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A New Paradigm to Reduce Nursing Rate Impact on Health Service Organizations (HSOs) Through Hedging

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A NEW PARADIGM TO REDUCE NURSING RATE IMPACT ON HEALTH SERVICE ORGANIZATIONS (HSOs) THROUGH HEDGING

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Nursing costs account for over 50% of Health Service Organizations budgetary expenses. In a financially contracting Healthcare market that is amidst the focus of current National and International economic concerns and political agenda, here a counterintuitive method to minimize exposure to rising nursing costs. Healthcare's conundrum is marked by rising nursing costs, growing patient population, rising uninsured rates and decreasing insurance reimbursements. Participants traditionally focus on nurse staffing to minimize costs, but in its inextricable link to scheduling, budgets are often inaccurately projected as compared to actual staffing quantities and costs; this is largely due to front-line staffing policies and unpredictable nursing rates. This paper presents a nationwide experimental and empirical study of ten healthcare participants in a cross market "Hedging" application in Nursing Services as an approach to reduce exposure to rising nursing costs based on nursing rate volatility notwithstanding nursing quantity needs and day-to-day staffing decisions, and considering Options as a primary hedging approach to reduce budget disparity and yield nursing expense savings. Nursing monthly costs and demand were collected for all participants over varying range of time periods. A correlation analysis indicated that total nursing costs are highly correlated to

nursing rate change, differing across participant types. Additionally, the data was analyzed for “asset” and “options” applicability, as well as tested for appropriateness of the Black-Scholes model for options pricing. The analysis concluded that nursing service qualifies as an underlying asset for options as a hedging technique and may be priced using the Black-Scholes model. The approach was tested on one of the participants, and indicated a savings of over 11% in nursing expenses and a decrease in budget disparity of approximately 14%. Hypothetical application across the non-tested participants alludes that the implementation results are likely to be sustainable across participant with dissimilar demographics.

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Chapter 1

Overview

Since the commencement of health services, nursing plays a pivotal role in patient care. Prior to the existence of Health Service Organizations (HSOs), known public and private centers such as hospitals, academic medical facilities and ambulatory care organizations that provide a variety of medical or health-related services, medical services were exclusively delivered in patient homes whereby nursing care was a clinical necessity for patients in critical condition with need for constant medical attention.

Hospitals were the first type of HSO introduced; and, were established in 1751 to service long and short-term medical needs. Since its inception, specialty hospitals such as Adult or Children have been established to offer demographic specific medical care. Academic Medical Centers were later formed in 1980 to enhance medical services and patient care via medical complexes consisting of medical school, hospitals, clinics, libraries, administrative facilities, etc. Then, in 1983, Ambulatory Care Centers were instituted to administer health services to individuals who do not require hospitalization or institutionalization. Today home healthcare is a lesser used form of HSO, but the role of nursing conserves its origin reason.

As patient care needs and medical services have evolved, HSOs are maintained as the foundation of healthcare. Numerous sector participants ranging from Fortune 500 companies to small businesses have been founded and/or spun-off to serve clinical enhancements such as medical devices and pharmaceuticals. Nevertheless, HSOs exist to

service patient needs with constant nursing supervision that would not otherwise be received: professional nursing care is the principal reason that patients are admitted to acute care hospitals (Joseph, 2007). As such, it is not surprising that since, dated back as early as 1950s, nursing payroll is responsible for over 50% of the total resources expended for health services in HSOs.

A recent (2009) survey of 113 hospitals nation-wide indicated that nursing expense still accounts for 50% or more of the operating budget. This Nursing conundrum is a leading factor in the crumbling health services financial crisis; and a source of great concern for hospital administration, government leaders, and health services associations and affiliates across the nation. The nurse problem, specifically, stems from a multi-fold complexity:

1) Registered Nurses (RN), constitute the largest single healthcare profession in the United States, as stated by the Kaiser Foundation; coupled with the well known global growing nursing shortage that was first observed in hospitals, intensive care units and operating rooms in the 1990s, with its corollary of rising nursing rates and volatility, as well as growing patient populations.

2) As mentioned earlier, nursing is the largest cost center in hospitals, accounting for over 50%; this is partly due to the fact that the majority of healthcare services provided are nursing services, and rising nursing rates, which have partially resulted from nursing shortages that have been encountered since World War II, as stated by the Kaiser

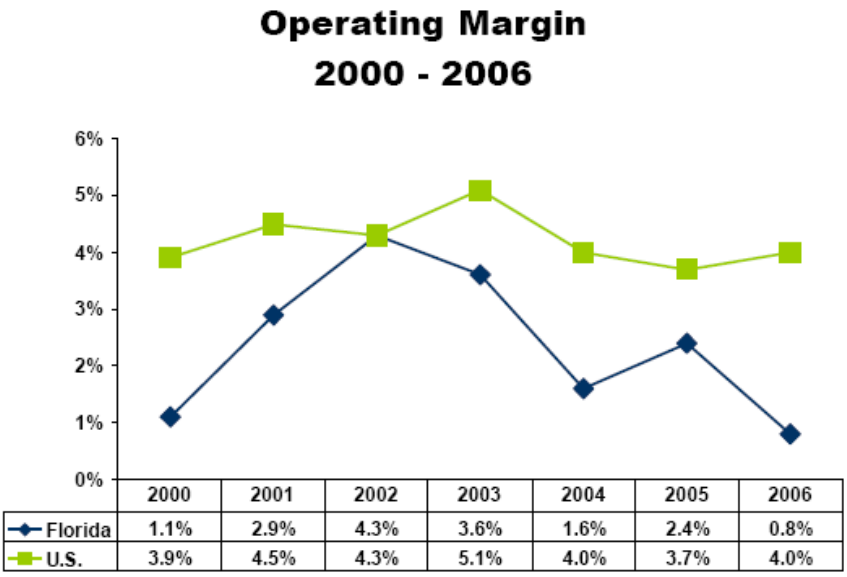
Foundation. The observed nursing shortages, and thus their impact, are cyclical for most nursing specialties, some such as intensive care and emergency have been relatively consistent.

3) Centers for Medicare and Medicaid Services (CMS) administer Medicare and Medicaid funds, the nation's largest health insurance program. The Medicare program covers individuals over the age of 65, disabled under 65 and facing permanent kidney failure treated with transplant of dialysis; Medicaid is a joint program between states and the federal government, which provides care to the poor and disabled. These government programs have been facing funding problems due to rising costs of maintaining, growing expansion of eligibility criteria leading to growing number of individuals covered and worsening economic conditions. The CMS funding crisis has resulted in capitated rates and reduced program coverage since the mid 1990s. More recently, in February 2008 the California Legislature passed Welfare and Institutions Code section 14105.19, requiring the State Department of Health Services to reduce fee-for-service payments to Medi-Cal providers by 10%. This applies to most fee-for-service payments, with some exemption written in the statute. The legislation took effect in July 1, 2008.

These complexities result in a health services industry where most services are offered by a field (nursing) with cyclical shortages by which increased rates are a readily used solution; this propagates continuously growing expenses. Coupled with decreasing revenues from capitated managed care rates, health services organization's profits are

squeezed near or past a point where expenses are exceeding revenues after reimbursements.

Figure 1 reflects operating margin for hospitals across U.S. and compares the margins to one of the more affected states: Florida. The chart indicates profit margins from 2000 through 2006, fluctuated between 3.7% and 5.1% nation-wide.; and, Florida hospitals fluctuated from .8% to 4.3%. It is noted that operating margins reflect the difference between reimbursements for patient care services and the cost of treating patients.



	2000	2001	2002	2003	2004	2005	2006
Florida	1.1%	2.9%	4.3%	3.6%	1.6%	2.4%	0.8%
U.S.	3.9%	4.5%	4.3%	5.1%	4.0%	3.7%	4.0%

Figure 1: Operating Margins from Florida Agency for Health Care

These healthcare financial concerns have been escalating since as early as the 1950s, inspiring academia interest with well-known and studied "Nurse Staffing" and "Nurse Scheduling Problem" (NSP). Where, the staffing problem has focused a high level staffing framework comprised of budgeting and planning, Operational Staffing/Scheduling and daily allocation. The literature seeks to answer the almost

grueling question: How many nurses do I need and how should they be scheduled? NSP, on the other hand, focuses on the Daily Allocation subset of a staffing framework, and aims to generate optimal nursing schedules that minimize nursing costs by managing patient demand and nursing supply. The motivation for the evolution of the problem lies in the belief that once an optimal schedule is achieved, it will lead to appropriate staffing levels.

There are several fundamental problems in the literature fruition and practical implementation: (1) there exists a natural linkage between the Nurse Staffing and Scheduling Problem, but have been evolved in isolation. (2) NSP practical application has been limited as most problems ease real-life constraints that make implementation infeasible. (3) staffing decisions such as budgeting and planning are made by HSO administrators and daily allocation is performed by front-line management based on expert knowledge; both functions are performed with conflicting goals since budget and planning intends to minimize cost and daily allocation simply finds nurses for patients with needs and cover nursing shortages by allocating temporary contracted nurses from third party nurse staffing agencies at non-constant rates that have risen over the past several years. This results in the posed risk of not having solvency for the nursing care needed to service patient need(s). Furthermore, “Forecasts are frequently prepared for the long-term, and thus, hospitals are unable to detect and respond to the short-term fluctuations. As a result, actual occupancy may run well below forecast for several months without adjustments being made…individuals are added to the staff in anticipation of an increase in patient load. Patient load, however, does not automatically

increase at the time budgets are approved; rather, it increases gradually over the budget period." (Meglino, 1979)

HSOs address decreasing profits by restructuring models for providing nursing services, with limited or no attention to the potential impact on the quality of patient outcomes: the restructuring and reengineering during the 1990s resulted in the replacement of costly professional nurses with less-expensive unlicensed staff. The Institute of Medicine (IOM) expressed grave concern over the dearth of empirical evidence regarding these organizational changes. (Joseph, 2007) This has led to the wide study of nursing staff levels on hospital quality outcomes, and growing nursing union concerns. In January 2004, California became the first state to establish minimum nurse-to-patient staffing requirements in acute-care hospitals, as discussed in the California Healthcare Foundation on February 2009. The ratios have been challenged thereafter to adjust for decreasing revenues. Many ratios are required to be maintained "at all times." This requirement in conjunction with meal breaks for staff has been a challenge. A solution has been to create "float pools," however, as discussed later in Chapter 2, most of the pool solutions potentially worsen the shortage, and lead to continued increasing wages. Furthermore, most of the quality measures analyzed for a study do not appear to have been directly affected by the decrease in RN staffing.

In this study, practical implementation of an approach that ameliorates solvency stability without encroaching on organizational structure and internal political decision making that are unique to individual HSOs is introduced. A new and counterintuitive method is

showcased that improves HSOs' financial outcomes from current nursing budget and planning practices using budget disparity (gap) as a key metric by applying Financial Derivative techniques, mainly Options, with Nurse Contracts as an underlying asset in order to yield common derivative benefits such as lower costs, hedging to manage risk of price movements, synchronizing cash flows, etc, - reduce (control) exposure to nursing price (cost). The method enables administration to plan for HSO needs, but protect them from the impact of day-to-day change and effect on the budget.

An empirical analysis is conducted using nursing cost and demand data from ten participating HSOs concentrated between Southern California (3), Arizona (1) and Florida (6) to demonstrate the feasibility, practicality and applicability of the proposed method.

In the following Chapters, the breadth of the nursing problem and exposure to rising rates with respective ramifications are explained (Chapter 2). Following, is a literature review in Chapter 3 that summarizes contributions and shortcomings in the nurse staffing and scheduling problems. Chapter 4 offers a major contribution in the Healthcare and Financial Sector with an introduction of a counterintuitive approach to reduce temporary nursing rate exposure on HSOs total nursing costs through an innovative application of *Hedging* and Black-Scholes (B-S) pricing model; it offers a detailed explanation and illustration of HSOs' Budget Process and opportunity for losses based on the behavior of nursing demand temporary nursing rates; then present a mathematical statement for quantification of nursing costs and budget disparity; and, depicts the "Nursing Options

Hedging Approach" (NOA) application to minimize nursing cost budget disparity using nursing contracts as an underlying asset. The previously mentioned participating HSOs' data is used to show the validation of nurse contracts as an underlying asset using underlying asset base criteria; and, discuss applicability of B-S options pricing model for NOA. In Chapter 5 an experimental pilot implementation in the 350-bed HSO 6 highlights that even with rising nursing needs and variable rates, budget disparity can be minimized by the use of NOA. The implementation yielded a savings of 11% in nursing expenses and decreased budget disparity by 14%. A hypothetical application across the other HSO participants alludes that implementation results are likely to be sustainable across participants.

