communication, product labeling, compounding, dispensing, administration, education, monitoring, and use).
4. Processing	Redundant work or activities that do not fundamentally change service delivery
Documentation	Recording patient care actions or patient information (e.g. test results, vital signs, notes) in the medical record; includes dictating
Paperwork	Recording non-patient care actions, including writing/taking off orders (clerk taking off orders is operations), filling out forms, requisitions, care plans, work lists, registration/billing data entry, copying information to alternate forms, filing/ organizing/printing paperwork.
Prep time	Equipment/room/procedure set-up, running quality control tests, etc.
Stocking	Counting, stocking, organizing inventory
5. Motion	Moving from place to place or waiting
Travel	Walking/moving from place to place (more than 10 steps; see locating)
Locating	Searching for missing items or people-if travel is required, log activity as locating, if searching for information, log as clarifying
Waiting	Idle time created when people, information, materials, or work are not available
6. Other	All other activities not categorized above, (e.g., cleaning the work area, talking to the observer)
7. Interruptions	Social conversation, breaks, personal phone calls, etc. (excluded from waste estimates)
	All unanticipated external (to the worker) requests from people or other external events that take attention away from work, including pages, telephone calls, monitor alarms, etc.
8. Location Changes	Location changes that require movement from one work area to another and more than 10 steps.

Source: *Patient Safety Resources: Definitions, National Patient Safety Foundation*

The TPS-Lean substudy was designed to estimate the cost of waste in a cross-section of acute hospital worker activities and provide a qualitative description of observed problems. The study grew out of ongoing operational TPS activities at Intermountain Healthcare. An observation tool with explicit definitions for categorizing worker activities and rules for estimating the hourly cost of waste was constructed and the reliability was verified. A single observer shadowed 61 health caregivers for 72 hours in tertiary academic and community hospital settings using structured, nonparticipant observation of worker activities across multiple care processes. Data yielded estimates of waste and a qualitative description of problems encountered.

The average cost of waste (i.e., the cost per hour per worker) ranged from USD $7.40 to USD $18.98 across all roles and functions. Overall, workers encountered an average of two problems per hour. Results are provided for specific roles and functions.

Sixty-one workers were observed for 72 hours (36 morning hours and 36 afternoon hours). Professionals included 8 physicians, 26 nurses, and 8 other roles. Of the registered nurses (RNs), 5 were ICU/emergency department staff, 10 were non-ICU medical/surgical staff, 5 were operating room/post-anaesthesia care unit nurses, 2 were house supervisors, 2 were patient care managers, 1 was a labour/delivery nurse, and 1 was an endoscopy lab nurse. The laboratory workers included two phlebotomists, two medical technologists, and two specimen processors; these workers were grouped together with other technical staff (n = 13). In general, the workers were experienced; only 5 (8%) had less than 1 year of experience in their role and 44 (72%) had more than 3 years.

The average, overall cost of waste (i.e., cost per hour per worker) across all staffing groups was USD $7.40 (low), USD $13.20 (medium), and USD $18.98 (high). Interruptions and location changes occurred at an average (standard deviation, range) rate of 8 (11, 0–80) and 13 (11, 0–58) times per hour, respectively (one technical worker assisting with a cardiac catheterization was uninterrupted during a 30-minute observation). Even though our sample size was limited, subgroup analyses of clarification activities suggested differences between roles. A more detailed description of the methods, results, discussion, and conclusions is provided in our manuscript (see Appendix C).

Our study suggests that the cost of waste for frontline health care worker activities is substantial. Given our data, the lowest cost of waste in caregiver activities for a single-day shift on one 46-bed medical unit (staffed with eight RNs, eight patient care technicians, two care managers, one social worker, one physical therapist, one pharmacist, one respiratory therapist, two clerks, and two hospitalists) is USD $2,309 (12 hours x 26 workers x $7.40 per hour); the annual cost for the same unit is USD $843,000 (USD $2,309 x 365). Because of our conservative assumptions, these estimates almost certainly represent an underestimate. During the observations, workers spent less than half of their time engaged in operations. Nonoperational activities were almost evenly split between clarifying (20%), processing (19%), and motion (17%). The subgroup analyses suggested physicians and supervisory RNs spent more time and technicians spent less time than the overall average in clarification activities. Given the nature of their functions, these data are not surprising, and one might argue that time spent by more senior health care workers in clarification activities is important. We note that some of the clarification may be necessary aspects of training given the current methods used in academic teaching hospitals. Outside of training, one could argue that clarification activities indicate a lack of specified processes and a high tolerance for ambiguity, resulting in greater waste of the most experienced workers in our system. It is easy to make the case that redundant documentation or paperwork is an unproductive use of workers' time. Despite the advanced information technology available at Intermountain Healthcare, redundant documentation and paperwork were not infrequent. Other investigators who have included observation methods to evaluate information technology in clinical work reported unanticipated results that would not have been uncovered without qualitative data. It is self-evident that motion (i.e., traveling, locating, and waiting) is wasteful and should be minimized whenever possible.

Increased attention to operational quality in health care is needed and could potentially decrease costs while increasing patient safety. Implications for poor operational quality and recommendations for action are presented in our manuscript, which is under review.

3.4 Conclusions

We have seen that each of our three methods can provide a perspective on the amount of quality waste present in the U.S. health system. The *Dartmouth Atlas* approach is perhaps the most refined at this point and the only approach we feel comfortable using to derive synthetic estimates for the national/policy level. The other methods have important limitations.

The process improvement efforts, for example, often struggle with isolating a process for improvement. Health care is extremely complex, some would say chaotic, and the health care industry simply has not done the work to more clearly define its work in terms of an organizational structure with established processes that are universally consistent across facilities. This is actually a major source of quality waste in that we do not understand our work processes. Theoretically, the steps involved would be:

1. quality control, developing a management system that allows for monitoring, managing, and stabilizing a process;
2. quality improvement (QI); and
3. redesign with innovations.

The health care industry jumped to Step 2 (QI) and never did Step 1 (quality control); most care delivery facilities have never built the measurement and management infrastructure necessary to systematically manage care processes. Thus, QI is disjointed, unfocused, uncoordinated, and much less effective than it could be. Attempts to identify processes for improvement have found processes embedded in complex systems that may resist efforts to change. As quality control-based measurement and management systems advance, our ability to directly measure, then eliminate, waste within health care delivery should increase rapidly. While we were able to find synthetic estimates of health care only at the Population Level, those alone were massive, representing 32 percent of total health care expenditures. Our work suggests, but does not demonstrate, that waste at the Episode and Patient Care Levels is of similar scale. If so, the total amount of waste within the health care delivery system will total well over 50 percent of all health care expenditures.

As important, our approach supplies the tools not just to identify waste but to eliminate waste through process management. As integrated delivery systems with real health care operations challenges, both Intermountain Healthcare and Providence Health System plan to vigorously continue this line of investigation. In particular, we hope to strengthen waste estimates at the Patient Care Level by more broadly applying our TPS observation tools, and we plan to create additional savings estimates from successful projects in clinical management.

Section 4. Recommendations for Next Steps

Our three-level model offers a strong framework to estimate total waste within health care delivery. It also helps identify several significant gaps, and thus suggests "next steps" in pursuing this useful topic. Specifically, we describe opportunities for furthering our work at each of the three levels in the overarching framework—population level, episode level, and patient level.

4.1 Population Level

At the **Population Level (Level 1)**, we relied on the Dartmouth Atlas's recent calculations of unnecessary specialty visits, testing, hospitalization, and ICU admits, to estimate overuse. The Dartmouth Atlas tools provide hospital-level estimates of clinical waste associated with unnecessary hospitalization. Wennberg and colleagues make compelling arguments that the patterns of overuse they identified within the Medicare program reflect general patterns of overuse in care delivery that extend to commercial insurance as well. However, that extension has not been empirically tested. In addition, the current Dartmouth Atlas analysis does not directly assess overuse associated with preference-induced demand. Preliminary, unpublished studies suggest that utilization for some preference-associated treatments may fall by as much as 50 percent when patients are given full information about their choices. However, the impact of better patient decision support on the total costs of care delivery has not been rigorously assessed. We note that Wennberg and colleagues at the Center for Evaluative Clinical Sciences (or CECS Group) are currently pursuing these analyses, which may be an opportunity to collaborate.

4.2 Episode Level

At the **Episode Level** ("number of units per case" – Level 2), we catalogued a large number of improvement projects that appeared to significantly reduce health care costs. Categorizing and generalizing this class of projects, to generate a broad framework that would lead to general estimates of this class of waste, remains the most challenging part of the project. It also presents a very promising avenue for future work.

For example, it may be possible to further classify Level 2 into quality waste (process failures, or defects) versus inefficiency waste, and processes that are inherently clinical versus those that supply subcomponents to clinical care. Care-associated clinical defects link this work to our parallel AHRQ Targeted Injury Detection System (TIDS) project. It appears that our TIDS work will provide a reliable lower bound estimate of broadly-defined injury rates in inpatient settings. Additional research to estimate the marginal costs associated with different levels and types of injury could lead to reliable estimates of care-associated waste for this entire subcategory. Such estimates could form a critical piece of the business case for patient safety, and a major subcomponent of developing pay-for-performance efforts. Similar generalizations around inefficiency waste and quality waste in non-clinical hospital operations may also lead to detection and management tools.

4.3 Patient Level

Application of Toyota Production System (TPS) observation approach at the Patient Level (Level 3) is perhaps the most useful part of the current work. We developed a set of structured observation tools that were used to demonstrate that inefficiencies at the point of care are very common, offering large opportunities to streamline care processes. When a care delivery group uses our toolset to detect such waste, they can produce not just estimates of the size of competing opportunities for improvement, but also generate detailed knowledge about the nature of the failures that produce the waste, leading to testable changes that result in savings when addressed. Such savings represent not just financial resources but also staff resources. For example, reducing wasted time and effort on a nursing unit effectively expands the capacity of that unit. In the face of severe nursing shortages, waste elimination at this level has the same impact on patient care as increasing the number of nurses, but without additional costs. While we tested our TPS observation tools on a reasonable number of work processes within Intermountain Healthcare and validated their use on a small scale at the University of North Carolina Hospital, a definitive analysis will require a broader scope replicated at several institutions.

4.4 Moving Towards an Overall Estimate of Waste in Health Care

If we are able to broaden and deepen our present work, we will be able to much more accurately estimate total waste within health care and do so in a more convincing manner. More importantly, our Level 2 projects suggest that such analysis can lead to effective improvement action. The three levels of our waste model are functionally independent, in the sense that patient injuries (Level 2) are as likely to happen with unnecessary, "supply-induced demand" care (Level 1), as with value-adding care; and inefficiencies in front-line staff functions (Level 3) apply whether treating an avoidable complication (Level 2), delivering unnecessary care (Level 1), or delivering value-added care. A complete waste model would draw from all three levels. For example, a combined final estimate might look something like this:

At **Level 1,** supply-induced demand and preference-induced demand are complementary categories. Thus, total value added resource consumption can be estimated as:

(1 – unnecessary supply-induced demand) = (1 – 0.32) = 0.68

ignoring preference-induced demand, for which estimates are not presently available.

For **Level 2**, clinical quality waste can be estimated as:

(1 - marginal costs associated with treatment of avoidable injuries / total care costs)

These estimates are not presently available, and they do not include other types of Level 2 waste beyond Chassin's misuse category.

Level 3, front-line waste in care delivery performance can be estimated as:

(1 – front-line time wasted / total work time) = (1 – 0.35) = 0.65

The total "value added" benefit of a health care delivery system is then the product of the three categories. For the estimates we have generated to date, while conservatively ignoring preference-induced demand and all Level 2 opportunities, this computes to 0.68 x 0.65 = 0.44. In other words, by our current very conservative estimates, only 44 percent of all resources consumed in health care delivery add value. Thus, 56 percent – more than half – represents potentially recoverable waste. We need to fill in the rest of the equation. Providing estimates in current gap areas has the potential to spur broad-spread waste reduction action; help to more clearly identify specific targets for savings; and enable those engaged in waste elimination to track which of their efforts are successful.