The study concludes that nurse hedging marks a major contribution to the field, as though other organization types such as airlines have traditionally used hedging to mitigate price exposure to their respective cost dependencies such as oil, it has never been applied to offset financial losses for HSOs. The concept is innovative, but may be culturally challenging to penetrate; application may, however, be facilitated with proven successes across several pilot HSOs, such as that of HSO 6. Furthermore, the shown feasibility, practicality and applicability of nurse hedging to improve HSO bottom-line, marks viable progress in reducing the industry implementation and literature gap.

Chapter 2

Nursing Problem Statement

There is a growing national nursing shortage in the United States (US), as well as other developed and underdeveloped countries across the globe; where, there are more open nursing positions then there are nurses for hire.

The current national nursing shortage of RNs in the United States (US) first began in hospitals, intensive care units, and operating rooms in the late 1990s, but quickly spread to general medical and surgical units. (Jones, Jurascheck, Lee, and W-H Lin, 2006) Nursing demand cycles have been overall appeared cyclical, but there is a national growing concern that the current shortage will not dissipate in the near or mid future, at least in specialty areas: on March 6, 2009, the U.S. Bureau of Labor Statistics reported that the healthcare sector of the American economy is continuing to grow, despite steep job losses in nearly all major industries. Hospitals, long-term care facilities, and other ambulatory care settings added 27,000 new jobs in February 2009, a month when 681,000 jobs were eliminated nationwide. As the largest segment of the healthcare workforce, nurses will likely be recruited fill a large portion of these new positions.

Other studies indicate that:

- Over 40% of today's nurses will retire over the next 10 years.(Simpson and Bolton, 2007)

- The U.S. Department of Labor projects between 2004 and 2014,1.2 million nurses will be required in order to fill both new and vacated nurse slots. (Lovell, 2006)

- The office of Program Policy Analysis & Government Accountability (OPPAGA) wrote in Report No. 07-04:
    - The Agency for Workforce Innovation estimates that between 2006 and 2014, Florida will average 7,440 annual openings for registered nurses.
    - Nursing shortage is a nationwide problem.
    - Faculty credential requirements set in rule will increase, which may limit nursing programs' ability to admit nursing students. See Exhibit 1.

Before expanding, consider basic Health Service concepts and definitions:

- A *Health Service Organizations* refers to centers that provide medical or health-related services (i.e. pharmaceutical, clinical laboratory, nursing and allied health professions).

- Various *Types of HSOs* include: Hospitals, Academic Medical Centers, Ambulatory Care, among others.
    - Hospitals are institutions that provide medical or health-related services. There are specialty hospitals such as Adult or Children only, which focus on medical care to patients of the respective demographic.

- Academic Medical Center - Medical complexes consisting of medical school, hospitals, clinics, libraries, administrative facilities, etc.
- Ambulatory Care - Those facilities which administer health services to individuals who do not require hospitalization or institutionalization.

These may be private (privately owned: for-profit and not-for-profit) or public (government owned). For further details on hospital types and their breakdown, you may visit: HTTP://WWW.LIBRARYINDEX.COM/PAGES/1831/HEALTH-CARE-INSTITUTIONS-TYPES-HOSPITALS.HTML

- Within a hospital or an academic medical center, there are *departments and clinical units*. Departments are main clinical areas such as cardiology, emergency, surgery, etc; there also exists ancillary support departments (i.e. lab, radiology, pharmacy). Units are breakdowns of clinical departments by patient type, specialty, and/or patient acuity. As an example, a "Mother-Baby" department may have a "New Born" unit. Medical teams such as nursing and physician are trained and experienced to assist respective unit patients. Unit types include:
  - Cardiovascular
  - Critical Care
  - Emergency Department
  - Intensive Care
  - Medical
  - Medical/Surgical
  - Neonatal Intensive Care

  - Neurology
  - Oncology
  - Operating Room
  - Orthopedics
  - Pediatric Intensive Care
  - Pediatrics
  - Psychiatric
  - Rehabilitation
  - Respiratory
  - Step-Down
  - Surgical
  - Telemetry
  - Women's and Children

- *Professional Medical Care*, such as nursing and physician, are particular to the breadth of training and experience: an adult medical care nurse is not likely to perform great care in a pediatric department. With a focus on nursing, in general, there are clusters of nurses that can service clusters of patients, based on the matching of the nurses' training and experience to patient acuity and type; and, depending on the nursing expertise, a respective cluster of nursing may service one or more clusters of patients. See Figure 2.

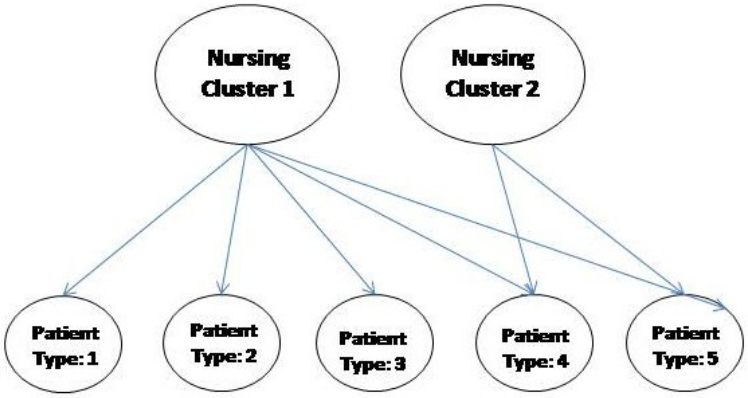


Figure 2: Nursing Clusters

As you can see, nursing cluster 1 can service patient types 1 through 5 based on acuity and patient type. Nursing Cluster 2 can only service patient types 4 and 5.

In this study, it is proposed that nurse utilization planning, policy setting and scheduling play a critical role in the magnitude and impact of the shortage; there may be enough nurses graduating to satisfy needed patient care, but not enough for open competing nursing positions.

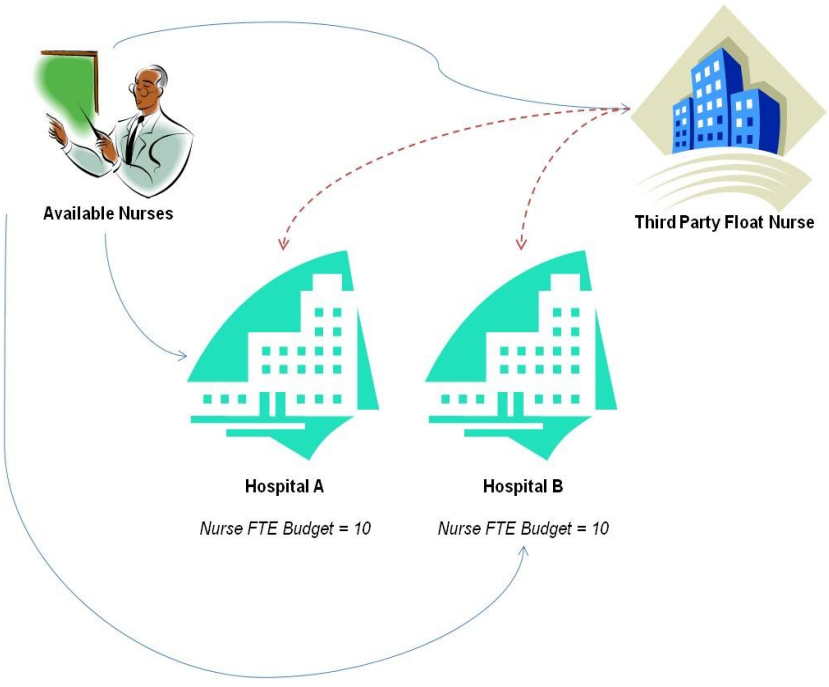


Figure 3: Nursing Utilization

In Figure 3, Hospitals A and B set the Full Time Equivalent (FTEs) nursing budget for 10 each. That is, each hospital will have 10 full-time nurses on staff. This budget is based on peak patient demand for the year. Additionally, a vendor relationship has been established with a nurse staffing agency such that the respective hospitals have access to nurses in the event that the full-time nurses no not meet capacity needs. This is a global and basic nurse staffing flow; it has multiple dynamics that impact the operating margin:

1) *Method for determining FTE budget.* "Forecasts are frequently prepared for the long term, and thus, hospitals are unable to detect and respond to short term fluctuations. As a result, actual occupancy may run well below forecast for several months without adjustments being made…individuals are added to the staff in anticipation of an increase in patient load. Patient load, however, does not automatically increase at the time budgets are approved; rather, it increases gradually over the budget period. The results in over staffing." (Meglino, 1979) Where applicable, staffing ratios play a major role in the budgeting process.

2) *Patient demand forecasting method.* Many hospitals forecast 24 hour census rather than patient demand. This results in inaccurate aggregation, as the census is a daily statistics of the average number of patients in house at a given time of the day. This does not account for the work needed for patients admitted and discharged, which are two of the more time consuming functions for nurses. Additionally, most of the intensive patient care occurs at the beginning of the admitted period, rather than the

end. As such, typically if a nursing unit has 10 new patients, it generates more work, than if they had 10 patients that were to be discharged within a day or so.

3) *Nurse skill set.* All nurses do not have the same skill set level. Specialized nurses such as those that work in intensive care units and operating rooms can be floated to non-specialty areas, but nurses without specialty cannot be floated to specialty areas. Furthermore, specialty nurses are more expensive than non-specialty..

4) *Available nurses.* Annually, there are a limited amount of available nurses for hire that are pulled from by all institutions seeking to hire nurses. The magnitude of the shortage exists globally, but varies by location and cyclical behavior within type.

5) *Staffing agencies.* Staffing agencies are third party established relationships that provide nurses to hSOs when needed in order to cover unplanned understaffing.

6) *Nurse scheduling.* scheduling is the process of developing a roster for nurses which assigns nurses to schedules in order to meet patient-load. The aim is to assign a work pattern in the form of a duty roster, while satisfying a host of legal and policy constraints, and simultaneously attempt to achieve an acceptable trade-off between some set of objectives.(Bester, Nieuwoudt, Van and Jan, 2007)

This process varies by facility based on respective strategy and policies. It is, mainly, managed by either the direct nursing units with a report into the Chief Nursing Officer, or from a central staffing office (CSO).

Considering Figure 3, assume on the same given day Hospital A only needs 8 nurses, where Hospital B needs 12. Assuming all nurses are the same specialty, current policy would lead Hospital A to do nothing, and for Hospital B to hire two outside (contracted) nurses.

Note that though the FTE nurse demand is 20 (10 for each hospital). Staffing policy leads to a perceived demand of 22: the initial 20 nurses plus the additional 2 contracted nurses needed for Hospital B to cover the demand gap. The additional 2 FTEs show as demand through the staffing agency. The core problem, may thus, lay in the ability to share (effectively) nurse resource pools across HSOs.

Industry Solutions

The problem has reached the attention of the House of Representatives; and a hearing before the committee on education and the workforce of the House of Representatives one hundred seventh congress, Serial No. 107-31 stated possible solutions as:

- Increase nursing recruitment.
- Higher wages.
- Increase access to education via grants and scholarships.

Other solutions introduced include:

- Funding collaborative investment vehicles to support nursing faculty shortage, recruitments, retention and diversity effort:(Simpson and Bolton, ###)
    - The Robert Wood Johnson Foundation's $10 million partners investing in nursing's future program is an effort to motivate local foundations to fund nursing programs, especially those that have never funded any nursing programs. This program, in partnership with the Northwest Health Foundation, has funded its first cohort, including 4 foundations that might have never considered funding a nursing program if not for Partners pInvesting in nursing's future program.
- *Staffing techniques/methods* are considered by hospitals and other health service facilities:
    - *Traveling nurse.* In the private sector the "Travel Staffing" was developed. Travel nurse agencies (third party) specialize in hiring and deploying their itinerant. The concept is exciting for newly trained nurses that aim to broaden their horizon, but is less accepted by the seasoned nurses. The given agency alleviates shortages in, at least in the short-term. States with preferred weather such as Arizona, California, Florida and Texas benefit the most. (Stacchini, 2004)

    - *Internal float pools.* Like the travel nurse, internal float pools hire nurses to float them across the hospital in order to cover shortages. Internal float pools

are an internal hospital department that hires nurses for the exclusive use of floating them to areas with understaffing.

- *Flexible work schedules*. The practice develops nurse schedules to accommodate nurse preferences. National recruitment experts encouraged nurse managers to develop unit schedules that satisfied individual nurse requests and promoted retention. (Kendrick and Hollabaugh, 1998)

- *Offering sign-on bonuses*. This serves as an incentive for new positions to be accepted, but inadvertently leads to financial competition for same nursing resource by numerous facilities, which drives up the average cost of nursing service.