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Appendix A:
Quality and Inefficiency Waste in the Peer-Reviewed Medical Literature

Quality and Inefficiency Waste in the Peer-Reviewed Medical Literature

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16 August 2000

Clinical quality improvement provides a theory and a set of practical tools for the measurement and management of health care delivery processes. It holds that all planned, human work, including health care delivery, is accomplished through such processes. It posits that every such clinical work process produces parallel medical and cost outcomes. That suggests that medical outcomes are directly related to cost outcomes. Clinical quality improvement describes three causal relationships that define that link. One of those relationships describes processes changes which produce better medical outcomes, but only through higher resource investment and costs. The other two relationships - quality waste and inefficiency waste – generate lower costs by improving medical outcomes, or while medical outcomes hold stable.

Estimates suggest that health care quality waste and inefficiency waste may account for more than 50 percent of all American health care expenditures. Growing pressure on health care costs have therefore generated an obvious interest in quality and inefficiency waste, as means to control costs and possibly expand health care access while maintaining high health care quality. But theory and estimates do not always translate into practice. As a first step, we therefore examined the peer-reviewed medical literature seeking instances showing quality waste and inefficiency waste mechanisms at work within current American health care delivery. Our aim was to see whether such phenomena exist in practice as well as theory, and to get some preliminary sense of their possible scale and, hence, potential.

Methods

We sought evidence of quality waste and inefficiency waste in American health care delivery through three sequential investigations:

(1) A convenience sample of documented health care savings arising from the elimination of quality waste or inefficiency waste

We contacted colleagues working in clinical quality improvement, and asked them to share articles describing waste and its elimination in American health care. As part of that effort, we posted a "call for published examples" for two months (August through September, 1999) on the Institute for Healthcare Improvement's (IHI) web site (www.ihi.org). We also sent a single broadcast e-mail request to all members of the IHI's Quality Management Network (QMN), a consortium of health care delivery systems working to implement quality improvement methods within their internal operations, through the IHI listserve that supports that group.

The results of those requests are shown in Appendix A.

(2) A detailed review of three clinical journals

We reviewed all issues of *The New England Journal of Medicine*, *The Journal of the American Medical Association*, and *The Joint Commission Journal on Quality Improvement*, published during a 32 month time period - January 1, 1997, to August 31, 2000. We identified all articles describing changes in clinical outcomes that also reported measured reductions in the associated costs or charge of care delivery, and classified them as representing quality waste or inefficiency waste.

We chose to review *The New England Journal of Medicine* and *The Journal of the American Medical Association* because of their reputation and wide readership among practicing American physicians. We reviewed *The Joint Commission Journal on Quality Improvement* because we perceived it as a widely read, leading publication within the field of quality improvement itself.

(3) A general Medline search

Using MESH headings identified from articles found during the journal review, we generated a set of Medline search parameters for similar articles. We applied those parameters in a Medline search for all peer-reviewed reports of randomized, controlled clinical trials (RCTs), clinical trials using other study designs, and meta-analyses, for the same 32 month time period from January 1, 1997, through August 31, 2000. That search used the following terms:

"quality of health care"[MESH] AND "cost savings"[MESH]
"health care quality access, and evaluation"[MESH] AND "cost savings"[MESH]
"health care quality access, and evaluation"[MESH] AND "evaluation"[MESH] AND "costs and cost analysis/economics"[MESH]
"health care category"[MESH] AND "cost control"[MESH]

Results

Medline using search terms derived from the foregoing sources B 1330 articles that show cost improvements associated with clinical change.

Conclusions

What we didn't review – things like the IHI Breakthrough Series

Note that this is a "proof of concept," rather than a quantitative assessment

Note that the measured cost savings do not always accrue to the sponsoring organization, and that they may appear much further along in the care process than the QI intervention

That said, there is good evidence that quality waste and inefficiency are common in American health care delivery, and that attacking them can produce significant cost savings (at least as illustrated by individual projects where this occurred)

Appendix A-1

Through conversations with colleagues we discovered a series of clinical trails that explicitly addressed the medical outcomes – cost outcomes relationship. These trials attempted to improve medical outcomes and simultaneously reduce costs, by applying process management methods such as care delivery protocols.

We eliminated a longer list of quality improvement projects that also explicitly related costs to clinical outcomes, because those projects had not yet been reported in peer-reviewed publications.

Those investigators undertaking these trials reported that, in many circumstances, major medical journals were not willing to publish complete cost data, or to explicitly explore the waste mechanisms that drove lower costs.

1. **Prevention of adverse drug events**

   Classen DC, Pestotonik SL, Evans RS, Burke JP. Computerized surveillance of adverse drug events in hospital patients. *JAMA* 1991; 266:2847-2851.

   Pestotnik SL, Classen DC, Evans RS, Stevens LE, Burke JP. Prospective surveillance of imipenem/cilastatin use and associated seizures using a hospital information system. *The Annals of Pharmacotherapy* 1993; 27:497-501.

   Classen DC, Pestotonik SL, Evans RS, Lloyd JF, Burke JP. Adverse drug events in hospitalized patients: excess length of stay, extra costs, and attributable mortality. *JAMA* 1997; 277:301-306.

   Case-control study, comparing patients with moderate or severe ADEs to matched controls without ADEs. Estimated marginal additional treatment costs for moderate and severe ADEs were $2262 per case; for severe ADEs alone, $3634 per case. Total excess costs to treat ADEs at study hospital were $4,483,000 over the four years covered by the study. Extended to all hospitals in the United States, estimated annual marginal treatment costs for moderate and severe ADEs of $79 billion. Estimated annual savings from reducing ADEs at study hospital of more than $500,000.

2. **Inpatient antibiotic decision support**

   Pestotnik SL, Evans RS, Burke JP, Gardner RM, Classen DC. Therapeutic antibiotic monitoring: surveillance using a computerized expert system. *The American Journal of Medicine* 1990; 88:43-48.

   Evans RS. The HELP system: a review of clinical applications in infectious diseases and antibiotic use. *M.D. Computing* 1991; 8:282-288, 315.

   Evans RS, Pestotnik SL, Classen DC, Burke JP. Development of an automated antibiotic consultant. *M.D. Computing* 1993; 10:17-22.

Pestotnik SL, Classen DC, Evans RS, Burke JP. Implementing antibiotic practice guidelines through computer-assisted decision support: clinical and financial outcomes. *Ann Intern Med* 1996; 124:884-890.

Evans RS, Pestotnik SL, Classen DC, Clemmer TP, Weaver LK, Orme JF, Lloyd JF, Burke JP. A computer-assisted management program for antibiotics and other antiinfective agents *N Engl J Med* 1998; 338:232-238 (22 Jan).

Between 1988 and 1994, proportion of patients receiving antibiotics increased from 31.8 percent to 53.1 percent in association with health system policies shifting less seriously ill patients to other facilities. Acquisition price of antibiotics increased 15 percent, while use of more expensive front line antibiotics, as a proportion of all antibiotics used, increased from 24 percent to 47 percent. With better antibiotic prescribing (fewer doses and fewer antibiotics per regimen) antibiotic costs fell by $81 per patient treated, from 24.8 percent of total pharmacy medication costs to 12.9 percent of total pharmacy medication costs, and from $987,550 to $612,500 total expense (in 1988 dollars).

3. **Prevention of deep surgical wound infections**

Classen DC, Evans RS, Pestotnik SL, Horn SD, Menlove RL, Burke JP. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *N Engl J Med* 1992; 326:281-286.

James BC. Quality improvement in the hospital: managing clinical processes. *The Internist* 1993; 34:11-13, 17.

Cost savings of more than $700,000 per year, associated with a fall in deep surgical wound infection rates from 1.8 percent to 0.4 percent.

4. **Long-term mechanical ventilation**

Young MP, Gooder VJ, Oltermann MH, Bohman CB, French TK, James BC. The impact of a multidisciplinary approach on caring for ventilator-dependent patients. *International Journal for Quality in Health Care* 1998; 10:15-26.

For patients managed on a mechanical ventilator for more than 72 hours in a medical intensive care unit, risk-adjusted cost per case fell by more than $20,000, counting both patients who lived and patients who died. Survival held stable or improved. Total annual savings at the study hospital exceeded $2.5 million.

5. **High Frequency Oscillating Ventilation (HFOV) for premature newborns**

Gerstmann DR, Minton SD, Stoddard RA, Meredith KS, Monaco F, Bertrand JM, Battisti O, Langhendries P, Francois A, Clark RH. The Provo multicenter early high-frequency oscillatory ventilation trial: improved pulmonary and clinical outcome in respiratory distress syndrome. *Pediatrics* 1996; 98:1-14.

Average reduction in hospital costs of $89,300 per case for premature infants with respiratory distress syndrome (RDS) $\leq$ 1 kg at birth, and $7,400 per case for premature infants with RDS > 1 kg at birth. Total net cost savings at study hospital of $3.7 million per year. Equivalent or superior medical outcomes across 9 major measures.

6. **Ventilator management of Acute Respiratory Distress Syndrome (ARDS)**
East TD, Morris AH, Wallace J, Clemmer TP, Orme JF Jr., Weaver LK, Henderson S, Sittig DF. A strategy for development of computerized critical care decision support systems. *Int J Clin Monit Comput* 1992; 8:263-269.

Henderson S, Crapo RO, Wallace CJ, East TD, Morris AH, Gardner RM. Performance of computerized protocols for the management of arterial oxygenation in an intensive care unit. *Int J Clin Monit Comput* 1992; 8:271-280.

East TD, Bohm SH, Wallace CJ, Clemmer TP, Weaver LK, Orme JF Jr., Morris AH. A successful computerized protocol for clinical management of pressure control inverse ratio ventilation in ARDS patients. *Chest* 1992; 101:697-710.

Morris AH, Wallace CJ, Menlove RL, Clemmer TP, Orme JF Jr., Weaver LK, Dean NC, Thomas F, East TD, Pace NL, Suchyta MR, Beck E, Bombino M, Sittig DF, Bohm S, Hoffmann B, Becks H, Butler S, Pearl J, Rasmusson B. Randomized clinical trial of pressure-controlled inverse ratio ventilation and extracorporeal CO_2 removal for adult respiratory distress syndrome. *Am J Respir Crit Care Med* 1994; 149:295-305.

Documented average hospital cost savings of $23,600 per case, with equivalent or superior survival outcomes as compared to next most viable alternative therapy ($ECCO_2R$); estimated annual savings of $295 million per year if applied to all ARDS patients treated in the United States.

7. **Improving core clinical processes in tertiary critical care**
Clemmer, Terry P., Spuhler, Vicki J., Oniki, Thomas A., Horn, Susan D. Results of a collaborative quality improvement program on outcomes and costs in a tertiary critical care unit. *Crit Care Med* 1999; 27(9):1768-1774.

Clemmer, Terry P., Spuhler, Vicki J. Developing and gaining acceptance for patient care protocols. *New Horiz* 1998; 6(1):12-19 (Society of Critical Care Medicine).

Significant improvements in glucose control, use of enteral feeding, antibiotic use, ARDS survival, laboratory use, blood gas use, radiograph use, and appropriate use of sedation. A severity-adjusted cost reduction of more than $2.5 million per year in 1991 dollars, or about 30 percent of total patient care costs. For those cost centers directly addressed, a documented cost reduction of 87 percent.

15. **Enteral feedings in pediatric ICU**

Chellis MJ. Sanders SV. Webster H. Dean JM. Jackson D. Early enteral feeding in the pediatric intensive care unit. *J Parenteral & Enteral Nutrition* 1996; 20(1):71-3 (Jan-Feb).

Chellis MJ. Sanders SV. Dean JM. Jackson D. Bedside transpyloric tube placement in the pediatric intensive care unit. *J Parenteral & Enteral Nutrition* 1996; 20(1):88-90 (Jan-Feb).

Harrison AM, Clay B, Grant MJ, Sanders SV, Webster HF, Reading JC, Dean JM, Witte MK. Nonradiographic assessment of enteral feeding tube position. *Crit Care Med* 1997; 25(12):2055-9 (Dec).

In addition to the specific clinical quality improvement projects listed above, colleagues also identified the following peer-reviewed articles reporting an association between better clinical outcomes and reduced cost outcomes:

1. Gheiler EL, Lovisolo JAJ, Tiguert R, Tefilli MV, Grayson T, Oldford G, Powell IJ, Famiglietti G, Banerjee M, Pontes JE, Wood DP Jr. Results of a clinical care pathway for radical prostatectomy patients in an open hospital- multiphysician system. *European Urology* 1999; 35:210-216.

2. Weingarten SR, Riedinger MS, Conner L, Lee TH, Hoffman I, Johnson B, Ellrodt AG. Practice guidelines and reminders to reduce duration of hospital stay patients with chest pain: an interventional trial. *Ann Int Med* 1994; 120:257-263.

3. Cooper CJ, El-Shiekh, Cohen DJ, Blaesing L, Burket MW, Basu A, Moore JA. Effect of transradial access on quality of life and cost of cardiac catheterization: a randomized comparison. *Am Heart J* 1999; 138:430-436.

4. Noguchi T, Miyazaki S, Yasuda S, Bab T, Sumida H, Morii I, Daikoku S, Goto Y, Nonogi H. A randomized controlled trial of prostar plus for haemostasis in patients after coronary angioplasty. *Eur J Vasc Endovasc Surg* 2000; 19:451-455.

5. Miccoli P, Bendinelli C, Berti P, Viginali E, Pinchera A, Marcocci C. Video-assisted versus conventional parathyroidectomy in primary hyperparathyroidism: a prospective randomized study. *Surgery* 1999; 126(6):117-121.

6. Roth A, Malov M, Carthy Z, Golovner M, Naveh R, Alroy I, Kaplinsky E, Lanaido S. Potential reduction costs and hospital emergency department visits resulting from prehospital transtelephonic triage B the Shahal experience in Israel. *Clin Cardiol* 2000; 23:217-276.

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8. Stoller J, Mascha EJ, Kester L, Haney D. Randomized controlled trial of physician-directed versus respiratory therapy consult service-directed respiratory care to adult non-ICU inpatients. *Am J Respir Crit Care Med* 1998; 158:1068-1075.

9. Falcon T, Paraiso MFR, Mascha E. Prospective randomized clinical trial of laparoscopically assisted vaginal hysterectomy versus total abdominal hysterectomy. *Am J Obstet Gynecol* 1999; 180(4):955-962.

10. Jones C, Palmer TE, Griffeths RD. Randomized clinical outcome study of critically ill patients given glutamine-supplemented enteral nutrition. *Nutrition* 1999 ;15(2):108-115.

11. Rosenheck R, Cramer J, Xu W, Graowski J, Douyon R, Thomas J, Henderson W, Charney D. Multiple outcome assessment in a study of the cost-effectiveness of clozapine in the treatment of refractory schizophrenia**.** *Health Serv Res* 1998; 33:1237-1261.

12. Heikkinen TJ, Haukipuro K, Koivukangas P, Hulkko A. A prospective randomized outcome and cost comparison of totally extraperitoneal endoscopic hernioplasty versus lichtenstein hernia operation among employed patients**.** *Surg Laprarosc Endosc* 1998; 8(5):338-344.

13. Heikkinen TJ, Haukipuro K, Hulkko A. A cost and outcome comparison between laparoscopic and lichtenstein hernia operations in a day-case unit: a randomized prospective study. *Surg Endosc* 1998; 12:1199-1203.

14. Tyrer P, Evans K, Gandhi EV, Lamont A, Harrison-Read P, Johnson T. Randomized controlled trial of two models of care for discharged psychiatric patients. *BMJ* 1998; 316:106-109.

15. Kirten OC, DeHaven B, Morgan J, Morejon O, Civetta J. A prospective, randomized comparison of an in-line heat moisture exchange filter and heated wire humidifiers: rates of ventilator-associated early-onset(community-acquired) or late-onset(hospital acquired) pneumonia and incidence of endotracheal tube occlusion. *Chest* 1997; 112:1055-1059.

16. Choong PFM, Langford AK, Dowsey MM, Santamaria NM. Clinical pathway for fractured neck of femur: a prospective, controlled study. *MJA* 2000; 172:423-426.

17. Heikkinen M, Aarnio P, Hannukainen J. Percutaneous dilational tracheostomy or conventional surgical tracheostomy? *Crit Care Med* 2000; 28(5):1399-1402.

18. Haaga JR, Nakamoto D, Stellato T, Novak RD, Gavent ML, Silverman SG, Bellmore M. Intracavity urokinase for enhancement of percutaneous abcess drainage: phase II trial. *AJR Am J Roentgenol* 2000; 174:1681-1685.

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21. Carere RG, Webb JG, Buller CEH, Wilson M, Rahman T, Spinelli J, Anis AH. Suture closure of femoral arterial puncture sites after coronary angioplasty followed by same-day discharge. *Am Heart J* 2000; 139:52-58.

22. Laroche C, Fairbairn I, Moss H, Pepke-Zaba J, Sharples L, Flower C, Coulden R. Role of computed tomographic scanning if the thorax prior to bronchoscopy in the investigation of suspected lung cancer. *Thorax* 2000 May; 23:271-276.

23. Stuck AE, Minder CE, Peter-Wuest I, Gillman G, Egli C, Kesselring A, Leu RE, Beck JC A randomized trial of in-home visits for disability prevention in community-dwelling older people at low and high risk for nursing home admission. *Archives of Internal Medicine* 2000 Apr 10; 160:107-113.

24. Casati V, Guzzon D, Oppizzi M, Cossolini M, Torri G, Calori G, Alfieri O. Hemostatic effects of aprotinin, tranexamic acid and epsilon-aminocaproic acid in primary cardiac surgery. *Annals of Thoracic Surgery*. 1999 Dec; 68:2252-2256.

25. Stowers SA, Eisenstein EL, Th Whackers FJ, Berman DS, Blackshear JL, Jones AD Jr, Szymanski TJ Jr, Lam LC, Simons TA, Natale D, Paige KA, Wagner GS. An economic analysis of an aggressive diagnostic strategy with single photon emission computed tomography myocardial perfusion imaging and early exercise stress testing in emergency department patients who present with chest pain but nondiagnostic electrocardiograms: results from a randomized trial. *Annals of Emergency Medicine* 2000 Jan; 35:17-25.

26. Lacey L, Hopkinson PK, Montainer J, Leblanc F, Gill MJ. An evaluation of the cost effectiveness of adding lamivudine to zidovudine-containing regimens in HIV infection. Canadian perspective. *Pharmacoeconomics* 1999; 15 Suppl 1:55-66.

27. Lacey L, Youle M, Truemen P, Staszewski S, Schrappe M, Behrens M. A prospective evaluation of the cost effectiveness of adding lamivudine to zidovudine-containing antiretroviral treatment regimens in HIV infection. European perspective. *Pharmacoeconomics* 1999; 15 Suppl 1:39-53.

28. Lacey L, Mauskopf J, Lindrooth R, Pham S, Sang M, Sawyer W. A prospective cost-consequence analysis of adding lamivudine to zidovudine-containing antiretroviral treatment regimens for HIV infection in the US. *Pharmacoeconomics* 1999; 15 Suppl 1:23-37.

29. Stewart S, Marley JE, Horowitz JD. Effects of a multidisciplinary, home-based intervention on unplanned readmissions and survival among patients with chronic congestive heart failure; a randomised controlled study. *Lancet* 1999 Sep 25; 354:1077-1083.

30. de Clerk GJ, van Steijn JH, Lobatto S, Jaspers CA, van Veldhuizen WC, Hensing CA, Bunnik MC, Geraedts WH, Dofferhoff AS, Van Den Berg J, Melis JH, Hoepelman AI. A randomised, multicentre study of ceftriaxone versus standard therapy in the treatment of lower respiratory infections. *International Journal of Antimicrobial Agents* 1999 Jul; 12:121-127.

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42. York R, Brown LP, Samuels P, Finkler SA, Jacobsen B, Persely CA, Swank A, Robbins D. A randomized trial of early discharge and nurse specialist transitional follow-up care of high-risk childbearing women. *Nursing Research* Sep/Oct 1997; 46:254-261.

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randomized clinical trial to compare filgrastim-mobilized peripheral-blood progenitor-cell transplantation and autologous bone marrow transplantation in patients with Hodgkin=s and non-Hodgkin=s lymphoma. *Journal of Clinical Oncology* 1997 Jan; 15:5-10.

Appendix A-2

Review of last three years of NEJM, JAMA, and JCAHO Journal on Quality Improvement

Rao PM, Rhea JT, Novelline RA, Mostafavi AA, McCabe CJ. Effect of computed tomography of the appendix on treatment of patients and use of hospital resources. *N Engl J Med* 1999; 338:141-152.

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Appendix B:
Excess Cost and Length of Stay Associated with Voluntary Event Reports in Hospitals

Excess Cost and Length of Stay Associated with Voluntary Event Reports in Hospitals

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Word Count: 5,034
Pages: 20
Tables: 3
Figures: 0

Context: Voluntary event reporting has proliferated in hospitals yet little is known about the cost and length of stay associated with events captured through this means.

Objective: To quantify excess costs and length of stay associated with voluntary patient safety event reports.

Study Design: Patient safety events were captured in an electronic registry at three urban, community hospitals in Portland, Oregon. Information was collected on a voluntary basis from any hospital care provider. All reported events were anonymous. Cost and length of stay was assessed by linking event reports to risk adjusted administrative data from a well-known national vendor-supported data set, CareScience.

Principal Findings: Hospital stays with any event report were 17% more costly and 22% longer than those without events. Medication and treatment errors were the most expensive and most common unplanned events, representing 77% of all unplanned event types and 77% of added costs. There was no significant difference in additional cost or length of stay by the outcome designated on the report.

Conclusions: Though rarely utilized to measure patient safety related costs, the events captured by voluntary reports add significantly to the cost and duration of hospital care.

Key Words: Patient Safety, Cost, Length of Stay, Voluntary Reporting

Excess Cost and Length of Stay Associated with Voluntary Unusual Event Reports in Hospitals

Although the cost of adverse events has been well established for some time (Thomas et al. 1999), few studies have quantified the cost of events captured by general purpose, voluntary event reporting systems.

Since the Institute of Medicine (IOM) report *To Err Is Human* (Institute of Medicine 1999), patient safety has gained greater national prominence and, as recommended in that publication, voluntary event reporting systems have started to proliferate at hospitals around the country (Martin et al. 2005; Mekhjian et al. 2004). Prior work to quantify patient safety related cost and length of stay has focused on adverse events or injuries that are defined by some level of patient harm (Classen et al. 1997; Bates et al. 1997; Einbinder and Scully 2001; Leape 2002; Samore et al. 2004; Senst et al. 2001; Suresh et al. 2004; Zhan and Miller 2003;)

By comparison, voluntary event reporting systems capture a broad range of unsafe conditions, events and patient outcomes that in many cases do not involve patient harm. As such, estimates of excess cost and length of stay using voluntary event reports measure different kinds of patient safety related costs than those associated with adverse events or injuries.

Few studies that we know of have used these data to examine the additional costs and length of stays associated with events collected in these types of unspecialized event reporting systems. By using a multivariate regression model with case matching, risk adjustment and log transformation of highly skewed dependent variables, this study represents a methodological improvement on the sole study (Nordgren et al. 2004) to estimate the excess cost and length of stay associated with voluntary event reports.

Methods - Data Sources

The Providence Center for Outcomes Research and Education (CORE) analyzed data from three Providence Health System (PHS) community hospitals in the Portland, Oregon metropolitan area. Providence St. Vincent Medical Center operates 451 beds, Providence Portland Medical Center operates 483 beds and Providence Milwaukie Hospital operates 77 beds.

To create a dataset containing patient encounter cost and length of stay data along with any associated event information, we extracted and linked data from two sources. One source was an administrative database and the other source was a database of voluntary event reports.

The administrative database, developed by CareScience (CareScience 2006), a benchmarking vendor, contained cost, actual length of stay, age, sex, payor, DRG, predicted cost and length of stay for each hospitalization, the unit of analysis. As a result, a patient with multiple hospitalizations during the study period would appear once for each hospitalization. In the CareScience database, cost is derived by applying cost to charge ratios to patient charge data. This database uses proprietary, diagnosis specific, risk adjustment models calculated from their client database of more than 200 hospitals representing over 4 million discharges. The risk models use variables for chronic diseases, comorbidities, principal diagnosis, major procedures, urgency of admission, age, sex, race, median household income in patient zip code, relative travel distance to facility, admission source and transfer status to provide patient specific estimates of expected cost and length of stay. Data for the present study included all 123, 281 discharges between 4/1/2002 and 4/30/2004 from the three Providence hospitals.