Limitations to Industry Solution(s)

The proposed and studied solutions pose one or multiple of the following limitations:

- *Expensive and unaffordable* by the industry's financial capability given the financial pressures created by the rapid growth of managed care in the mid-1990s: capitated rates have placed immense pressure on hospitals. (Kendrick and Hollabaugh, 1998) Dated back as early as 1964, personnel payroll is responsible for over 60% of the total resources expended for health services. (Meglino, 1979) To save money, many hospitals restructured nurse staffing by cutting wages and jobs of registered nurses. (Charting Nursing's Future, 2007) This is in large due to the fact that in 2000, more than one third of hospitals received revenues that fell below the cost of delivery of

care, and 50% of hospitals lost money treating Medicare patients. (Zhao et. Al, ###) A survey of 113 hospitals nation-wide was conducted for this study. The results indicate that nursing expense exceeds 50% of the operating budget. See Exhibit 2.

Additionally, the number of uninsured and charity cases serviced by hospitals is rapidly growing; this presents additional and significant financial constraints. In Florida alone, costs associated with charity patients accounted for 54.9% of total uncompensated care costs, as discussed in 'Finance Health of Florida's Hospitals – overview (2000-2006).' See Figure 4.

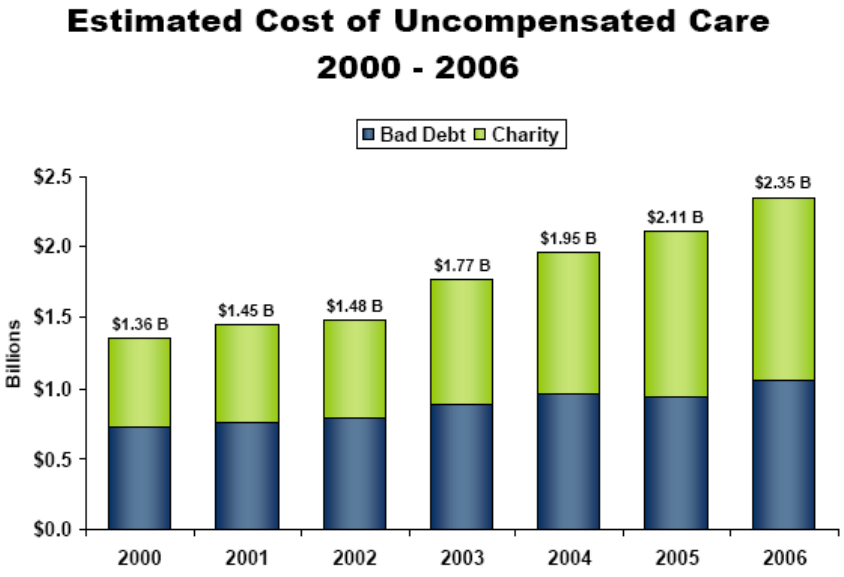


Figure 4: Cost of Uncompensated Care[i]

National data on hospital payment-to-cost ratios highlight that government payers pay less than what it costs to deliver care to their patients; nationally, hospitals received $.858 for every dollar of care provided to Medicaid patients in 2006, down from $.945 in 2000. As a result, the short-fall between payments and costs are passed on to private-pay patients. See Table 1.

Hospital Payment-to-Cost Ratios
U.S.
2000 - 2006

Year	Medicare	Medicaid*	Private Payer
2000	99.1%	94.5%	115.7%
2001	98.4%	95.8%	116.5%
2002	97.9%	96.1%	119.0%
2003	95.3%	92.3%	122.3%
2004	91.9%	89.9%	128.9%
2005	92.3%	87.1%	129.4%
2006	91.3%	85.8%	130.3%

Table 1: Payment to Cost Ratios

Current national, regional and internal health service solutions such as the "Travel Nurse" and "Internal Float Pool" do not address this problem as a vehicle to reduce nursing shortage. Rather, they exacerbate the limitations by pulling on the same group of graduating nurses, and leading the service to higher prices, which as mentioned earlier pose a different limitation on hospitals.

The solutions discussed up to now, result in one or more of the following problems:

- *Financial paradox*. Focus is placed on increasing recruiting effort by providing monetary or benefit reward that create a paradox with the mentioned financial constraints from managed care caps in health services, making it hard to make a profit or breakeven. This is evidenced by nurse staffing restructures whereby RN jobs are

replaced with lower-paid licensed vocational nurses (LVN) and ancillary staff to fill gaps in services rendered by eliminated nurses. (Charting Nursing's Future, 2007)

- *Lack of focus on patient quality outcomes.* Flexible schedules considered did not reflect unit patient needs and were often unbalanced, i.e. the fewest nurses were scheduled for the most frequently requested days off, Fridays and weekend shifts. (Kendrick and Hollabaugh, 1998) Other cases include nurse staffing restructures where collateral damage to patient quality indicators such as infections and number of falls were not considered. Exhibit 2, introduced earlier, indicated that 44% of the hospitals surveyed do not measure patient quality outcomes when making staffing decisions.

- *Gap-utilization.* Drivers for staffing patterns are not considered. Per Exhibit 2,
  1) Staffing patterns are largely driven by union contracts, where applicable (i.e. California and Florida). 88% of hospitals indicated that their staffing decisions is largely impacted by union or law mandate.
  2) Staffing policies and management are local to the immediate hospital, even within a system. 96% of hospitals indicated that staffing their staffing approach is local to the respective organization.
  3) Third party agencies (like travel nurse) and internal pools are used to cover shortages, as internal transfers are widely considered prior to seeking outside support. 39% of hospitals surveyed do not float nurses between units; and, 0% of hospitals float nurses between hospitals.

Chapter 3

Literature Overview

Healthcare financial concerns have been escalating since as early as the 1950s, inspiring academia interest with well-known and studied 'Nurse Staffing' and 'Nurse Scheduling Problem' (NSP). Where, the staffing problem has focused a high level staffing framework comprised of budgeting and planning, operational staffing/scheduling and daily allocation. The literature seeks to answer the almost grueling question: How many nurses do I need and how should they be scheduled? NSP, on the other hand, focuses on the daily allocation subset of a staffing framework, and aims to generate optimal nursing schedules that minimize nursing costs by managing patient demand and nursing supply. The motivation for the evolution of the problem lies in the belief that once an optimal schedule is achieved, it will lead to appropriate staffing levels.

The staffing problem is one that originated in the field of psychology, and has developed into an operations research modeling problem and evolution. The staffing problem and model essentially consists of defining the work to be done, identifying individual-level characteristics that are hypothesized to predict performance with respect to the work to be done, and developing measurement instruments to assess the relative standing of job applicants on each of the individual-level characteristics.(Cascio and Aguinis, 2008)

The problem exists (in some form) in every industry and business type; as, there is always a need to staff and match staff capabilities to required job functions. The general problem considers the following:

- Demand,
- Service Level,
- Service Length,
- Wait Times,
- Throughput,
- Customer Abandonment,
- Arrival times and Periods,
- Inventory,
- Impact on Quality and Regulatory Requirements,
- Customer Types,
- Forecast Potential and Past Relevance,
- Safety,
- Security,
- Staff Supply,
- Staff Variability,
- Staff Motivation.

A 2007 survey of nearly 37,000 employers in 27 countries by Manpower, Inc. found that 41% of them are having trouble hiring the people they need. (Cascio and Aguinis, 2008) A reason for this is the complexity of staff to job matching. Workers differ in their educational level, skills, speed, and/or quality, and they randomly leave, or turn over. Each period the firm must decide how many workers of each type to hire or fire in order to meet randomly changing demand forecasts at minimal expense. When the number of

workers of each type can be continuously varied, the operational cost is jointly convex in the number of workers of each type, hiring and firing costs are linear, and a random fraction of workers of each type leave in each period, the optimal policy has a simple hire-up-to/fire-down-to structure. However, under the more realistic assumption that the number of workers of each type is discrete, the optimal policy is much more difficult to characterize, and depends on the particular notion of discrete convexity used for the cost function. (Ahn, 2005)

Traditional developments followed manufacturing operations literature and practices, which state that 'customers will wait for as long as necessary to obtain a product (backordering).'(Armony, Plambeck, Seshadri, 2005) In service areas, this means customers calling will call back, or come back for service. This assumes a level of customer loyalty that is in disconnect with evolving competitive markets across all industries, including those once considered to be safe in status quo (i.e. healthcare).

Industry areas experiencing staffing problems include:

- *Call centers:* Every FORTUNE 500 company has at least one call center, which employs on average 4,500 agents. Call center agents represent 4% of the workforce in US, 1.8% in Israel and 1.5% in UK. More than $300 billion is spent annually on call centers worldwide, and about 70% of the money is human resource cost, such as agent hiring/training expense, compensation and benefit. (Shen, Huang, Lee, 2007)

- *Label switched path (LSP)* reservations in MPLS networks, QoS connections in two-tier ad hoc networks, and Service Level Agreements (SLAs) between peering autonomous systems are just a few scenarios where delays or costs in making adjustments suggest a proactive approach to resource allocation. (Chi, Fu and Walrand, 2004)
- *Next generation air transportation system.*
- *Routing and scheduling of vehicle crews.*
- *International staffing for venture capital management*, as they compete to a large extent on the basis of human resources.
- *Outsourced calling center service level agreements.*
- *Scheduling a routing workforce.*
- *Bus drivers.*
- *Military manpower planning.*
- *Casino security officers.*
- *Nurse scheduling and staffing.*

This study takes specific interest in the nursing application as pertains to HSOs; studied approaches thus far in academic literature are discussed, as well as the respective connection with NSP.

Academic literature shows there is great interest in both the nurse staffing and Scheduling problem, from as early as the 1950s. They are, however, studied with narrow isolated focus and solved for with different academic approaches (qualitative and quantitative,

respectively). In reality, however, staffing and scheduling problems have a dependency relationship; staffing policies drive constraints to scheduling solutions and/or decision variables. This contributes to a well-known disconnect between academic research and industry application: what researchers consider to be some of the most important scientific contributions in staffing are virtually ignored by practitioners. (Rynes, Giluk and Brown, 2007) Researchers believe that the responsibility for narrowing the much discussed academic–practitioner gap lies mainly with academics. (Cascio and Aguinis, 2008)

NSP involves the "construction of duty rosters for nurse staff and assigns the nurses to shifts per day maximizing the overall quality of the schedule. The quality of the schedule is measured by satisfying the nurses' personal requests as possible while violating the constraints as little as possible." (Meanhout and Vanhoucke, 2007) This was an evolution from nurse flexibility consideration to make available positions more attractive, as described earlier in section 2.1. Figure 4 showcases a sample of the interdependencies and flow of decision with respect to the composition of daily schedule optimization.

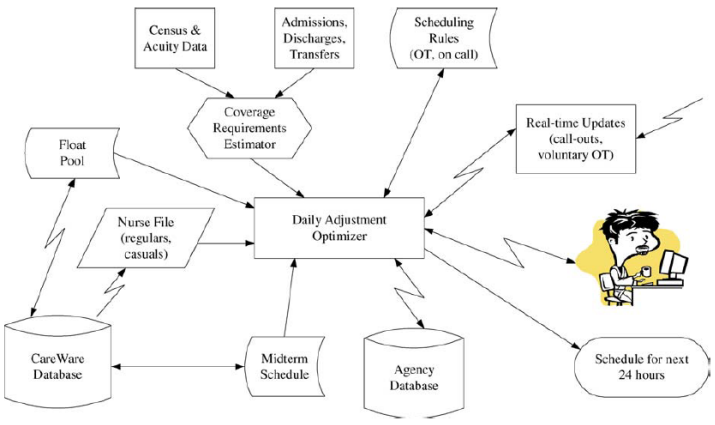


Figure 5: Orders of Demand

The orders of demand for Figure 5 follow:

1. Look for an internal unit volunteer
2. Try to reach casual per diem nurses
3. Float nurses from over staffed units
4. Contact unscheduled unit staff
5. Management call agency nurse
6. Exercise mandatory overtime

This conceptual algorithm varies by hospital and policy. Exhibit 2 showcases the fluctuation and local decision base for hospitals.

In its simplest form, the number of nurses staffed on any given shift must meet or exceed those needed per patient demand, while minimizing the total cost of the schedule:

$$Minimize \sum_{j=1}^{N} c_j$$

Subject to:

$$\sum_{j=1}^{N} x_j \geq d_i \text{ for } i = 1,2,....,M$$

$$x_j \geq 0 \text{ and integer for } j = 1,2,....,N$$

Where,

c_j = Cost of shift j,

x_j = Number of people working shift j,

d_i = Demand for staff in period i,

A_{ij} = $\begin{cases} 1 \text{ If shift } j \text{ calls for work in period } i, \\ 0 \text{ Otherwise.} \end{cases}$

The formulation appears simple. In reality, however, the complexity stems from the variation in the specific variables:

- The cost varies by skill level and/or specialization,
- There are multiple methods of determining patient demand - as mentioned earlier,
- Number of nurses staffed varies by patient load that in its self varies,
- The shift term (i.e. 8 hours, 12, hours, and combination of shift type within a given organization),
- As described earlier, schedules have flexed to nurse preferences. This is one of the larger limiting factors, as the schedule variation will vary based on specific employees, and relative managerial policies and approvals,
- Scheduling approach such as day-off, shift, tour, among numerous used in industry,
- Finally, staffing policies, which drive constraints to scheduling and decision variables, are known to be unique to state regulations and local organizational preferences with respect to strategic initiatives and nursing union policies. These variants add complexity to the scheduling problem.