The voluntary event report database contained 29,019 submissions from the three hospitals between 4/1/2002 and 4/30/2004 related to different event "types": medication errors, patient falls, treatment events, equipment problems, behavioral issues and loss/exposure events. Throughout this analysis these are referred to simply as event reports.

Beginning third quarter 2001, event reports could be submitted to a centralized database using machine readable paper forms and in late 2003 an online system was added. Hospital leadership has strongly encouraged the reporting of as many close calls and unsafe practices as possible rather than limiting reporting to actual incidents. Managers receive regular feedback about the events that occur in the areas for which they are responsible.

In our system, event reports could have more than one type-category assigned to it and multiple causes related to each type. Within each type-category there were also between 5 and 15 subtypes. For example, medication event reports could describe a variety of missteps including sub-types such as those of omission, patient mis-identification, dosage, timing, and adverse reactions (Table 4). Fall event reports included whether or not the event was observed and whether or not the fall was assisted from a variety of locations such as bed, toilet, or chair (Table 5). Treatment event reports included a wide variety of event sub-types such as delayed, omitted or incorrect treatment, patient mis-identification, latex sensitivity, or injury (Table 6). Equipment events included misuse or malfunction of equipment or improper disposal of supplies

(Table 7). Behavioral event reports could document threats of or actual physical or verbal abuse, legal action, complaints, leaving against medical advice or the presence of contraband such as drugs or weapons (Table 8). Loss event reports included theft and exposure to materials and fumes (Table 9).

Each report was also assigned an outcome using fourteen categories that described the events' potential impact using NCC MERP scale (National Coordinating Council for Medication Error Reporting and Prevention 2006) or for falls, the NDNQI (National Center for Nursing Quality 2006) scale. An outcome could be categorized as "No Incident", "Error/No Harm", "Error/Harm", and "Error/Death". "No Incident" outcomes were those without the capacity to cause any disruption in care. There was no option for a "No Incident" fall since by its nature it constituted a disruption. "Error/No Harm" outcomes included events that occurred but did not reach the patient or reached the patient but did not cause harm. "Error/Harm" outcomes were events that occurred and resulted in additional treatment, prolonged hospitalization, permanent patient harm, or a near-death event. "Error/Death" outcomes were those where the patient died. Each report was reviewed by the manager of the department where the event occurred and by hospital quality management personnel. Department managers and quality management staff each review the event and make corrections as needed to ensure accuracy of the outcome and all other information.

During the time period analyzed, the account number or medical record number of the patient were manually entered into the web-based system or stamped with the patient identifiers in the paper version. In both submission formats, this information was optional to encourage greater anonymity in reporting. In this system it is also possible to report a general safety issue that may not be specific to a patient, obviating the need for patient identifiers. Records with patient identifiers made the event report specific to a particular hospital encounter. Interestingly, the percentage of reports linked to an encounter (51%) was similar in both paper and online reporting formats. Reports could be completed for events involving patients, visitors, and employees although the majority were related to patients. This study includes only events related to patients.

Merging both data sources produced 15,851 encounters that were linked to a voluntary event report. This left 10,352 reports with some information entered in the patient identification fields but were not able to be successfully linked with the CareScience data. The event reports that were linked to an encounter in the CareScience data had a distribution of report types and outcomes similar to those that were not successfully linked.

Case Matching

Patient encounters with voluntary event reports were matched against 1 to 4 controls using facility, initial department, DRG, sex, and age (± 10 years). This follows the methodology used by Zhan and Miller (2003) and was done to create a dataset with controls that were similar to patients with a voluntary event report. In particular, maternity cases represented a large portion of hospital volume, had relatively few event reports and had costs and length of stay that differed from other hospital cases. The initial department was the first hospital department where a room and board charge was recorded for a given hospitalization. In the hospitals' administrative data, charges were recorded at midnight. The goal of this procedure was to control for differences in hospital processes that might influence the likelihood of an error and of the event being reported. Matching was done without replacement so that each case was matched to a different control. Of the 15,851 encounters linked to an event report, 11,568 were successfully matched with at least one control case. The matched cases and controls represented the distribution of patient types found in the overall hospitals' patient population in all areas other than obstetrics and newborns which had a relatively small number of event reports relative to their large proportion of hospital volume (Table 1).

Multivariate Modeling

To isolate the influence of an event itself from patient characteristics that influence cost and length of stay, we initially constructed two linear regression models. A cost model used the logarithm of cost as the dependent variable and included as independent variables, the logarithm of expected cost, the logarithm of expected LOS, age, sex, payor, a surgery indicator variable, a dummy variable to indicate that a event was reported for that patient encounter, interaction terms for payor and the log of expected cost and the log of expected LOS. We also constructed a second model for length of stay using the same independent variables as the cost model and the logarithm of length of stay as a dependent variable. In these two regression models, the coefficient assigned to the event indicator variable was interpreted as the increase in cost or length of stay associated with a event while accounting for differences in patient characteristics.

To model the cost or length of stay of a particular event type or outcome, we replaced the event dummy variable with dummy variables for each event type or outcome category. This yielded a total of eight regression equations; two overall cost and length of stay equations, two equations for cost and length of stay by type, two equations for cost and length of stay by outcome, and two equations for cost and length of stay by type and outcome (Table 2). Significant differences between types and/or outcomes were identified by examining 95% confidence intervals around the parameter estimate for the respective event dummy variable. This approach is similar to a two-tailed t test.

Using the logarithm of cost or length of stay was necessary to ensure that our models satisfied the assumptions of linear regression (William 1993; Manning 1998). The result of this transformation is that the coefficient of the event indicator variable now estimates the logarithm of the proportional change in cost or length of stay and must be transformed to be more easily interpreted (Austin, Ghali, and Tu 2003). This was done by taking the anti-log of the event dummy coefficient which provided the proportional change in cost or length of stay given an event report. This was then multiplied by the median cost or length of stay of non-event report patient encounters to provide a "per event" cost or excess days as a result of an event. This "per event" estimate was then multiplied by the total number of events in the dataset after matching to calculate the overall total cost and days. All models had an R-square of .72 and the overall length of stay model had an R-square of .51. All analyses were performed using SPSS 13.0 (SPSS 2004).

Results

In our analysis, after controlling for patient risk factors, hospitalizations with any type of event report were 17% more expensive than those without an event report (Table 2). Similarly, length of stay was 22% longer for patients with a event report compared to those without (Table 3). Medication and Fall events were the most expensive (21% higher cost), followed by behavioral events (15%), loss/exposure (13%), treatment (12%) and equipment events (11%). Both Medication and Fall events were significantly more expensive than other event types. Medication and Treatment event reports were the most common, representing almost 77% of all event types.

Overall, there was a significant difference in cost increase between “No Incident” events (11% - 15% confidence interval) and more serious events (“Error/No Harm”, 18% - 21% and “Error/Harm”, 17% - 23% confidence intervals respectively) (Table 2). There was no significant difference in cost increase between events with harm and those without harm.

Fall event reports were associated with the greatest increase in length of stay (34% longer LOS) followed by medication events (26%), loss/exposure events (25%), behavioral events (21%), treatment events (13%) and equipment events (10%) (Table 3). There was not a consistent, statistically significant pattern of greater incremental length of stay for any particular event type. Overall, there was a significant difference in LOS between “No Incident” events (16% - 21% confidence interval) and more serious events (“Error/No Harm”, 22% - 25% and “Error/Harm” 19% - 26% confidence interval respectively). As was observed with the cost model, there was no significant difference in length of stay increase between events with and without harm.

Extrapolation of Cost and Length of stay

Percentage increases in cost and length of stay can be translated into dollars and days by multiplying the increase in cost and length of stay by the corresponding non-event report median values. This step provides a picture of the total impact of voluntary event reports since it combines both the percent increase in cost or LOS and the frequency of each event type. In the two years represented by our study, unplanned patient care events have added an estimated $8.3 million in additional patient care costs and additional 4800 patient days (Table 3). Medication events which were both common and relatively expensive per event, accounted for an estimated $4 million in patient care costs and more than 2300 bed days alone. Treatment events were the next most expensive, accounting for roughly $2.3 million in extra costs followed by Fall events which accounted for more than $900,000 in additional costs. Falls had the greatest per event increase in length of stay and accounted for more than 1100 additional bed days over two years.

Discussion

In our study, the events collected through voluntary reporting add significantly to the cost of patient care. While the exact causes for greater costs are not yet known and need to be investigated further, we suspect that the additional costs are due to rework, the need for additional testing and treatment, and lengthened stays due to patient monitoring.

Our study differs from other efforts to measure patient safety related costs primarily in the means used to identify and define events. While voluntary event reporting systems have been criticized as underreporting the extent of patient harm, their strength is in the collection of data on "near misses" and unsound practices that have the potential to cause future patient harm and might not be discovered through other means (Aspden et al. 2004; Jha et al. 1998; Thomas and Petersen 2003). In contrast to other studies of adverse events and injury which define some level of harm, thirty percent of the reports in our study were assigned a "No Incident" outcome and ninety percent did not cause patient harm. Consequently, we are measuring a different type of event than those included in other studies. For example, Zhan and Miller (2003) report higher estimates of length of stay because Patient Safety Indicators (PSI) are generally more acute events (postoperative sepsis or accidental puncture or laceration, for example) than the majority reported in our system (90% did not involve patient harm). In that study, 13 of 18 PSIs had excess length of stay of 1.34 days or more versus .43 days per voluntary event report. Bates et al (1997), Classen at al (1997) and Senst et al (2001) likely show greater cost and length of stay (for all ADEs, $2100 - $2500 in 1997 and 2001 and 1.9 - 2.2 days) than those we observe ($913 and .52 days for all medication related voluntary event reports) because ADEs are defined with some level of patient harm. Many voluntary event reports, particularly those that do not cause harm, may not be sufficiently documented elsewhere to trigger Patient Safety Indicators, chart review criteria, or automatic detection systems described in these studies.

To date calculations of the national cost of patient safety events have been based on studies that define some level of patient harm. Including the types of events reported here expands the picture of costs associated with lapses in patient safety to include a wider range of events. Unfortunately, we cannot make national extrapolations with our data and add these to existing national estimates since there is undoubtedly some overlap between the types events reported here and those in other studies. Further, our study is limited to three hospitals in one city and would need to be replicated on a much larger scale to be nationally representative.

The present study estimates a very large aggregate effect of events and near misses. However, there is reason to believe that these estimates still under represent total costs. They do not include the costs of review and investigation, risk management, or non-billable costs. Taking all these costs into account, it is clear that the events documented thought voluntary patient safety reporting identify a major area of waste and inefficiency.

Limitations

Our study is limited by reporting biases inherent in voluntary reporting systems that influence the type and severity of events reported. Voluntary reports do not cover the whole extent of patient injury or offer a means to asses the prevalence or incidence of errors. These biases are reflected our results in much lower estimates costs and length of stay and add support to our hypothesis that even the less acute events captured though voluntary reporting add to total cost and length of stay.

This study is constrained to three hospitals within a single health system. Other hospitals may have different reporting cultures and systems that capture different event types and frequencies. This limits our ability to generalize our findings but should still shed light on the costs of hospital systems and processes that may not cause major harm or death but are inefficient.

There are certainly costs associated with the events in our database not captured by administrative systems. For example, the cost of investigation and review of these events is not billable. Costs are also not captured for the numerous instances of miscommunication among medical care teams. Nurses are often required to resolve these communication failures reducing clinical productivity, thereby increasing hospital operating costs. In the case of falls, sitters are often assigned to watch patients at high risk of falling. This time is also not billable and reduces efficiency. Although cost is only captured through billable activities, length of stay is not, so any patient specific delays in care or reduced efficiency would be captured by length of stay measurements.