NSP is NP-hard, as “most real-life scheduling problems are NP-hard, meaning that for even the moderate-sized problem, algorithms will find them difficult to solve, due to the

exponential size of the solution space. The non-linearity of the surface of the objective function, with many local optima, also makes solution difficult." (Aickelin and White, 2004)

In recent years, variant exact optimization and meta-heuristic methods have been applied to NSP, including well-known and studied scheduling approaches. The solutions have marginal improvements and cost-benefit balance. Exact optimization reaches optimal solutions, but become computationally complex and often infeasible due to the large number of constraints and scalability of the problem. The opposite is also true, meta-heuristic approaches are quick at yielding solutions, but are not likely to reach an optimal solution. The solutions mainly vary in application and assumption, but none have breakthrough solutions with real application. Appendix 1 shows a detailed list of relevant literature.

Staffing literature is qualitative in nature; contributions attempt at proving policy setting guidelines in order to ease the mismatch between staff needed and staff available.

Two of the approaches studied and implemented in practice have been academically studied: travel nurse and float pools; both are part of nurse staffing studies and were discussed in section 2.1. Other approaches include:

- *Hiring new graduates into float pools*: the approach is innovative in that historically seasoned nurses have shunned on the idea. This program resulted in a 96% retention rate. The program offered our medical surgical units a strong

> clinical support float nurse, our managers a staffing solution in times of need, and the new graduate RN a broad range of clinical experiences making them more valuable members of the healthcare team. (Crimlisk, McNulty, and Francione, 2002)

A first quantitative study that looks at the inter-relationship of staffing and scheduling was published in IEEE in 2007. (Cheng, Ozaku, Kogure, Ota and Kawahara, 2007) They realized that staffing levels are an impediment to the scheduling problem; their proposed method considers that "similar to job shop scheduling problems, nursing care scheduling problems can be defined as the constraints satisfaction problems to perform a set of nursing activities as planned in the worksheets. (Cheng, Ozaku, Kogure, Ota and Kawahara, 2007) The emphasis is on processing times of activities; and, constraints considered are traditional to the job (i.e. release time, procedure, capacity, due date, etc.), and since the view is changed from nurse to activity, the hard constraints due to nurse preference are ignored. Dispatching rule based methods are developed and tested. The method further supports the construction of an online system that supports the management of real-time activities to be managed by the nurse managers, as is done now. The tool and method serves as a form of empowering and equipping nurse managers with the ability to execute patient related activities in the required time period. The study is a significant contribution to the nurse scheduling problem as a focus on the specific problem and alignment to ease staffing policy, but has several limitation with include union restrictions and traditional nursing views and applications.

Summerizing the literature review, There exists a natural linkage between the nurse staffing and scheduling problem, but contributions have been evolved in isolation. Early literatures of the nurse staffing problem focused on planning and forcasting of patient load with specific metrics that isolate the variation that may than be transferred in to unmanageable execution of staffing and scheduling.

NSP, on the other hand , has had marginable contributions, but have not been practical applications for implementation, as most problems ease real-life constraints that make implementation infeasible.

Chapter 4

Proposed Method: Reducing Temporary Contracted Nursing Rate Exposure on HSOs Total Nursing Costs Through Hedging

Financial risk exposure in healthcare is a growing concern. The sensitivity of the exposure is largely associated with cyclical fluctuating nursing costs; the largest single component of hospital budgets, typically accounting for over 50% of all costs (Kazahaya 2005). Cost oscillation is associated with shortages of nurses occurring since World War II, as stated by the Kaiser Foundation. The current nursing shortage crisis first began in hospitals, intensive care units, and operating rooms in the late 1990s, but quickly spread to general medical and surgical units. (Jones, Juraschek, Lee, and W-H Lin, 2006) Some studies suggest that there are improvements (Buerhaus, Staiger, and Auerbach, 2003) in the current shortage. The *California Cooperative Occupational Information System* (CCOIS) data, however, do not indicate any significant improvement in the shortage from 1999 to 2003. Moreover, the United Kingdom, Canada, Australia, Southeast Asia, and Southern Africa are among many nations and regions that report nursing shortages of varying magnitudes. (Aiken, Clarke, and Sloane, 2002) This alludes that improvement in the nursing shortage and resulting nursing costs are likely intermittent and not sustainable in the long-term; squeezing profits with tightening reimbursement from the largest healthcare insurer in the nation.

The Centers for Medicare and Medicaid (CMS) has been facing funding constraints from rising costs of maintaining, continued expansion of eligibility criteria (increased number of individuals covered) and worsening economic conditions. The crisis has resulted in capitated rates and reduced program coverage since the mid 1990s. More recently, in February 2008 the California Legislature passed Welfare and Institutions Code section 14105.19, requiring the State Department of Health Services to reduce fee-for-service payments to Medi-Cal providers by 10%. This applies to most fee-for-service payments, with some exemption written in the statute. The legislation took effect in July 1, 2008.

HSOs address decreasing profits by restructuring models for providing nursing services, with limited or no attention to the potential impact on the quality of patient outcomes: the restructuring and reengineering during the 1990s resulted in the replacement of costly professional nurses with less-expensive unlicensed staff. The Institute of Medicine (IOM) expressed grave concern over the dearth of empirical evidence regarding these organizational changes. (Joseph, 2007)

The challenge lays collectively in the following fundamental problems: (1) there exists a natural linkage between the nurse staffing and scheduling problem, but literature contribution has been evolved in isolation for each respective problem type. (2) NSP practical application has been limited as most problems ease real-life constraints that make implementation infeasible and/or impractical. (3) staffing decisions are confounded between administrative and frontline roles. HSO

administrators determine staffing count, while frontline staff makes daily allocation decisions based on expert knowledge. Both functions are performed with conflicting goals since budget and planning intends to minimize cost and daily allocation simply finds nurses for patients with needs and cover nursing shortages by allocating temporary contracted nurses from third party nurse staffing agencies at market rates. This results in the posed risk of not having solvency for the nursing care needed to service patient need(s). Furthermore, "Forecasts are frequently prepared for the long-term, and thus, hospitals are unable to detect and respond to the short-term fluctuations. As a result, actual occupancy may run well below forecast for several months without adjustments being made…individuals are added to the staff in anticipation of an increase in patient load. Patient load, however, does not automatically increase at the time budgets are approved; rather, it increases gradually over the budget period." (Meglino, 1979)

This chapter introduces a revolutionary *hedging* application of temporary contracted nursing service costs (hourly rates) to protect HSOs financial exposure to rising rates. Hedging is a financial tool used to protect against risky price positions of core business costs. Many organizations use it as part of their corporate financing policy in order to maximize the value of the business. (Smith and Stulz, 1985) O*ption* agreements, with nursing service contracts as an underlying asset, are explored as a hedging approach to ameliorate solvency and financial stability without encroaching on individual HSO organizational structure and corresponding decision-making. The success of the study is assessed by its feasibility, practicality and applicability.

The *Nursing Options Approach (NOA)* improves HSOs' financial outcomes by yielding common derivative benefits such as lower costs, hedging to manage risk of price movements, synchronizing cash flows, etc. The method enables administration to plan for HSO needs, but protect them from the impact of day-to-day change and effect on the budget.

In order to deliver reliable conclusions about the feasibility, practicality and applicability of NOA, an empirical analysis is conducted using nursing hourly rates, gross nursing costs and demand as well as patient demand (measured using Patient Days) data from ten participating HSOs concentrated between Southern California (3), Arizona (1) and Florida (6).

The ten participants selected for the study consist of a wide variety of HSO types within complex medical service geographic regions: one 2,200-bed Public Academic Medical Center (HSO 1), one Public Ambulatory Medical Center (HSO 2), One 400-bed Public Critical Care Hospital (HSO 3), one 100-bed Public Rehab Center (HSO 4), one 700-bed Public Adult Medical-Surgical Hospital (HSO 5), one 350-bed Private-for-Profit Hospital (HSO 6) - used for the pilot implementation, one 316-bed Not-for-Profit Acute Care Hospital (HSO 7), one 334-bed Not-for-Profit Hospital (HSO 8) with primary service lines in Heart, Cancer, Spine and Women's Health, one 411-bed Not-for-Profit Hospital (HSO 9), and one 389-bed Not-for-Profit Hospital (HSO 10).

The number of data points within the "data set" for each HSO varies between 8 and 48 months, and spans back within the last 24 to 36 months.

The study begins with an explanation of the HSO budget process and illustrates opportunity for financial losses based on the behavior of nursing demand and temporary contracted nursing rates with their impact on gross (total) nursing costs. Thereafter, this chapter presents a mathematical statement for quantification of nursing costs and budget disparity; followed by demonstration of NOA feasibility and practicality: (1) *feasibility* is determined by validating nursing services as an underlying asset to options agreements using underlying asset (securities) base criteria; and, (2) *practicality* is deciphered by the applicability of NOA pricing for sale and purchase; this is achieved by building on the Black-Scholes options pricing model and testing its underlying asset criteria using the characteristics of nursing services and their corresponding rates.

Applicability is addressed later in Chapter 5 with the illustration and results from a pilot implementation experiment in the 350-bed HSO 6, which highlights that even with rising nursing needs and variable rates, budget disparity can be minimized and overall costs can be reduced with NOA. Facts about the experiment are used in discussion throughout this chapter for illustrative application of NOA concepts throughout this chapter.

Budget Process

Budgets extend over a predetermined period of twelve months based on calendar or fiscal years, and are commonly assessed monthly. Ideally, monthly and complete period budgets are satisfied or have minimal disparity. This is practical with uniform demand and constant pricing; but is unlikely where demand is a non-uniform random variable, or is seasonal, with non-constant pricing. The actual is a complex moving target that is difficult to meet at each monthly assessment. For HSOs, nurse-staffing (allocation) decisions are reactive with minimal planning on a short-term basis (daily, weekly and monthly). This impacts financial outcomes as measured by budget disparity:

Criteria:	Minimize nursing cost budget disparity
Test:	Budget Disparity = [Nursing Budgeted Cost - Actual Nursing Cost]
Decision:	If Budget Disparity > 0, budget disparity analysis is conducted.

A budget department with administrator input and approval typically determines Full-Time Equivalent (FTE) nursing staffing levels for departments, and HSOs in aggregate, during the budget and planning period for a following forthcoming budget year. Once completed, they are given to the respective departments as a measure of their corresponding success. When the “new” budget period begins, the following daily allocation decisions are taken by front-line management based on expert opinion to meet patient needs: (1) calculate patient volume variability from budget, (2) determine the number of FTEs needed to meet patient demand, (3) if increase in

nurses is needed, offer overtime at the additional rate, (4) if no overtime is available, hire temporary contracted nurse at going rate. Traditionally, staffing was primarily added to meet shortage; today, HSOs preferably staffing to flex up and down in affiliation with patient demand.

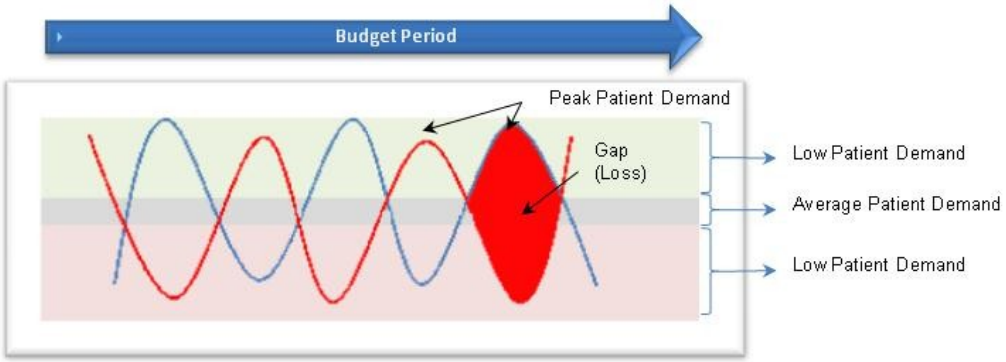


Figure 6a: Budget Period

Shortfalls in the current staffing methodology include: (1) budget decisions for an upcoming budget period are executed in the imminent time frame and may conflict with current environment needs. If a decision to hire is made, additional costs may be incurred that are not needed at the current time. (2) HSOs commonly staff FTE nurses to either peak or average patient demand, but must cover all demand levels. HSOs that staff to peak demand have patient needs covered at all times, whereas those that staff to any level below peak must cover nursing shortage with temporary contracted nurses. Figure 6a, visually depicts the budget period with demand cycles and staffing methods, and shows potential losses. Analyzing organization A within Figures 6a and 6b, staffing FTE nurses to peak patient demand results in losses for all non-peak demand cycles, the entire red section below the top peak point in Figure 5a is a

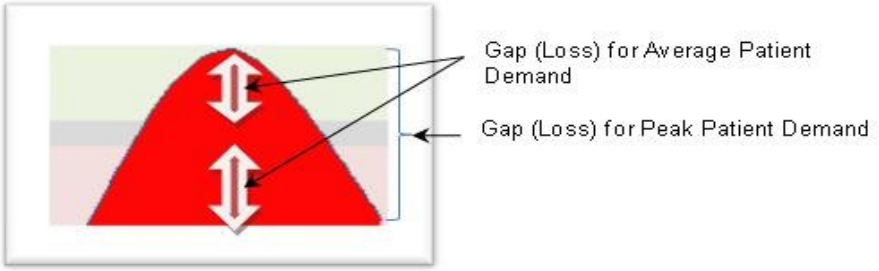


Figure 6b: Potential Losses

financial loss because nursing expenses are incurred with no corresponding need; whereas, staffing to average patient demand generates a gap (loss) above and below the average demand as indicated in Figure 6b. Losses below the average are due to having more nurses on payroll than needed; while losses incurred above the average result from a planned shortage that forces facilities to pay premium (volatile) prices for temporary contracted nurses. All of the participants in this study staff FTEs to average (or approximate), and are exposed to temporary contracted rates.