Table 1: Major Diagnostic Category, Age, and Sex

	Encounters excluded from analysis	Matched Encounters with a event report	Matched Encounters, no event report
Major Diagnostic Category (percent of encounters)			
Circulatory	13.4	19.9	20.5
Musculoskeletal	7.8	15.2	15.6
Digestive	8.1	11.4	10.8
Respiratory	4.6	9.5	9.1
Pregnancy	*19.7*	*9.2*	*10.7*
Nervous System	*3.6*	*5.8*	*5.2*
Newborns	*21.5*	*4.8*	*5.6*
Kidney	2.7	3.8	3.5
Female Reproductive	4.2	3.6	4.0
Mental Health	*1.6*	*3.1*	*3.5*
Hepatobiliary and Pancreas	*2.6*	*3.0*	*2.6*
Endocrine, Nutritional and Metabolic	2.0	2.4	2.2
Infectious	*1.1*	*2.2*	*1.7*
Skin	*2.1*	*1.5*	*1.2*
Injury	*1.2*	*1.2*	*0.9*
Others (< 1% each)	*3.9*	*3.6*	*2.9*
Mean age, years	*40.6*	*57.9*	*56.7*
Percent female	62.8	59.5	60.4
Number of Encounters	72713	11568	39000

Note: Italics indicate significant difference ($p < .05$, using a two tailed z-test or t-test for means) between matched encounters with and without a event report.

Table 2: Percent Increased Cost and Length of Stay by Event Type and Outcome

	All Harm Levels % Increase (95% Confidence Interval)	**No Incident** % Increase (95% Confidence Interval)	**No Harm** % Increase (95% Confidence Interval)	**Harm** % Increase (95% Confidence Interval)	Death
Medication					
Cost (%)	21.2 (19.5 - 23.0)	19.2 (15.6 - 22.9)	21.1 (19.0 - 23.2)	26.2 (20.7 - 31.9)	-
LOS (%)	26.0 (23.9-28.1)	24.3 (20.1-28.7)	25.9 (23.5-28.4)	30.2 (23.8 - 36.9)	-
N	4543	929	3167	447	-
Treatment					
Cost (%)	11.7 (10.1 - 13.3)	8.5 (6.0 - 11.0)	14.1 (11.9 - 16.3)	10.8 (5.8 - 15.9)	ns
LOS (%)	12.6 (10.7-14.4)	11.9 (9.1-14.9)	14.2 (11.8-16.7)	6.9 (1.6-12.6)	-
N	4622	1687	2499	424	12
Fall					
Cost (%)	20.9 (17.4-24.4)	na	22.4 (18.5-26.5)	16.1 (8.7-24.1)	-
LOS (%)	34.2 (29.8 - 38.7)	na	36.4 (31.5 - 41.6)	28.4 (19.2 - 38.4)	-
N	1025	na	828	197	-
Equipment					
Cost (%)	11.4 (7.3 - 15.6)	10.2 (4.0 - 16.8)	9.1 (3.5 - 15.1)	28.4 (13.9 - 44.8)	-
LOS (%)	9.8 (5.2 – 14.6)	10.1 (3.1 –17.6)	6.8 (0.6 – 13.4)	25.5 (9.5 – 43.7)	-
N	635	261	312	62	-
Behavioral					
Cost (%)	15.3 (10.9 - 19.9)	12.1 (6.3 -18.1)	19.7 (12.0 - 27.8)	20.9 (6.4 - 37.3)	ns
LOS (%)	20.9 (15.6 – 26.4)	19.0 (12.2-26.3)	21.4 (12.6 – 30.9)	33.5 (15.5 - 54.2)	-
N	569	316	198	53	2
Loss / Exposure					
Cost (%)	12.8 (8.4 – 17.5)	14.9 (9.1 – 21.1)	9.9 (2.9-17.5)	ns	-
LOS (%)	24.5 (18.9 – 30.2)	27.4 (20.1 – 35.2)	21.2 (12.5 – 30.7)	ns	-
N	542	318	196	28	-
All Report Types					
Cost	17.4 (16.2-18.6)	13.3 (11.4-15.2)	19.1 (17.7-20.6)	19.9 (16.7-23.3)	ns
LOS	21.6 (20.3 - 23.0)	18.3 (16.1 - 20.5)	23.3 (21.7 – 25.1)	22.5 (18.7 – 26.4)	-
N	11568	3432	6957	1165	14
Outcome (%)		29.7	60.1	10.1	0.1

na = not an option on the form; ns = not significant at p < .05; - = < 15 cases

Note: Since reports can include multiple event types and only one outcome in our system, the number of cases reported by type will not match the total. Values in parenthesis are a 95% confidence interval for the respective variable's coefficient.

Table 3: Total Incremental Cost and Patient Days Associated with Voluntary Event Reports

	Cost per Event	Number of Events	Total Cost	Days per Event	Total Days
Medication	$913	4543	$4,149,346	0.52	2364
Treatment	$501	4622	$2,316,702	0.25	701
Fall	$897	1025	$919,507	0.68	1162
Equipment	$489	635	$310,808	0.25	124
Behavioral	$659	569	$375,126	0.20	238
Loss/Exposure	$552	542	$299,448	0.42	265
Overall	*$749*	11936	$8,370,937	*0.43*	4854

Notes: Total cost and days for each event report type of is calculated by multiplying the type-specific per event estimate by the number events of that type. The total cost and days reported above is the sum of the type-specific total cost and days to reflect the frequency of each event type. The overall cost and days per event estimate reported above in italics is from the initial regressions that did not contain type dummy variables and is not used in the calculation of total cost and days.

Table 4: Distribution of Medication Event Sub-Types

Medication Sub-Type	Percent of Medication Events	Percent with No Harm
Omission	30%	95%
Other	14%	86%
Wrong Dose	11%	95%
Wrong Time	9%	99%
Wrong Drug	7%	97%
Infiltration/Phlebitis	6%	35%
Incomplete Documentation	6%	98%
Wrong Rate	5%	94%
Wrong Patient	3%	99%
Narcotic Count Related	2%	99%
Wrong Solution	2%	96%
Wrong Route	2%	93%
Wasted Blood/Blood Products	1%	91%
Wrong Preparation	1%	90%
Adverse Reaction	1%	49%
Contra Indication	1%	91%

Table 5: Distribution of Fall Event Sub-Types

Fall Sub-Type	Percent of Fall Events	Percent with No Harm
From Bed	35%	82%
From Walk/Stand	34%	81%
From Commode/Toilet	10%	78%
From Chair/Stool	8%	89%
Other	6%	75%
Visitor Fall	3%	79%
In Hallway	1%	82%
From Wheelchair	1%	100%
From Table/Stretcher	1%	57%
From Shower/Tub	0%	80%

Table 6: Distribution of Treatment Event Sub-Types

Treatment Sub-Type	Percent of Treatment Events	Percent with No Harm
Delayed	27%	94%
Omitted	26%	94%
Incorrect	15%	92%
Other	14%	90%
Procedural Complication	3%	52%
Wrong Patient	3%	89%
Count Discrepancy	3%	99%
Skin Issue	2%	51%
H&P Issue	1%	100%
Contamination	1%	92%
Unattended Delivery	1%	95%
Wrong Time	1%	96%
Injury	0%	65%
Test Discrepancy	0%	100%
Unexpected Death	0%	50%
Latex Sensitivity	0%	83%
Wrong Site	0%	100%

Table 7: Distribution of Equipment Event Sub-Types

Equipment Sub-Type	Percent of Equipment Events	Percent with No Harm
Malfunction	49%	91%
Other	19%	89%
Not Available	16%	88%
SMDA Related	8%	86%
Incorrect	6%	97%
Improper Disposal	3%	95%

Table 8: Distribution of Behavioral Event Sub-Types

Behavioral Sub-Type	Percent of Behavioral Events	Percent with No Harm
Complaint	35%	91%
Other	26%	94%
Verbal Abuse	9%	98%
Physical Abuse/Threat	8%	77%
Unable to Contact Physician	6%	97%
Elopement	4%	100%
Self Inflicted Injury	4%	50%
AMA	4%	100%
Suicide Attempt	2%	73%
Legal Action/Threat of Action	1%	100%
Trespassing	1%	100%
Contraband	1%	100%
Illegal Drugs/Weapons	0%	100%
Sexual Abuse	0%	100%

Table 9: Distribution of Loss Event Sub-Types

Loss Sub-Type	Percent of Loss Events	Percent with No Harm
Lost/Damaged/Stolen	41%	98%
Other	35%	92%
Exposure	13%	90%
Environmental	10%	96%
Signage Not Used	0%	100%

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Appendix C:
Estimating Waste in Frontline Health Care Worker Activities

Estimating Waste in Frontline Health Care Worker Activities

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Running Head: Estimating Waste in Frontline Care Activities

Key Words: quality, waste, inefficiency, lean health care

Abstract

Rationale, Aims, and Objectives

The Agency for Health Care Research and Quality (AHRQ) funded a study to examine the factors contributing to waste and inefficiency in health care. Investigation took place at three levels: the community level, the organizational system level, and the frontline level. The latter aspect of the study used structured observation, guided by Toyota Production System (TPS) principles. These observations, completed as part of a separate operational initiative, was designed to estimate the cost of waste in a cross-section of acute hospital worker activities and provide a qualitative description of observed problems.

Method

An observation tool with explicit definitions for categorizing worker activities and rules for estimating the hourly cost of waste were constructed and reliability verified. A single observer shadowed 61 health caregivers for 72 hours in tertiary academic and community hospital settings using structured, nonparticipant observation of worker activities. Data yielded estimates of waste and a qualitative description of problems encountered.

Results

The average cost of waste (i.e., the cost per hour per worker) ranged from USD 7.40, to USD 18.98 across all roles and functions. Overall, workers encountered an average of two problems per hour. Results are provided for specific roles and functions.

Conclusions

Increased attention to operational quality in health care is needed and could potentially decrease costs while increasing patient safety. Implications for poor operational quality and recommendations for action are presented.

Introduction

The Agency for Health Care Research and Quality[1] (AHRQ) funded a study to examine the factors contributing to health care waste and inefficiency. Investigation took place at three levels: the community level, the organizational system level, and the frontline level. The latter aspect of the study incorporated results from an operational initiative that was guided by Toyota Production System (TPS) principles.[1,2]

Projected U.S. health care spending in 2005 is USD 1.9 trillion,[3] and macroeconomic estimates of 50% waste across the health care services sector have been reported.[4] With spending expected to reach $3.6 trillion by 2014,[3] we cannot tolerate continued waste and inefficiency in our industry. U.S. health care outcomes are no better, and in some cases worse, than in other countries with less spending.[4-6] Payroll costs—the largest hospital operating expense—increased at an annual rate of 6% per capita in 2004, compared with 0.9% per capita in 1994.[7]

The substantial labour expenses involved in developing skilled frontline health care workers makes understanding and minimizing waste at the sharp end an important research activity. As part of a larger project designed to provide hospitals with financial estimates of waste within their individual settings, this initiative used observational data to estimate the cost of waste and describe problems in a cross-section of health care worker activities. Observations were completed at Intermountain Healthcare (Intermountain) and the University of North Carolina Health Care System (UNC).

Literature Review

Observational studies of health care workers commonly report chaotic workflow and substantial time spent on nonpatient care activities. Whittington observed 20 psychiatric nurses

[1] AHRQ contract #290-00-0018, Task 11, L.A. Savitz, Project Director

for 178 hours and documented that only 42.7% of their time was spent with patients.[8] Degerhamer observed nurses before and after a primary nursing care model was introduced to a surgical unit. They reported an increase in direct patient care time from 23% to 61%.[9] Potter's detailed observation of one registered nurse's (RN's) day-shift work illustrated fragmentation in work activities.[10] Tucker shadowed RNs on hospital nursing units for 296 hours to examine problems at the bedside. The report described "nursing work to be highly fragmented," with an average of 6.5 "operational failures" per 8-hour shift, requiring 9% of nurses' time to resolve and costing approximately $95 per hour per nurse;[11] we note that this was the only identified paper that reported the financial impact of waste.