The impact temporary contracted nursing rates have on total nursing costs is assessed with a correlation analysis of the two metrics across the ten HSOs. The correlation coefficients are listed in Table 2. Participants' correlation coefficient vary. The differences may be due to: (1) data count disparity (number of data points), (2) characteristic differences across HSO type, (3) geographic location, and (4) staffing practices.

Table 2: HSO Correlation Analysis

HSO	Total Nursing Costs and Temporary Nursing Rates
HSO 1 ρ=	.78
HSO 2 ρ=	.78
HSO 3 ρ=	.70
HSO 4 ρ=	.65
HSO 5 ρ=	.72
HSO 6 ρ=	.90
HSO 7 ρ=	.61
HSO 8 ρ=	.63
HSO 9 ρ=	.38
HSO 10 ρ=	.37

Table 2: HSO Correlation Analysis

HSO characteristics and data points are inspected to understand the differences among the correlation coefficients: (1) HSOs 1 through 5 have less than 24 data points (ranging between 8 and 22), where HSO 6 through 10 have between 36 and 40 data points. HSO 6 has the highest correlation; it is not likely that the number of data points highly influences the affinity. (2) The characteristics of HSO 6 through 10 are also closely related based on number of beds and services offered, and they have disparate correlation results. HSO type is, therefore, not likely to largely influence the relationship between temporary contracted nursing rate and total nursing costs. (3) HSOs 7 through 10 are in different geographic locations, but HSO 7 and 8 have similar correlations, as do HSOs 9 and 10; this is not likely to be a strong factor. (4) staffing practice, on the other hand, is a strong factor in the correlation, as HSOs 9 and 10 increase FTEs to approximate peaks. Staffing to peak reduces temporary

contracted nursing service price exposure, but is not cost effective or feasible in high nursing shortage cycles. The correlation analysis supports that temporary contracted nursing service rates have a strong impact on total nursing cost.

Individual Moving Range (I-MR) control charts are used in Figure 7 to determine the degree and type of volatility of temporary contracted nursing rates. The control charts illustrate the individual moving values of the rates (top chart) and moving average of the range between rates (bottom chart). The centerlines represent the average of both the individual values and the moving range; the top and bottom lines are the upper and lower control limits. Data points that fall outside of the upper and bottom control limits are out of control and a special cause of variation. Temporary nursing rates across HSOs exhibit random individual values and moving range behavior. Temporary contracted rates have a significant impact on total nursing costs, and considerable expected variability (volatility) that heightens HSOs' risk exposure to temporary nursing rates.

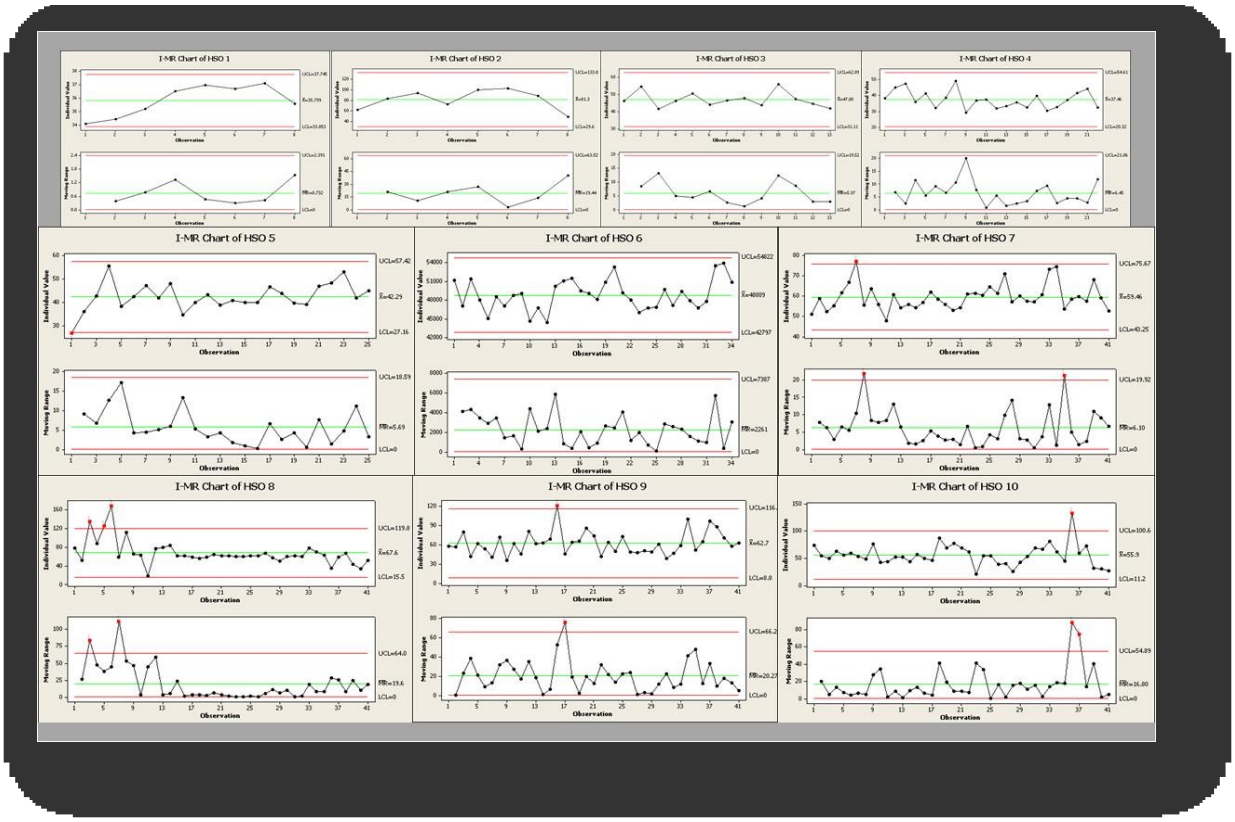


Figure 7: HSO Blended Temporary Nursing Rates I-MR Charts

To gain further insight, a comparison of FTE versus temporary contracted rates is conducted (Figure 8). With the exception of HSO 2, public participants have higher FTE rates than temporary contracted rates; this could be a consequence of largely driven union wages. These participants are less likely to be affected by lower FTE staffing to cover shortage with temporary contracted nurses, but the variable nature of the rates does represent some risk. In the case of HSO 2 and all non-public participants, temporary contracted rates are above FTE rates; coupled with their current staffing method, these participants are exposed to losses from temporary contracted rate volatility.

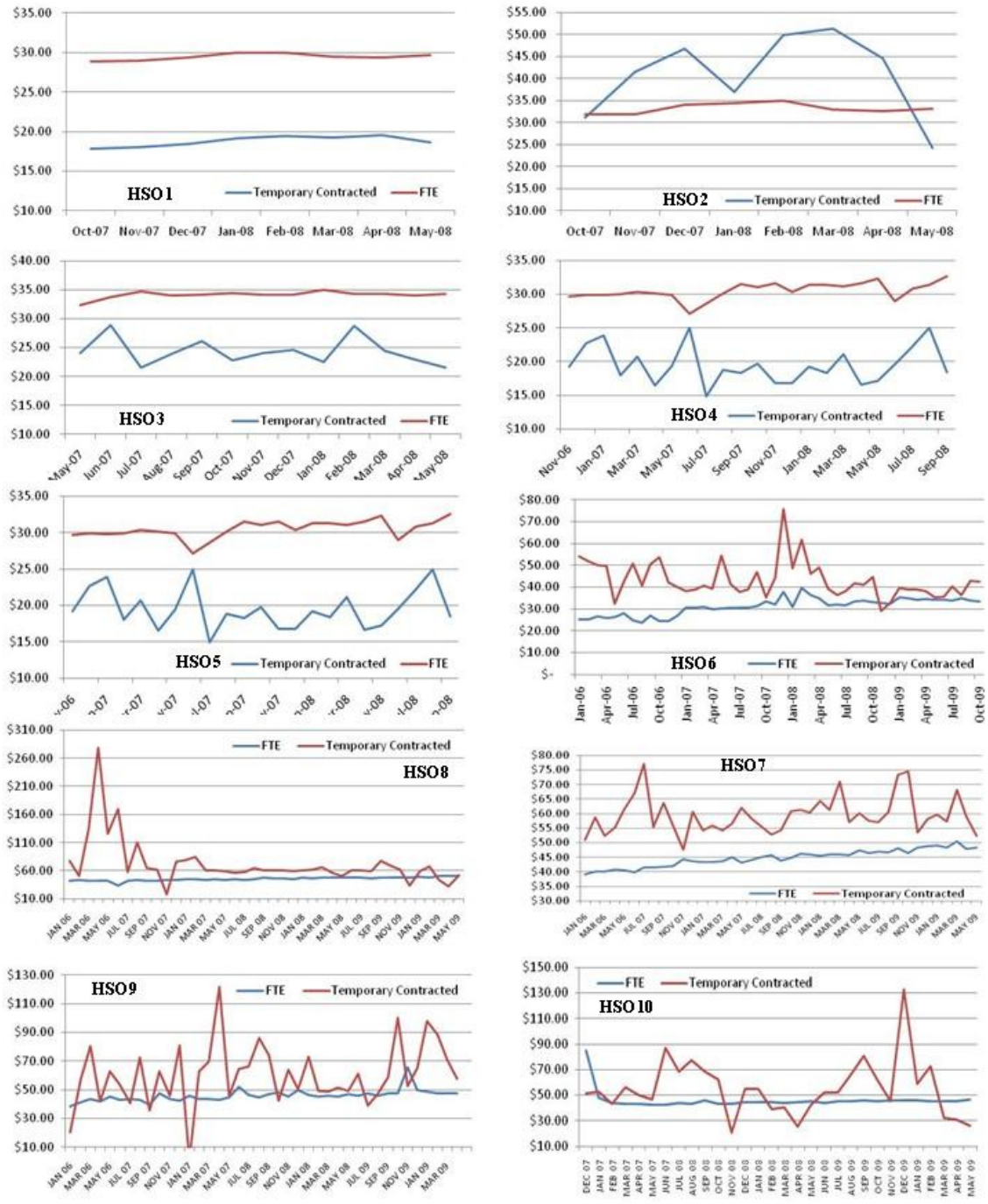


Figure 8: Temporary Nursing Rates versus FTE Rates

Nursing Cost and Budget Disparity Mathematical Statement

Temporary contracted nursing services are pulled from the open nursing market at the "Nursing Spot (Current) Market Rate" (the "Spot Market") across all nursing types, based on training and specialty (experience): these "spot rates" are herein described as random variables S_m for $m =$ 1 to M types of nursing. S_m is the price process for the m th nursing type and is noted as $S_m = \{ \ (t) : 1, ..., T \}$ with k possible states: $\Omega = \{ \ , ..., w_k \}$.

Consider an HSO with multiple departments, such as a hospital, and assume two nursing types (pediatrics and intensive care), the nursing cost for a department is the number of hours for each respective nursing type times the corresponding hourly rate for FTE and temporary contract nursing hours. Generalizing over M nursing types for $t = 0$ to $t = T$, the total nursing cost incurred within a department is

$$C(t) = \sum_{m} \ _{0m}(t) S_{0m} + T_m(t) S_m(t)) \qquad \text{for } t = 0 \le t \le T \tag{1}$$

and, aggregate nursing costs over all departments within HSOs is the cumulating the function C over N departments at time t; the total cost over N departments and M Nursing types is

$$C_{Total}(t) = \sum_{n} \sum_{m} \ _{0nm}(t) S_{0m} + T_{nm}(t) S_m(t)) \qquad \text{for } t = 0 \le t \le T \tag{2}$$

Where,

$E_{om} =$ Number of FTE nursing hours worked for nursing type $m = 1$ to M,

$E_{onm} =$ Number of FTE nursing hours worked for nursing type $m = 1$ to M in department $n = 1$ to N,

$T_m =$ Number of temporary contracted nursing hours worked for nursing type $m = 1$ to M,

$T_{nm} =$ Number of temporary contracted nursing hours worked for nursing type $m = 1$ to M in department $n = 1$ to N,

$S_{om} =$ Hourly cost for FTE nursing hours for nursing type $m = 1$ to M. This cost is subject to increases based on raises, benefits, etc,

$S_m =$ Hourly cost for temporary contracted nursing hours for nursing type m; this rate is subject is based on the spot market for nursing type $m = 1$ to M.

Total actual cost C_{Total} is compared to the total budgeted cost C_B to yield the budget disparity θ_{Total} for the given budget period; the same applies at the department level using

$C_{B(n)} =$ Nursing cost budget for department $n = 1$ to N,

$C_n =$ Nursing actual cost for department $n = 1$ to N,

$\theta_n =$ Department budget disparity for department $n = 1$ to N.

The total and departmental budget disparity is

$$\theta_{Total} = \left[\; _B - C_{Total} \right] \tag{3}$$

$$\theta_n = \left[\quad_{B(n)} - C_n \right] \tag{4}$$

$$\theta_{Total} = \left[\quad_B - C_{Total} \right] = \qquad \sum_n \quad_n = \sum_n \quad_{B(n)} - C_n \right] \tag{5}$$

Nursing costs and budget disparity continuously change with nursing rates and regular nursing utilization. Nursing costs and the respective nursing budget disparity are referenced over a period of 0 to T in order to measure the flow of outcomes. (3) through (5) is expressed cumulative over a given time period, or budget term, as

$$\int_0^T \theta_{Total}(t)\,dt = \int_0^T \left[\quad_B(t) - C_{Total}(t) \right] dt \tag{6}$$

$$\int_0^T \theta_n(t)\,dt = \int_0^T \left[\quad_{B(n)}(t) - C_n(t) \right] dt \tag{7}$$

Where,

$$\int_0^T C_{Total}(t)\,dt = \int_0^T \sum_n \quad_m \quad_{0nm}(t)S_{0m} + T_{nm}(t)S_m(t) \right] dt \tag{8}$$

$$\int_0^T C_n(t)\,dt = \int_0^T \sum_m \quad_{0nm}(t)S_{0m} + T_{nm}(t)S_m(t) \right] dt \text{ for } n = 1 \text{ to N} \tag{9}$$

Then,

$$\int_0^T \theta_{Total}(t)\,dt = \int_0^T \left[\quad_B - \sum_n \quad_m \quad_{0nm}(t)S_{0m} + T_{nm}(t)S_m(t) \right] \right] dt \tag{10}$$

$$\int_0^T \theta_n(t)\,dt = \int_0^T \left[\quad_{B(n)} - \sum_m \quad_{0nm}(t)S_{0m} + T_{nm}(t)S_m(t) \right] \right] dt \tag{11}$$

$S_m \rightarrow \infty$, (8), (9), (10) and (11)$\rightarrow \infty$, and is considered a worst case budget disparity; a best case is observed as the limit tends to a minimum constant a, or a pre-established constant a based on business parameters.

In the current healthcare economic crisis, staffing FTEs to peak demand is not realistic, but neither is the exposure to S_m, leading to high levels of θ_{Total}. The goal is to mitigate financial losses due to S_m volatility and control θ_{Total} by introducing traditional hedging techniques to nursing services.

Hedging Approach

The atypical application of hedging to nursing services minimizes HSO budgetary exposure to nursing rate volatility and mitigates exposure to S_m.

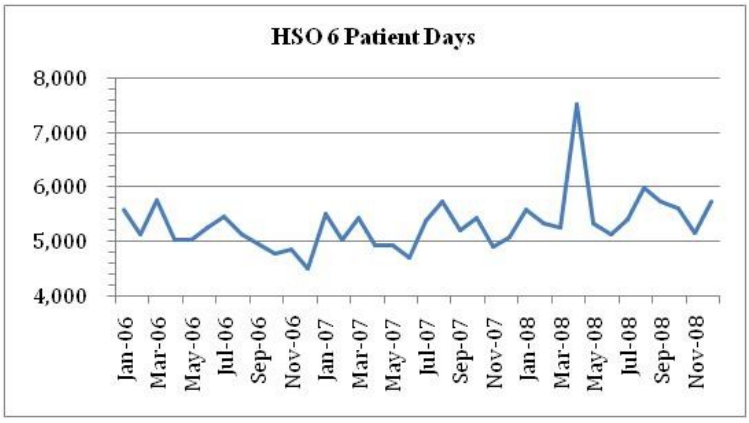


Figure 9: HSO 6 Unit FTEs

Given the volatility of patient needs (see Figure 9) and the corresponding staffing fluctuations, the focus herein is on agreements that give HSOs the right to purchase or sell nursing services at a predetermined exercise rate (strike or exercise price) within

a period of time – formally an option. Generally, the right to "purchase" is known as a call option and the right to "sell" is a put option. These options give the purchaser (holder) the right to buy or a sell the underlying asset at the fixed strike price. Regardless of the holders choice, the seller of the option (call or put) must sell or buy the underlying asset as stated in the agreement. A failure to adhere to the agreement is deemed a default, and is a known risk of derivatives.

Call options protect HSOs and their units/specialty areas from upward price movements by providing the ability to take delivery of nurse services at strike price, or settle for the cash equivalence. Selling options offset payroll expenses by receiving a premium from the sale of the contract. See Figure 10. Selling an option is riskier for an HSO than buying one, since if a delivery is exercised, the HSO will have to deliver the nurse services or offer the cash equivalent.

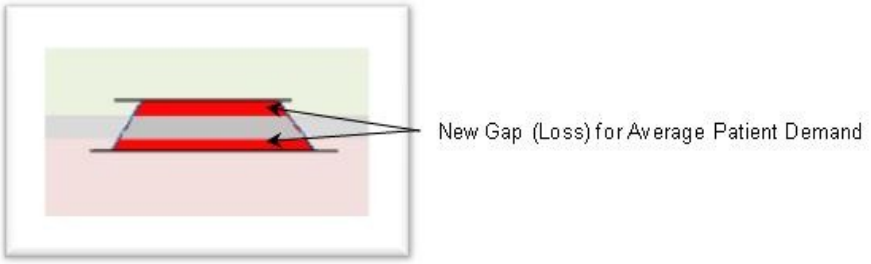


Figure 10: Mitigated Losses

Nursing market makers are primarily comprised of HSOs and third party nurse staffing agencies; this is where the bulk of the nursing exchange occurs. In the exchange of nursing options or nursing services (assets), sales transactions can be established between HSOs and third party agencies. Traditionally, temporary contract nursing services have been pulled from third party agencies and are herein also

referred to as the nursing "Spot Market;" the associated hourly rates (prices) are "Spot Market Rates" or "Spot Rates (Prices)."

There are four commonly known types of underlying assets (listed in Table 3). The underlying assets satisfy three criteria that deem them valid for exchange and appropriate for use in a derivative: (1) Mutual exchangeability, (2) Liquidity, and (3) Price variability.

Type	Characteristics	Exchange Platform
Commodities	• Are wholesale physical goods, grown or manufactured and processed. Examples are grains, metals, foods. • Difficult to take delivery. • Not highly liquid.	• Exchange (i.e. Chicago Board of Trade, New York Mercantile Exchange)
Interest Rates	• A charge for borrowing money from another party. These vehicles are known as loans or bonds, and are a form of debt. The money borrowed is known as the principal, and the charge for borrowing, "interest rate," is based on a percent of the borrowed amount.	• OTC • Exchange
Foreign Exchange	• Currency from all countries. • Highly liquid	• OTC • Exchange
Equities	• Corporate Shares (% company ownership)	• OTC • Exchange

Table 3: Underlying Assets

Following the same criteria for nursing services, are nursing services (1) Mutually exchangeable? As discussed in Chapter 1 and illustrated in Figure 1, nursing work is assignable based on a predetermined training and experience criteria to patient needs – specialty clusters. Within these criteria, nurses are mutually exchangeable, as any nurse with the required credentials can care for the respective patient populations. (2) Liquid? Are there always buyers and sellers? As long as there is fluctuation in the nursing market, there is someone needing to buy and someone wanting, needing or willing, to sell. The random nursing demand behavior is exhibited for all participants in Figure 11; this is an indication that there is nursing service liquidity. (3) Prices variable? The spot market rate volatility seen in Figures 7 and 8 offer evidence that nursing spot market rates are variable.

Based on these criteria, nursing services can be exchanged and used as an underlying asset in derivatives; and, options are a viable approach to reduce price volatility exposure.

Table 3, lists the available and corresponding exchange platforms for underlying assets. These platforms are used for the exchange of both assets and derivatives: (1) Over the Counter (OTC) agreements - privately structured agreements between two parties that indicate particulars on how a transaction is to be settled in the future. (2) Mercantile exchange – a market place with buyers and sellers (i.e. New York Stock Exchange or the Chicago Board of Trades).

Exchange of derivatives has two primary risks: (1) The hedged position moves against you. For example, in Figure 7 on April 2008, temporary contracted rates dropped below FTE rates for HSO 10. In this case, a nursing shortage is covered with spot market nurses versus exercising NOAs. (2) The counter party fails to deliver on contract terms; this risk is lessened with backup option agreements.

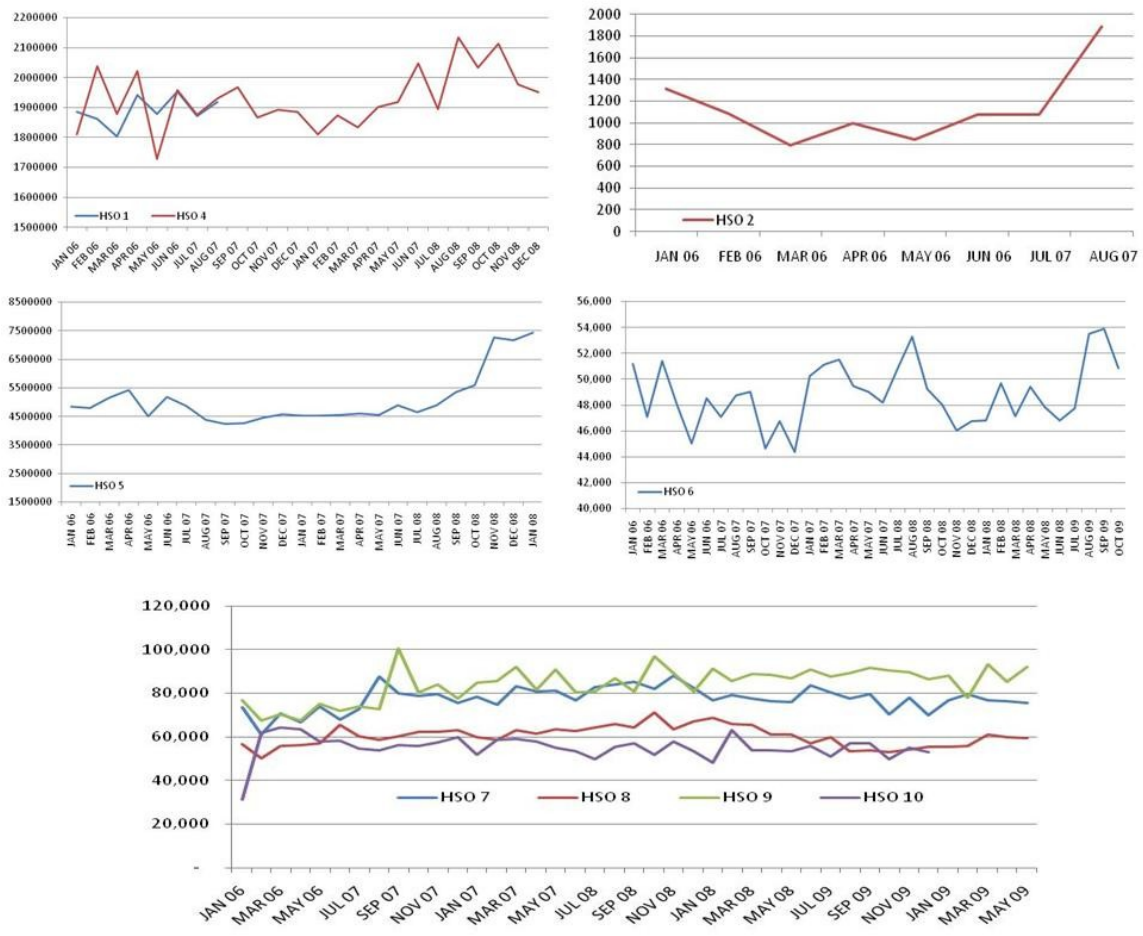


Figure 11: Nursing Market Place (Hours)

Options control price exposure risk and financial outcomes; but, can they be valued in a standard form for purchase and sale? The practicality of NOA pricing is explored

using Black-Scholes by validating the model's fundamental assumptions for underlying assets.