Observation of 14 residents in a Swiss teaching hospital revealed an average of 360 changes in work activities during a 12.5-hour workday; 44% of residents' time was spent performing procedures, while the rest was spent on administrative tasks (21%), travelling/waiting (9%), breaks (8%), personal education (3%), teaching students (1%), and projects (14%).[12] Lurie's nighttime observation of internal medicine house staff revealed frequent work and sleep interruptions, infrequent patient contact, and considerable time spent documenting cases.[13] Interns' and residents' work activities, studied prior to changes in work-hour rules, indicated rapid movement between activities and less than 35% of time actually spent with patients.[14,15]

Random observations of pharmacokinetics residents at a teaching hospital revealed that 36% of their work was related to pharmacokinetics consultations, with the remaining time divided between meetings and teaching.[16] Hollingsworth observed nurses, faculty physicians, and residents in a 36-bed emergency department; overall time spent in direct patient care was 32%, indirect patient care was 47%, and nonpatient care was 21%.[17] While most studies reported detailed activity data for observed workers, they were limited to investigation of physicians, nurses, and pharmacists. Our intention was to study a more varied sample of health care workers.

The two major observation methods used in ethnographic research to understand health care worker activities are work sampling and time-and-motion studies,[18-35] and there is disagreement regarding the method of choice. We reviewed numerous studies when seeking a suitable method for our research[8,9,11-15,17,23,24,28,31,35]; our decision to use structured observation was guided by the need to quantify the time spent in each activity. Data collection in most studies typically involved either continuous or random observation intervals, where activities were timed and detailed notes or a categorical activity list were used.[8,11-15,24,31,35] After evaluating a number of tools and methods, including the Nurses' Daily Activity Recording System (NURDARS),[8] Kitson's Therapeutic Nursing Function Matrix,[28] the NASA-Task Load Index,[24] multidimensional work sampling,[16] studies of primary care internist and pediatrician activities,[35] pharmacy functions and pharmacokinetics resident activities,[16,31] hospital house staff (resident and intern) work activities,[12-15,23] cognitive shifts and interruptions in RN work,[10] and unlicensed versus licensed nursing staff activities,[33] we elected to develop a tool.[2]

METHODS

Observation Tool Development

Worker Activity Measurement

Initially, one observer shadowed two different RNs for 60 and 90 minutes, respectively, using unstructured observations. The observer recorded a description and timed the duration of all activities with a stopwatch. Data were entered into a spreadsheet and a category was assigned to each activity. Nine activity classification categories, consistent with TPS principles, emerged

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[2] A copy of this tool is available upon request from the corresponding author.

from the data. We included summaries of total observation time, time spent in each activity category, and frequency of location changes and interruptions, along with field notes and a text narrative of each observation. From these data, a structured observation worksheet was developed.

[Insert Table 1 here]

During the next 13 observations, four additional activity classification categories emerged, and we documented the mutually exclusive definitions with explicit measurement rules (Table 1). Activity classification categories were reviewed with the observed workers. Three clinicians with research experience also reviewed the definitions. Guided by concepts from the manufacturing literature, we grouped the activity categories into six major classes.

Waste Estimates

We found no quantitative data regarding waste in frontline health care worker activities; consequently, we created rules for a range of estimates. Our estimates were based on the concept of waste (*muda*) within the context of the TPS.[1,2] In the TPS organization, *muda* includes defects in products or services, overproduction of unnecessary products or services, unnecessary processing, unnecessary movement of people or goods, waiting, and excess inventories.[1] We assumed that waste in operational activities at the front line of health care is common and generally unrecognized.[11,36] Given our current health care processes, policies, and regulatory environment, some waste may be unavoidable, but until we learn to recognize waste, we cannot seek to reduce or eliminate it.

The following waste estimate rules apply:

1. Assume no waste in time spent on operations.
2. Time spent dealing with defects, errors, locating, waiting, and other categories is 100% waste.

3. Estimate a range of waste (low is 20%, medium is 50%, and high is 80%) for time spent clarifying, processing, stocking, and travelling.

A spreadsheet was developed to calculate the waste estimates after each observation was finished (see Data Collection).

Problem Identification and Coding

Problems documented in the field notes were initially defined as errors, defects, missing supplies, and rework. It was apparent after a few observations that a broader definition was needed. Problems were then defined as an "undesirable gap between an ideal and actual state that hinders a worker's ability to complete his or her tasks, impacts service quality or patient satisfaction."[11] Most problems were directly observed; some were reported by the worker as recent (i.e., within the past 24 hours) or recurrent frustrations.

The coding schemes for problems emerged during qualitative analysis of the problem database. Problem categories sometimes overlapped with activity categories. Field notes were sufficiently detailed to determine if the problem disrupted workflow or therapy. Disrupted workflow was defined as interference with the worker's ability to complete the task at hand. Disrupted therapy was defined as interference with a time-sensitive diagnostic evaluation or therapy (e.g., overbooked CT scanner schedule causing delays in emergency patients' evaluations). We used a simplified scale derived from Tucker's research[11] to evaluate errors in terms of risk to patients or staff. For each error, the risk was coded as follows: very low—no foreseeable risk, low—error caused patient discomfort, moderate—potential for risk given other conditions being present (example, unclear medication orders), or high—foreseeable potential for harm.

Data Collection

The principal observer, a doctorally prepared nurse with extensive acute care nursing and research experience, completed all observations during the morning (0600–1200) or afternoon (1201–1800) hours. Workers were asked to conduct their normal routines and were assured that the observer would be unobtrusive. Elapsed time was monitored with a digital stopwatch. Field notes, activity categories, location changes, and interruptions were logged at 1-minute intervals. The data were transferred into a spreadsheet and summary report, and text narrative was reviewed with the worker during a post-observation debriefing. The summary report, through automatic links to the spreadsheet, displayed the frequency of interruptions, location changes, time spent in each activity category, and a range of waste estimates, both in minutes and as a percentage of the total. Problems extracted from the field notes were entered as text into a separate spreadsheet. To verify quantitative data quality, individual data files were double checked when transferred to a summary file.

Sample Size and Setting

A purposive sample of 61 health care workers from Intermountain and UNC Hospitals was selected so we could observe a variety of roles. Both health systems are integrated delivery networks with excellent reputations, although most of the observations (N = 52) were completed at Intermountain. Hospitals included two large (500- to 688-bed) tertiary academic referral centres (one at UNC) and three Intermountain community (200- to 300-bed) hospitals. Prior to our observations, we constructed a list of hospital departments and roles. Resource limitations demanded a focus on major caregiver roles, including physicians, nurses, respiratory therapists, social workers, pharmacists, physical therapists, and various technical workers. Departments included intensive care units (ICUs), medical/surgical units, procedural units (e.g., operating rooms, labour/delivery rooms, cardiovascular labs, endoscopy labs), radiology labs, other laboratories, central processing stations, and emergency departments. Observations were generally scheduled through the department managers; physicians were contacted directly. Participation was voluntary and we obtained verbal consent prior to observation; none of the departments or workers we contacted declined to participate. We also obtained approval of an application for exempt research from the sponsoring (Intermountain) Institutional Review Board.

Data Analysis

Statistica 5.5 (Statsoft, Inc.) was used to summarize descriptive statistics (i.e., frequencies, averages, and 95% confidence intervals). To estimate the cost of waste per hour of observation, multiple public resources (most derived from Bureau of Labour Statistics data up to 2004) and wage data from the Intermountain Human Resources database were used to construct a table (see Appendix, Table A-1) of hourly base salaries plus 30% fringe benefits for each worker's role (physician salaries did not include benefits).[37-40] We intentionally made conservative assumptions with respect to salaries. The range of waste estimates (low, medium, and high) was the product of the percentage of estimated waste and total hourly salary. Inductive analysis of problems was used to categorize their frequency. Errors and defects were defined a priori; all other problems were defined during data analysis.

Reliability Assessment

To verify the reliability of the method, we compared observations from eight different untrained observers with simultaneous, independent observations from the principal observer. Observed workers included two medical doctors, four RNs, one respiratory therapist, one radiology technologist, one pharmacy technician, and one pharmacist. The observers included two nurses, one pharmacist, one health research analyst, one quality improvement analyst, one radiology technologist, and two students with minimal medical backgrounds. Prior to data collection, the observers were briefly introduced to the observation tool and activity categories. Observations were 30 to 60 minutes in length for a total of 9 hours (1 hour n = 7, 45 minutes n = 2, 30 minutes n = 1). Intraclass correlation for percentage of time spent in operations (0.82, P = .01), waste (0.88, P = .003), frequency of location changes (0.82, P = .007) and frequency of interruptions (0.67, P = .054) indicated good (0.6–0.74) to excellent (greater than 0.74) interrater agreement.[41]

Reliability of waste estimates between health care systems was conducted by the principal observer. A comparison of repeated observations in 17 roles (11 at Intermountain, 7 at UNC) and 42 observations (32 at Intermountain, 10 at UNC) yielded comparable overall average estimates (all 95% confidence intervals overlapped) for operations (48% versus 38%), clarifying (19% versus 13%), errors/defects (2% versus 3%), processing (15% versus 24%), motion (15% versus 19%), other (0.1% for both systems), and waste estimates (medium) of 36% versus 27%.

Results

Sixty-one workers were observed for 72 hours (36 morning and 36 afternoon hours). Table 2 summarizes workers' demographic data. Professionals included 8 physicians, 26 nurses, and 8 others. Of the RNs, 5 were ICU/emergency department staff, 10 were non-ICU medical/surgical staff, 5 were operating room/post-anaesthesia care unit nurses, 2 were house supervisors, 2 were patient care managers, 1 was a labour/delivery nurse, and 1 was an endoscopy lab nurse. The laboratory workers included two phlebotomists, two medical technologists, and two specimen processors; these workers were grouped together with other technical staff (n = 13). In general, the workers were experienced; only 5 (8%) had less than 1 year and 44 (72%) had more than 3 years of experience in their role.

[Insert Table 2 here]

Figure 1 summarizes the proportion of total observation time spent in six major activity categories. A table with more detailed activity data is in the Appendix (Table A-2). The average, overall cost of waste (i.e., cost per hour per worker) across all staffing groups was USD 7.40 (low), USD 13.20 (medium), and USD 18.98 (high). Interruptions and location changes occurred at an average (standard deviation, range) rate of 8 (11, 0–80) and 13 (11, 0–58) times per hour, respectively (one technical worker assisting with a cardiac catheterization was uninterrupted during a 30-minute observation).

[Insert Figure 1 here]

Even though our sample size was limited, subgroup analyses of clarification activities suggested differences between roles. For all workers (see Appendix), the average proportion (with 95% confidence intervals) of the observations spent clarifying was 20% (N = 61, 14%–25%). For physicians the average was 43% (n = 8, 31%–56%), for supervisory RNs (house supervisors and care managers) the average was 68% (n = 4, 38%–98%), and for technical workers the average was 7% (n = 19, 3%–10%).

The 95% confidence intervals for the hourly cost of waste in the nursing supervisory subgroup (n = 4), under all assumptions, far exceeded those for all other nonphysician staff (n = 41) (e.g., low hourly cost of waste was $9.45–$19.52 versus $4.49–$6.73). The 95% confidence intervals for the medium and high costs of waste in the nursing supervisory subgroup also far exceeded those of all nonphysician, nontechnical staff (i.e., respiratory therapists, pharmacists, social workers, physical therapists [n = 8]), and low costs overlapped only slightly (USD 9.45–USD 19.52 versus USD 2.14–USD 10.07). The house supervisors' time was spent assessing staffing issues, finding information for or directing visitors, travelling, and waiting.

One nursing supervisor confirmed that waiting and travelling were common activities. Care managers spent most of their time on the telephone, in patient care conferences, or looking for information to justify admission or plan for discharge of individual patients. We observed one care manager engaged in rework for a patient discharge that was previously arranged but was delayed because of lacking physician coverage.

Physician and pharmacist observations included waiting, travelling, and clarifying. Fifty-five minutes of one 2.5-hour afternoon observation of a hospitalist was spent waiting for a patient admission. An ICU physician spent 10 minutes travelling in order to spend 2 minutes with an outpatient in his office. Pharmacists spent significant time on the telephone clarifying incomplete, illegible, or potentially erroneous orders.