Derivative Pricing Models

Options provide a decision (not obligation) to buy or sell an underlying asset; the "optional" characteristic creates unpredictable price paths with uncertain events of occurrences, which makes pricing complex.

Basic pricing rules/guidelines include: (1) The value of an option is between zero and the price of the current market price of the underlying asset. Intuitively, if the value of an option is greater than the current market price of the underlying asset, then it makes sense to purchase the underlying asset instead of the option. (2) The longest time to expiry is infinity. In the nursing application, this means that positions can be established to overlap budget years.

Options are priced based on their Intrinsic and Time Value. Intrinsic value is the difference of the underlying asset current market price and the strike or exercise price. A call has intrinsic value if the price of the underlying asset (the underlier) exceeds that of the strike price; then, the intrinsic value is the difference between the price of the underlier (S) and the strike price (K): Max(S – K, 0). The reverse is true for a put. A put has intrinsic value if the strike price is greater than the price of the underlier; and, the intrinsic value is the Max(K – S, 0). At time of expiration the only value an option has is Intrinsic, and the option is said to be "in the money" (ITM). Assuming a

strike price of $25 per hour for an NOA call and the October 2009 spot market rate of $42 per hour for HSO 6, the NOA is ITM. The intrinsic value at that point in time is $42 less $25, or $17 per hour. The two other likely call positions are when the strike price is equal to or less than the price of the underlying asset. In these cases, the call is said to be at the money (ATM) or out of the money (OTM), and neither have intrinsic value.

Time value, on the other hand, is the worth of potential upside with covered downside; it is the price paid to cap otherwise potential losses – this is largely driven by price volatility. It is the cost of planning or having a win-win position. The longer the agreement term, or time to expiration, the higher the time value. At expiration, there is no time value, and the only value that can exist is intrinsic.

Options are only exercised when there is intrinsic value; otherwise, the premium paid serves as an insurance policy and offers protection against price hikes. Referring back to Figure 8 and maintaining the experimental strike price of $25 per hour for a call: in HSO 10, the price spike in December 2009 to about $130 per hour would not have affected the participant. The holder, in this case HSO 10, may exercise or sell the option for a profit. Selling the NOA represents additional monies (revenue) to offset payroll by the value of the option.

$$\text{Option Value} = \text{Time Value} + \text{Intrinsic Value} \qquad (12)$$

The Black Scholes is quite accurate and widely used in pricing European calls and puts. The notation varies across publications. Macbeth and Merville (1979) conducted one of the most extensive empirical applications of the Black Sholes model showcasing the degree of accuracy of the model with respect to its time and intrinsic value: “Empirical Examination of the Black Scholes Call Option Pricing Model.” The notation used is carried in the NOA.

Black Scholes is based on the notion that for any given time period t, the value of a (European) call option is a deterministic quantity based only on the current value of the underlying asset and the time remaining to expiration. The assumptions for the underlying asset(s) are: (1) Cash can be borrowed and lent at a known constant risk-free interest rate, (2) Prices follows a geometric Brownian motion process with constant drift and volatility, (3) There are no transaction costs, (4) The asset does not pay a dividend, (5) All assets are perfectly divisible (i.e. may have fractioned amounts), (6) There are no restrictions on short selling, (7) There is no arbitrage opportunity.

The fundamental idea behind the pricing is to establish a value equal to the price of a leveraged asset portfolio that replicates the payoff of an option. The quantifiable market value of a call option $C(S,t)$ depends on market value of the underlying asset S, the strike price K, time to expiration t, the short-term (continuous and constant) interest rate r, the variance σ^2 of the rate of return for the underlying asset, and the cumulative normal density function $N(d_i)$ evaluated at d_i. Referencing formula

(13), $C(S,t)$ is the difference between the expected value of receiving the asset, in this case nursing services hourly rates, in the event of non-exercise ($S \bullet N(d_1)$) less the cost of paying the strike price in the event of exercise $Ke^{-rt} \bullet N(d_2)$. $N(d_i)$ is the cumulative normal density function at d_i. Intuitively, as the probability of exercise (paying the strike price) increases, so does the value of the Option.

$$C(S,t) = S \bullet N(d_1) - Ke^{-rt} \bullet N(d_2) \tag{13}$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(+ \sigma^2 / 2\right)t}{\sigma\sqrt{t}} \tag{14a}$$

$$d_2 = d_1 - \sigma\sqrt{t} \tag{14b}$$

Later developments of the Black Scholes approach with non-constant interest rate and drift, as well as and applicability to other types of option (non-European) have been explored. These extensions are out of the scope of this study.

In application of NOA, S is replaced with S_m. Assume the strike price of $25, a 12 month out expiration, and use HSO 6 return volatility for 2006 and 2007 budget period (.03). Inserting this data into Black Scholes call formula, the NOA call price with a spot market rate of $22.95 is $1.005 per share (in this case hour); option prices decline rapidly as the date of expiration approaches.

Practically, the total price of a call option for 1,000 nursing hours is $1.00 x 1,000 = $1,000. Assuming an FTE rate of $30 per hour, purchasing an option is significantly

less expensive than carrying the equivalent on staff: 1,000 x $30 = $30,000.

Exercising the option yield a cost of the strike price plus the premium; if it expires without exercise, the premium is the only cost incurred. In general, it is more cost effective to staff below peak and carry options.

The assumptions of the underlying assets are validated: (1) Cash can be borrowed and lent at a known constant risk-free interest rate? There is no reason to assume otherwise, as health service organizations borrow and lend money through bond issuance and purchases. (2) Do prices follow a geometric Brownian motion process with constant drift and volatility? In order for this to be tru, the natural log of the nursing spot rate at $t+1$ less natural log of the nursing spot rate at t over a series of data must be normally distributed. This criteria was tested for all ten HSOs using the anderson-darling normality test; and, with the exception of HSO 8, the differences of the logs can be reasonable assumed normally distributed with a p-value greater than .05. The results are displayed in Figure 12. HSO 8 was tested using the last twelve months of data points, and the differences of the logs were normally distributed. Prices can, therefore, be assumed to follow geometric brownian motion and appropriate for valuation with the Black Scholes model. (3) There are no transaction costs. There is no charge other than the price itself to use nursing services (i.e. sales tax). (4) The asset does not pay a dividend. Nursing is a form of expense. So, it will not yield dividends. (5) All assets are perfectly divisible (i.e. may have fractioned amounts). Nursing use is fractional, as a fraction of a nursing hour maybe hired. (6)

There are no restrictions on short selling. There is no stipulation prohibiting the short-selling of a nursing position. Nursing services can be offered without having the nurse on staff. (7) There is no arbitrage opportunity. This is true within geographic locations, although there may be pricing discrepancies across geographic location such as California versus New York.

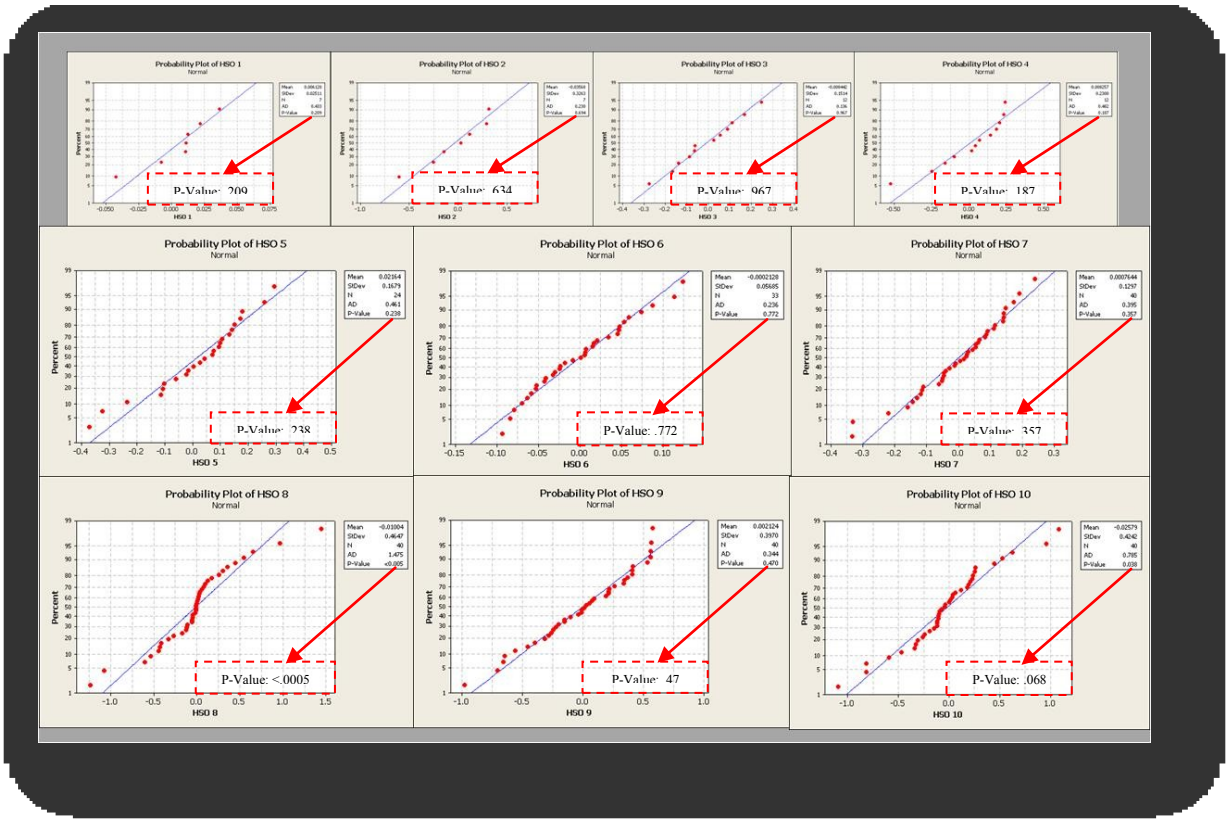


Figure 12: Nursing Spot rate Natural Log Difference Normality Test

Chapter 5

Computational Results: Experiment (Pilot) Findings

Reducing expenses has been a consistent focus for HSOs. Many organizations achieve it by reducing labor, improving efficiencies, etc. In the last quarter of 2007, HSO 6 committed to reducing costs through a structured project that reduced exposure to Temporary Contracted Nursing Cost as discussed in Chapter 4. The experiment was championed by the Hospital's Chief Executive Officer and Chief Nursing Officer and began with an in-depth study of Temporary Contracted Nursing Usage and Hourly Rates as well as their impact on Total Nursing Costs. The goal was to reduce total Temporary Contracted Nursing Costs by 10%, which translates into a savings in excess of $500,000 per annum.

The initiative began by an in-depth analysis of the nursing allocation process and study of Temporary Contracted and FTE Nursing Rates, Gross Temporary Contracted and FTE Nursing Costs, and Nursing Hours Used (Temporary Contracted and FTE) data from January 2006 through September 2007. The problem description followed that there are large numbers of nursing vacancies that have not been able to be filled and have led to improper scheduling and scheduling gap management process; this resulted in excess of 40% fill rate of needed positions. These positions were filled using Temporary

Contracted Nursing Services and led to over $5,000,000 of unplanned nursing costs (Budget Disparity).

The nursing allocation process was formalized as:

Step 1: Nursing Directors Complete Schedule,

Step 2: Nursing Directors call staff nurses to fill vacancies with Overtime and Bonuses (This is as or more expensive then Temporary Contracted Nursing Services),

Step 3: Nursing Supervisor gets Administrative Approval for Temporary Contracted Nursing Hours,

Step 4: Nursing Supervisors Contract Temporary Nursing Services.

The core drivers for shortage leading to need for Temporary Contracted Nursing Services were identified as: (1) Vacant Positions, (2) Scheduling, (Increase in Census), (4) Sick Calls and (5) Lack of Compliance to Policy. These drivers and Temporary Contracted Nursing Usage were broken down by department, and Critical Care and Emergency were identified as the priority problem areas with Telemetry, Labor and Delivery, Ambulatory, Recovery Room and Oncology following shortly. The data was also analyzed by week day and weekend and it seemed that week days were more problematic throughout all shifts; and, though the problem existed throughout all months, it was more prominent in July, August, March, May, April, January, February and June. Some drivers are more pertinent in some departments than others.

Specifically, 2006 ICU/ CCU accounted for over 35% of Temporary Contracted Nursing Usage and 28% in 2007; 2006 weekdays accounted for over 30% and over 35% in 2007; the mean Temporary Contracted Nursing Usage was 8% in 2006 and rose to 13% in 2007.

The data evidenced that though the HSO's intent was to fill vacant positions, there needed to be a plan to reduce exposure to Temporary Contracted Positions in order to reduce costs and have predictable outcomes. In order to achieve this, an OTC Agreement was established with a Third Party Agency that would enable the HSO to draw the nurses needed for the respective departments. The agreement extended over a period of one year with five renewals and allows the organization to contract temporary nursing services at an FTE equivalent rate. HSO 6 arranged to pay a premium rate per nursing hour used in addition to the pre-negotiated nursing rate.

The agreement is a form of the NOA discussed in Chapter 4 and can be considered a Call Option. The Call Price (Value) is captured using formula (13) with the following inputs, based on the data mentioned earlier in this chapter:

1)Spot Price (S) = \$22.95

2)Strike Price (K) = \$25.00

3)Volatility (σ) = 19%

4)Risk-less Rate (r) = 1%

5)Term (t) = 1(Year)

The resulting Call value (\$1.005) is multiplied by the anticipated number of temporary

contracted nursing hours (84,472) based on prior annual data, to yield the contract premium value ($1.005 x $84,472 = $84,894.36).

The premium is paid whether or not the nursing services are utilized (that is, the NOA is exercised). At the time of the nursing use, the strike price is paid for the used number of nursing hours.

Year	Patient Demand	Budget ($)	Budget (No.)	Actual ($)	Actual (No.)	Diff. ($)	Diff. ($,%)	Diff. (No.)	Diff. (No, %)
2006	61,409	$13,029,691	3,135	$17,019,420	3,597	$3,989,729	31%	462	15%
2007	62,257	$13,774,488	3,213	$17,797,453	3,722	$4,022,965	29%	509	16%
2008	67,774	$15,729,652	3,450	$18,022,520	4,015	$2,292,869	15%	565	16%

Table 4: HSO 6 Savings Analysis

The experiment results after ten months are displayed in Table 4. In 2008, the budget allowed for $15,729,652 with 3,450 in nursing use. The actual nursing use was higher

Table 4: HSO 6 Savings Analysis

than expected by 565. Using the market rate at the time ($48 per hour), the total incurred nursing costs would have been approximately

$20,070,849; compared to the allowed budget using (3), the budget differential θ_{Total} would have resulted in -$4,341,197. Instead, the shortage was covered with a strike price of $25 per hour; and, the total nursing cost incurred for 2008 was $18,022,520. The actual θ_{Total} was $2,292,869, a 14% reduction from the prior year differential %; with the same nursing use differential of 16% from the prior year.

This application was extended to the other HSOs, and estimated an average per annum

savings ranging from $72,493.60 to $2,494,798.25. The savings were calculated by taking the difference between the experiment strike price and the respective month spot market rate for the corresponding HSOs. This difference is then multiplied by the total number of Temporary Nursing Hours used. The savings results are compared to the corresponding correlation coefficients for the respective HSOs, and it is observed that the greatest savings were yielded by the participants with the highest correlation coefficient between Total Nursing Costs and Temporary Nursing Rates. These can, therefore, be used as an indicator for organizations seeking to implement the concept; any coefficient in excess of 70% is likely to yield sizable savings. Further, not all organizations have equal characteristics or revenue potential; that is, an approximate savings of $72,493.60 for a 100-Bed Rehab Center that has approximate Gross Revenue of $100MM is relative to a savings of $2MM for a 2,200-Bed system with about $2 Billion in Gross Revenues. The proposed application, thus, shows significant relative savings across HSOs with no change or intrusion to the allocation process; and concludes that it is *applicable*.

Chapter 6

Closing Remarks

The motivation for this study originated from a consistently growing financial concern that connects to healthcare, and its linkage to temporary nursing rates. The study involved ten participating HSOs from two key medical service geographic locations. The aim was to prove that derivatives, a financial markets tool, and options in specific, can be applied to the nursing market to offset losses that would otherwise be incurred – in the form of an NOA.

An in-depth explanation of the well-known nursing shortage problem and its ramification was discussed in chapter 2; as well as a literature review in chapter 3 consisting of academic contribution to alleviate the nursing conundrum and collapsing healthcare financials. chapter 4 introduced the proposed method, offering contribution in the healthcare and financial sector by introducing a counterintuitive approach to reduce temporary nursing rate exposure on HSOs total nursing costs through an innovative application of hedging and Black-Scholes pricing model. A detailed explanation and illustration of HSOs' budget process illustrated opportunity for financial losses based on staffing principles such as staffing to average, which results in planned losses due to having to cover the shortage by way of third party temporary contracted nursing services at market rate. mathematical statement of financial losses and budget disparity was presented, as well as a detailed discussion showcasing nursing options agreements as a

form of a call and/or put; differing from traditional options agreements by using nursing contracts as the underlying asset.

Aforementioned participating HSOs' data was used to showcase the feasibility, practicality and applicability of the approach. Feasibility and practicality were proven by validating temporary contracted nursing data with underlying asset criteria and B-S assumptions for underliers, respectively. chapter 5 an showed the applicability of NOAs through an experimental pilot implementation in HSO 6, which highlighted that even with rising nursing needs and variable rates, budget disparity can be minimized by the use of NOA. The implementation yielded a savings of 11% in nursing expenses and decreased budget disparity by 14%. A hypothetical application across the other HSO participants alludes that implementation results are likely to be sustainable across participants.

In closing, it is reasonable to assume that nursing costs can be capped to enhance planning and stabilize financial outcomes by curbing exposure to higher nursing wages. This approach provides HSOs with the ability to plan and hedge fluctuations in the number of nurses needed, and offers significant financial savings. Additionally, it offers a realm of expansion for academic evolution that includes, but is not limited to, establishing trading practices, mercantile for the nursing market, nursing market options pricing models using Monte Carlo Simulation among other techniques; and, expanding to other forms of derivatives such as swaps.

EXHIBIT 1: The Board of Nursing Requirements for Faculty Credentials Will Increase in August 2009

Current	August 2009
Rule 64B9-2.005 Faculty Qualifications	Rule 64B9-2.015 Standards of Nursing Education
Fifty percent or more of nursing faculty shall hold either a bachelor's degree in nursing plus a master's or doctoral degree in related field or master's or doctoral degree in nursing.	By August 2009, 60% or more of nursing faculty shall hold a bachelor's degree in nursing plus a master's or doctoral degree in nursing.
Each nursing faculty member who does not meet this requirement shall have a bachelor's degree with a major in nursing and meet one of the following:	Each nursing faculty member who does not meet this requirement shall have a bachelor's degree in nursing and meet one of the following:
• Equivalent of at least two years of full-time experience in clinical practice as a registered nurse (RN).	• Equivalent of at least three years of full time experience in clinical practice as an RN.
• Actively engaged in studies leading to the next highest degree. Degree must be in nursing or a related field.	• Actively engaged in studies leading to the next highest degree. Degree must be in nursing or a related field.
• At least two full-time academic years of experience as a teacher of nursing.	• At least two years full-time experience as a nurse educator.
• Certification as an advanced registered nurse practitioner (ARNP) in Florida	• Certification as an ARNP in Florida.

EXHIBIT 2

Nurse Staffing Survey

Total Number of Hospitals Surveyed: 113

	% Yes	% No	Common Answer
Do you use a system wide staffing approach?	4%	96%	
Do you have staffing requirements by law or union mandate?	2%	98%	
If yes, does it impact your staffing decisions?	88%	12%	
Do you float nurses between units?	62%	38%	
If yes, is this a preferred approach to agency or internal float pool nurse use?	57%	43%	
Do you measure quality outcomes when making staffing decisions?	56%	44%	
If yes, what indicators do you use?	0%	100%	1) Falls 2) Wounds 3) Urinary Track Infections 4) Blood Stream Infections
Do you have vendor staffing systems?	1%	99%	
Do you use proprietary staffing systems?	93%	7%	
if yes, what is the basis of the staffing methodology?	0%	100%	Expert Knowledge
Do you consider patient load in staffing decisions?	100%	0%	
If yes, how do you measure it?	0%	100%	1) Census 2) Patient to Nurse Ratio
Do you consider patient accuity in staffing decisions?	6%	94%	
Do you cancel nurses?	51%	49%	
If yes, what approach do you follow?	0%	100%	Agency, over-time, part-time and full-time
Is you Nursing Buget 50% or more of your Operating Budget?	56%	44%	
Do you float nurses between internal hospitals?		100%	

APPENDIX 1: Nurse Scheduling Problem Approaches

Exact Methods

- *Integer Programming* (Bard and Purnomo 2005a, 2005b; Belien and Demeulemeester 2007;Dowsland and Thompson 2000; Jaumard et al. 1998; Mason and Smith 1998; Valouxis and Housos 2000; Warner 1976b; Warner and Prawda 1972;Aickenlin and White 2004; Moz and VazPato 2003; Aickelin and Li 2007;Miller et. Al 1976; Kwak and Lee 1997; Wright, Bretthauer, and Cote 2006). Purnomo and Bard introduce the concept of a rolling horizon strategy, which aims to minimize costs while satisfying nursing requests, as best as possible; and rolling assignments such that there is no laps in coverage. In this approach, as is the case with the other literatures presented for an integer programming approach, floats are considered within a local dynamic (single hospital) in satisfying unit demand. The method proved to generate significant cost savings, but has application limitations that do not allow shits to be segmented. That is, once it starts, it cannot be altered.
- *Multi-objective Goal Programming* (Azeiz and Al Sharif 2005; Arthur and Ravindran 1981; Parr and Thompson 2007). The method breaks the nurse availability based on preference pool; and uses a greedy approach to search for rotations. Solution space is then defined using exact methods. Noising is then combined to solve for an optimal cost function. The noising method involves varying the cost function during a search by adding random error to the data.
- *Constraint Programming* (Cheng et al. 1996; Wong and Chun 2003).
- *Stochastic Programming* (Punnakitishem et al. 2005).
- *Multi-commodity flow* (Moz and Pato 2004).

Meta-heuristics techniques

- *Simulated Annealing* (Dige and Lund 1992; Bailey, Garner and Hobbs 1997).
- *Tabu and other local neighborhood searches* (Aickelin et al. 2007; Dowsland and Thompson 2000; Valouxis and Housos 2000).

- *Evolutionary algorithms* (Aickelin and Dowsland 2003; Beddoe and Petrovic 2006).
- *Hyper-heuristics* (Cowling et al. 2002; Burke et al. 2003).
- *Expert systems and artificial intelligence methods* (Chen and Yeung 1993; Li et al. 2003).
- *Probabilistic and data mining techniques* (Li and Aickelin 2003, 2004, 2006)
- *Ant Colony Optimization* (Gutjahr and Rauner 2007). This application extracted the well-known nursing problem from a local hospital solution to a solution integrating nursing supply and demand for a regional health system, a set of hospitals.

The heuristic was first introduced by Dorigo in 1992 as a new heuristic for discrete problems. The study follows the live pattern of ant decision making. It follows that when making decision, ants base it on a right or left turn, and since they are unsure of the correct path, they choose at random. The shortest path is achieved by the ants choosing the lower path versus the upper path. When tracking the behavior, the heuristic learns the behavior of the ants choosing the shortest path, and presents future ants' decision on the probability of quicker arrival from past performance. Dorigo and Di Caro discuss the mathematical construction in Ant Colony Optimization: A New Meta-Heuristic. In 1999, Dorigo applied the approach solving the well-known and previously mentioned traveling salesman problem. Interest in the approach for solving optimization has continued to grow, and was more recently applied to the Nurse scheduling problem. Gutjahr and Raunerin 2007 aimed at anw approach to the nurse scheduling problem that focus on misdistribution and poor utilization of nurse. The hospitals considered fall within a system of hospitals owned and run by one corporate office. In the approach nurses schedules must be defined and communicated within a user-defined number of calendar days; and, decisions are always successive in order. The methodology helped cover and balance unforeseen peaks of workforce demands by considering different preferences and costs using a cost function. The results are favorable, but have certain limitations: 1) Most of the schedules are in

advance, not truly accounting for shift-to-shift variation, which from prior publications has proven to be one of the greatest areas for operational and cost fall-back. 2) Hospitals are considered as large units with sub-units, with no consideration to practical differences such as the realm of services and practices that would constitute the hospitals to be comparable and, therefore, peer sites. 3) Patient acuity as related to direct nursing care for true estimate of load is not considered.

- *Knowledge discovery techniques* (Petrovic et al. 2002, 2003).
- Electromagnetic Meta-Heuristic. (Meanhoutand , 2007).
- *Artificial Intelligence Case Method and Genetic Algorithms*. This method was introduced by Petrovicet. Al. It imitates human-like decisions using knowledge about known solutions to like problems.

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