Documentation (7%) and paperwork (8%), noted to be redundant in 50% (6/12) of the problems classified as rework, were the main processing activities. Although the observation scheme did not quantify all redundancies, a review of the narrative summaries revealed that 26% (16/61) of observations mentioned specific examples of redundant documentation or paperwork. Of these, 22% (14/52) occurred at Intermountain, where advanced information technology was available, and 22% (2/9) occurred at UNC, where manual documentation was predominant. We also noticed frontline workers at Intermountain facilities copying data from computer to paper in order to organize the information to fit their needs. It was common for workers at Intermountain to carry printed reports covered with handwritten notes and data copied from electronic sources. The following are some examples of Intermountain processing redundancies:

- A clerk filed printed copies of electronic nursing shift reports in the paper chart and the medical records staff discarded the files after discharge.

- A pharmacist was observed entering medication use data from the hospital information system into two separate computer applications and on paper.
- A nurse copied pre-admission medication lists (available as dictated text in the hospital information system) from a handwritten form to a handwritten kardex and a separate discharge order form.
- A hospitalist spent 29 minutes looking through electronic and paper charts to double check discharge orders and produce a dictated discharge summary.

UNC redundancies included the following:

- A respiratory therapist entered paper documentation into a billing system.
- Physician documentation was repetitive from day to day and required searching for information recorded by other caregivers.

Almost 10% of all observation periods was spent travelling, and 20% (12/61) of workers spent more than 15% of the observation time travelling. Of the 12 workers, 8 technicians spent an average (standard deviation, range) of 27% (7%, 17%–38%) of time travelling. The house supervisors spent 20% and 32% of time travelling, respectively. Eight workers (13%) spent more than 15% of the observation time waiting. The average for these was 24% (9%, 16–40), and included a radiology technician (40%), hospitalist (33%), operating room circulating nurse (30%), clerk (23%), nursing supervisor (20%), patient care technician (16%), and two RNs (16% and 18%).

A total of 159 problems (12 reported by workers) were documented in 85% (52/61) of the observation periods (see Table 3). We calculated an average rate of problem occurrences (two per hour) based on direct observation of 147 problems. Resource limitations precluded a detailed evaluation of the impact of problems on patients or staff. Eighty-six percent (114/133) of problems disrupted workflow and 5% (6/133) disrupted therapy. Twenty-five percent (n=4) of errors were coded as high risk (see Table 4).

[Insert Table 3 here]

[Insert Table 4 here]

Our intention is not to depict the observed workers as inattentive; in the majority of cases, quite the opposite was true. Most workers did not question the waste estimates during debriefing and welcomed the opportunity to assess their work process. Many workers offered illustrative examples of waste. An ICU physician in a teaching hospital estimated that at least half of the time he spends documenting is wasted by the need to locate information already recorded by others and by the repetition of day-to-day notes. A social worker indicated that delivering transportation vouchers and locating clothing wasted her time. A physical therapist expressed frustration over daily work interruptions related to the lack of designated physical therapy staff scheduling for the unit. A circulating nurse in a community hospital operating room described recurrent time wasted working around an inflexible, computerized, case cart system. A radiology technician, who spent 40% of the observation waiting for physician instructions, confirmed that waiting is a typical part of the daily work routine. The workers responded to problems by overcoming immediate obstacles and continuing work; management involvement was only observed once, when a phlebotomist mislabelled a blood specimen.

The following examples serve to illustrate typical responses to problems: When asked if the cramped workspace was distracting, a phlebotomist in an emergency department responded, “It’s all part of the madness.” A unit clerk, during a 1-hour morning observation, was interrupted 80 times while transcribing orders. A nurse opened an automated dispenser to retrieve a scheduled medication; even though the medication was available in the dispenser, it was missing from the electronic order file. The nurse sighed and then contacted a pharmacist to enter the order, delaying the medication administration by 10 minutes. During a routine review of drug-level results, a pharmacist discovered a Vancomycin dose missing from the electronic record. After briefly commenting on the fact that the drug levels indicated the dose was given, the pharmacist continued work without correcting the error. A physician, who found a worker erroneously administering oral contrast solution to a patient despite a cancelled written order, stopped the worker and had the clerk delete the order from the electronic record. When asked if he reported the problem or sought other remedies, he said, “I’ve tried it, and it doesn’t do any good.”

Time pressure was a prominent feature of the workflow, particularly of physician workflow. A physician in an urgent care clinic, who reported feeling fatigued because of limited sleep (related to clinical and academic demands) the previous night, was on the phone with his office receptionist and reviewing E-mail while four house staff waited for his time. An intensivist in a community hospital was conducting morning rounds with staff while writing orders and fielding interruptions. After finishing the discussion for each patient, the intensivist dictated a progress note on his mobile phone as other staff members waited. A conservative estimate of staff time spent waiting during the dictation was 42 minutes (not included in the waste estimates). During observation of two emergency department physicians, one did not hear his mobile phone ring, and the other hurried into an exam room and then suddenly stopped and remarked, “I forgot why I came in here.” We could cite many other anecdotes that provide qualitative validation of our quantitative results.

Discussion

Our study suggests that the cost of waste for frontline health care worker activities is substantial. Given our data, the lowest cost of waste in caregiver activities for a single-day shift on one 46-bed medical unit (staffed with eight RNs, eight patient care technicians, two care managers, one social worker, one physical therapist, one pharmacist, one respiratory therapist, two clerks, and two hospitalists) is USD 2,309 (12 hours x 26 workers x 7.40 per hour); the annual cost for the same unit is USD 843,000 (USD 2,309 x 365). Because of our conservative assumptions, these estimates represent an underestimate. Tucker's estimates of the annual losses to operational failures (for nurses alone) in a 204-bed hospital with 75% occupancy range from a lower limit of USD 51,000 to a maximum of USD 27 million per year.[11]

During the observations, workers spent less than half of their time engaged in operations. Nonoperational activities were almost evenly split between clarifying (20%), processing (19%), and motion (17%). The subgroup analyses suggested physicians and supervisory RNs spent more time and technicians spent less time than the overall average in clarification activities. Given the nature of their functions, these data are not surprising, and one might argue that time spent by more senior health care workers in clarification activities is important. We note that some of the clarification may be necessary aspects of training given the current methods used in academic teaching hospitals. Outside of training, one could argue that clarification activities indicate a lack of specified processes and a high tolerance for ambiguity,[42,43] resulting in greater waste of the most experienced workers in our system. It is easy to make the case that redundant documentation or paperwork is an unproductive use of workers' time. Despite the advanced information technology available at Intermountain, redundant documentation and paperwork were not infrequent. Other investigators who have included observation methods to evaluate information technology in clinical work reported unanticipated results that would not have been uncovered without the qualitative data.[44] It is self-evident that motion (i.e., travelling, locating, and waiting) is wasteful and should be minimized whenever possible.

Limitations

The main study limitations relate to sampling and the observation method. Although our sample was larger than most observational studies, we note that it was a small, nonrandom sample. A larger sample with more complete representation across job classes would strengthen the external validity of our research. Other factors that limit the external validity of our results include the short duration of observation and the limiting of observation periods to weekday mornings and afternoons. With the exception of the urgent care clinic physician, the endoscopy nurse, and the radiology technician, only inpatient hospital staff were observed. In addition, we were unable to evaluate time spent on problem resolution and differences in work activities related to worker roles, experiences, or time of day.

The observation method, which is inherently subjective, has several limitations. The data collection tool was newly developed, and although reliability appears good for capturing general frontline worker activities, formal validation would strengthen the results. The activity categories are explicitly defined but may not be useful for nonfrontline staff (e.g., management, leadership, ancillary support staff). Our analysis did not lend itself to a full description of shifts between activities or multitasking that was particularly apparent in physician and RN work. Finally, we did not test the reliability of the coding scheme for problems or error severity.

Conclusions

Despite the limitations, the data are consistent with other reports of persistent workplace and patient safety problems within our current health care system.[11,45-47] With the intent to guide quantitative study and generate hypotheses for future research, this study advances our understanding of the magnitude of the problem and the heterogeneity of the sample adds to the literature. Validation of the data with observed workers, our reliability assessment, explicit assumptions, and standardized data collection also lend credibility to the study. We noted a number of similarities between our study and another investigation with respect to daily operational problems, including problems' frequent occurrence and repetitive nature, as well as similar worker problem-solving behaviour and a lack of management involvement.[11] Time pressure, a tolerance for ambiguity, and insufficient cross-departmental communication most likely contributed to the poor operational quality observed.[11,36,42,48] The participating institutions are nationally recognized for their excellence; therefore, our results are not explainable on the basis of selecting poor quality health systems.

Our results indicate that attention to operational quality is needed and could potentially improve patient safety. Results can be used to justify in-depth examination of targeted processes. In particular, results suggest the following recommendations for quality/safety initiatives:

1. Minimize the need for clarification by explicitly specifying work processes and integrating problem-solving resources into the daily work flow.
2. Focus attention on nursing supervisors and care managers—those roles with the highest observed cost of waste for nonphysician staff.
3. Eliminate unnecessary documentation and paperwork.
4. Investigate and target unnecessary workflow disruptions.

5. Design facilities with attention to travel patterns and locate services where they are most accessible to users.

Recent successful use of TPS (or "lean") principles in health care have shown promise as a global operational quality improvement intervention.[42,43,47,49-55] Successful application of TPS principles in other industries has created competitive, flexible organizations with the capacity to deliver operational excellence despite constant change.[1,42,56-60] The overarching goal of the TPS is the pursuit of ideal product or service delivery. In health care, ideal is defined as exactly what the patients need, when they need it, with immediate response to problems, without error or waste, in a physically, emotionally, and professionally safe environment[61] Four organizing principles guide the pursuit of ideal health care delivery:[61]

1. Work activities are highly specified as to content, sequence, timing, and outcome.
2. Pathways for all services are simple and direct.
3. Requests and customer-supplier connections are simple, direct, and unambiguous.
4. Improvements are made as close to the work as possible, by those most familiar with the work, guided by a coach trained in the use of the principles.

All workers, at all levels, are taught to apply the principles and to maintain a relentless focus on solving operational process problems. The methods and tools employed to enact the principles are varied (e.g., standardized work, cross-trained workers, standardized problem solving using the A3 method),[1,50-52,56,62-65] but the emphasis on principles is critical.

Health care leaders, policy makers, and health services researchers have been unsuccessfully seeking a cure for the escalating cost of health care. None of the change programs used so far (e.g., total quality management, continuous quality improvement, quality circles, work redesign, matrix structures, information technology, pay-for-performance) have been shown to successfully slow unsustainable growth in health care spending. This is not to imply that such efforts are of no value, but it is hard to argue that more of the same will produce different results.

Currently, it is too early to cite a model of health care TPS success,[42] but substantial evidence of successful transformation in manufacturing and other service industries should capture the attention of health care leadership.[1,42,56-60] There is no standard for implementing TPS principles, but there are key requirements for managing TPS-driven change.[1,42,55,61,66,67] First, view people as the organization's most important resource. It is hypothesized that developing frontline problem-solving capacity will lead to receding waste. Second, emphasize process over content. Third, recognize the limitation of across-the-board programmatic change; sustainable change is a learning process that spreads unit by unit or department to department. Fourth, discard the idea of a quick fix and persist for the long term. Fifth, prepare for management roles to change from that of solution giver/strategic planner to mentor/competency developer. Line managers will become problem-solving coaches. Middle managers will support line managers by participating on cross-functional teams, developing line-manager competencies, and communicating across departmental boundaries. Upper management will provide the vision, commitment, resources, and corporate structure to remove barriers to change. Finally, remember that if upper management does not "apply to themselves what they have been encouraging their general managers to do, the whole process can break down."[66] Frontline caregivers are responsible for the quality and safety of care delivery; increased attention to and support for the effectiveness of their activities is requisite for sustainable health system improvement.

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figure legend

Figure 1. Activities and Estimated Waste for All Staff

Appendix

Table A-1. Salary Table

Role	Average Salary (USD)	Average Fringe (USD)	Cost/Hour (USD)
RN bedside, non-ICU, ICU, emergency department, labour/delivery, PACU, operating room, outpatient	27.14	8.142	35.282
RN house supervisor, care manager	36.76	11.028	47.788
Pharmacist	41.11	12.333	53.443
Physical therapist	29.35	8.805	38.155
Respiratory therapist	20.76	6.228	26.988
Clinical social worker	19.10	5.730	24.830
Unit secretary/clerk	13.99	4.197	18.187
Technical—pharmacy technician	10.70	3.210	13.910
Technical—bedside patient care	11.89	3.567	15.457
Technical—phlebotomist/specimen processor	10.55	3.165	13.715
Technical—medical lab technician	17.93	5.379	23.309
Technical—radiology technician	23.81	7.143	30.953
Technical—central processing equipment tech	10.46	3.138	13.598
Technical—cardiac catheterization lab tech	17.93	5.379	23.309
Technical—surgical scrub	15.36	4.608	19.968
MD, intensive medicine	90.50	0.000	90.4962
MD, emergency department	94.35	0.000	94.3487
MD, internal medicine	70.98	0.000	70.9799
MD, hospitalist	70.98	0.000	70.9799

Note: RN = registered nurse; ICU = intensive care unit; PACU = post-anaesthesia care unit; MD = medical doctor.

Table A-2. Activity Data: Percentage of Overall Observation Time (N=61): All Staff Groups and Hospitals Combined

Waste Activity	Mean (5)	CI –95.000% (%)	CI +95.000% (%)	Minimum (%)	Maximum (%)	Range (%)	Std. Dev. (%)	Standard Error (%)
Operations	40.75	34.7	46.8	0.0	97.5	97.5	23.7	3.0
Defect	1.76	0.7	2.8	0.0	21.3	21.3	4.3	0.5
Error	0.45	–0.1	1.0	0.0	15.0	15.0	2.2	0.3
Clarifying	19.64	14.0	25.3	0.0	89.5	89.5	22.0	2.8
Documentation	7.37	5.1	9.6	0.0	28.8	28.8	8.7	1.1
Paperwork	8.02	4.8	11.2	0.0	57.3	57.3	12.4	1.6
Doc/PW	15.39	11.7	19.1	0.0	57.3	57.3	14.3	1.8
Preparation	2.73	1.5	3.9	0.0	20.5	20.5	4.7	0.6
Materials/stocking	0.99	0.2	1.8	0.0	12.7	12.7	3.0	0.4
Travel	9.64	7.3	12.0	0.0	38.2	38.2	9.2	1.2
Locating	1.80	1.2	2.4	0.0	9.3	9.3	2.4	0.3
Waiting	5.79	3.5	8.1	0.0	39.6	39.6	8.9	1.1
Other	1.07	0.5	1.6	0.0	9.2	9.2	2.2	0.3
Breaks	0.6	0.1	1.0	0.0	8.3	8.3	1.8	0.2
Total (no breaks)	100.0	100.0	100.0	100.0	100.0	0.0	0.0	0.0

Note: Doc/PW = documentation and paperwork; CI = confidence interval.

Table 1. Activity Categories and Definitions

Category	Definition/Description/Examples
1. Operations	**Bedside caregivers:** Caregiver is with the patient or family performing physical, mental, or emotional care. **Nonbedside staff:** Worker is engaged in operations specific to their job (e.g., phlebotomist drawing blood, scrub tech assisting surgeon).
2. Clarifying	Discussion (direct or by telephone) of day-to-day operations, workload, staffing, work processes. Meetings, reports, rounds, teaching, "huddles," looking through medical records, locating information, paging.
3. Error/Defect	Mistakes or interruptions in work that require a corrective response.
Error[†]	1. Failure of a planned action to be completed as intended (e.g., mislabelled lab specimen). 2. The wrong action is taken or the wrong plan is used to achieve an aim (deviation from policy, procedure, orders, or accepted standards). 3. Medication error: A preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional (prescribing, communicating order, labelling product, compounding, dispensing, administrating, educating, monitoring, and using).
Defect	Equipment, computer, or supply-related problem that requires time to correct (e.g., missing supplies).
4. Processing	Redundant work or activities that do not fundamentally change service delivery.
Documentation	Recording patient care actions or patient information (e.g. test results, vital signs, notes) in the medical record, includes dictating.
Paperwork	Recording nonpatient care actions, including writing/taking off orders (clerk taking off orders is operations); filling out forms, requisitions, care plans, work lists;

Category	Definition/Description/Examples
	entering registration/billing data; copying information to alternate forms; filing/organizing/printing paperwork.
Preparations time	Equipment/room/procedure setup, quality control tests, etc.
Stocking	Counting, stocking, organizing inventory.
5. Motion	Movement from place to place or waiting.
Travel	Walking/moving from place to place (more than 10 steps, see locating).
Locating	Searching for missing items or people; if travel is required, log activity as locating; if searching for information, log as clarifying.
Waiting	Idle time created when people, information, materials, or work are not available.
6. Other	All other activities not categorized above (e.g. cleaning the work area, talking to the observer).
Breaks	Social conversation, breaks, personal phone calls, etc. (exclude from waste estimates).
Interruptions	All unanticipated external (to the worker) requests from people or other external events that take attention away from work including pages, telephone calls, monitor alarms.
Location Changes	Location changes that require movement from one work area to another and more than 10 steps.

†*Patient Safety Resources: Definitions*, National Patient Safety Foundation.

Table 2. Worker Demographics and Total Hours Observed

Roles	N	Sex F/M	Age + SD (Range)	Years of Experience + SD (Range)	Total Hours Observed
Professional					
MD—intensivist (3), emergency department (2), hospitalist (2), urgent care clinic (1	8	0/8	42 ± 9 (31.0 – 58.0)	15 ± 8 (4.0 – 30.0)	14
RN—bedside (22), nonmanagement supervisor (4)	26	21/5	42 ± 12 (22.0 – 65.0)	15 ± 13 (0.2 – 36.0)	30
Other—pharmacist (3), social worker (2), respiratory therapist (2), physical therapist (1)	8	6/1	42 ± 7 (34.0 – 51.0)	7 ± 1 (6.0 – 8.0)	9
Technical					
Patient care assistant (4), unit clerk (2), cath lab tech (1), radiology tech (1), lab (6), central processing tech (1), OR scrub tech (1), pharmacy tech (3)	19	13/6	33 ± 12 (21.0 – 61.0)	7 ± 7 (0.8 – 25.0)	19
Total	**61**	**41/20**	**39 + 12**	**13 ± 11**	**72**

Note: SD = standard deviation; MD = medical doctor; RN = registered nurse; OR = operating room.

Table 3. Problem Frequency

Problem Category	Definition	N	Percent (%)
Missing information	Missing or wrong information, missing charts, unclear orders, or unclear work processes disrupt workflow	35	22
Defects	Equipment or supply-related problem requires time to correct (equipment/computer problem, missing supplies)		
Missing supply/ medication	Unavailable supplies or medications	26	16
Computer problem	Computer software or hardware problems	17	11
Equipment problem	Equipment failures, missing or defective parts, staff unfamiliar with equipment	14	9
Errors	See Table 1	16	10
Waiting	Staff or patients are waiting when people, equipment, materials, or work are unavailable	15	9
Rework	Redundant work processes (duplicate documentation, paperwork, data collection), reviewing or repeating already completed work	12	8
Environmental problems	Workflow is interrupted or impeded by cluttered, cramped, noisy, or chaotic work environment	10	6
Multitasking/fatigue	Worker is engaged in multiple simultaneous tasks or verbally expresses fatigue or forgetfulness	7	4
Difficult IV insertion	More than two attempts or more than one worker involved in starting IV	4	3
Other	RN's time spent on customer service calls, leaky IV bag	3	2

Problem Category	Definition	N	Percent (%)
	dropped on floor during transport, pharmacy inventory waste		
Total		**159**	**100**

Note: IV = intravenous.

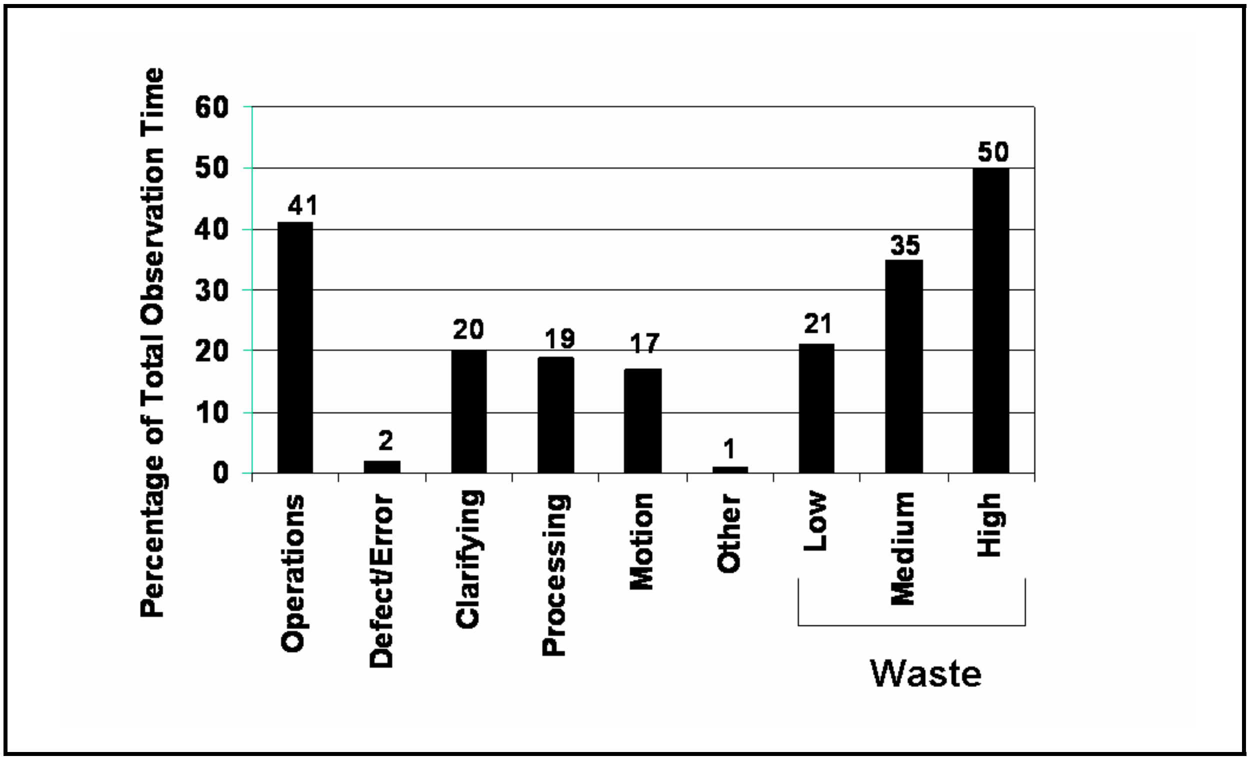
Table 4. Summary of Error Risk and Description

N	Risk	Description
8	Very low	Breakfast tray delivered to a fasting patient (removed before eaten), MD asked RN to obtain consent for bronchoscopy procedure (against hospital policy), electronic order entry errors (n=2) caught and corrected, Diazepam dose error (0.25 mg) on medication history form, Ofloxacin allergy listed in hospital information system was missing from MD and nursing history, premixed IV narcotics bag left at nurses' station, wrong preprinted name label attached to prescription slip (clerk caught and MD corrected error)
1	Low	Venipuncture repeated to correct a blood specimen labelling error
3	Moderate	RN copied 18 prescription drugs from patient history form to admission order form after MD wrote order to "continue previous meds," wrong medication strength found in electronic drug order file, pharmacist checking drug levels found Vancomycin dose not documented
4	High	Laboratory worker recapped a needle after processing a fluid specimen, technical worker assisted a patient out of bed despite postpacemaker insertion bedrest order, RN discovered wrong Total Parenteral Nutrition solution infusing,* MD found a worker administering oral contrast solution to a nauseated patient at high risk for aspiration despite cancelled order*

*Worker-reported error.

Note: MD = medical doctor; RN = registered nurse; IV = intravenous.

Figure 1. Activities and Estimated Waste for All Staff



Note: N = 61 observations, 72 hours.

Appendix D:
TPS Tools for Structured Observation

Intermountain’s TPS structured observation tools include 3 elements:

1. A training document, entitled **Front-Line Activities in Acute Care: Recording and Reviewing Structured Observation Data**, that describes how observations should be performed and recorded;

2. A hard-copy **Observation Flow Sheet**, that the observer uses to manually record observations at the worksite; and

3. A set of Microsoft Excel spreadsheet templates, to store results and provide summary data

(documents are included here? Attached as separate files?)