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Effectiveness of Evidence-Based Computerized Physician Order Entry Medication Order Sets Measured by Health Outcomes

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Final Dissertation Report

by

Jacob Krive

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in
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An Abstract of a Dissertation Submitted to Nova Southeastern University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy

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In the past three years, evidence based medicine emerged as a powerful force in an effort to improve quality and health outcomes, and to reduce cost of care. Computerized physician order entry (CPOE) applications brought safety and efficiency features to clinical settings, including ease of ordering medications via pre-defined sets. Order sets offer promise of standardized care beyond convenience features through evidence-based practices built upon a growing and powerful knowledge of clinical professionals to achieve potentially more consistent health outcomes with patients and to reduce frequency of medical errors, adverse drug effects, and unintended side effects during treatment. While order sets existed in paper form prior to the introduction of CPOE, their true potential was only unleashed with support of clinical informatics, at those healthcare facilities that installed CPOE systems and reap rewards of standardized care.

Despite ongoing utilization of order sets at facilities that implemented CPOE, there is a lack of quantitative evidence behind their benefits. Comprehensive research into their impact requires a history of electronic medical records necessary to produce large population samples to achieve statistically significant results. The study, conducted at a large Midwest healthcare system consisting of several community and academic hospitals, was aimed at quantitatively analyzing benefits of the order sets applied to prevent venous thromboembolism (VTE) and treat pneumonia, congestive heart failure (CHF), and acute myocardial infarction (AMI) – testing hospital mortality, readmission, complications, and length of stay (LOS) as health outcomes.

Results indicated reduction of acute VTE rates among non-surgical patients in the experimental group, while LOS and complications benefits were inconclusive. Pneumonia patients in the experimental group had lower mortality, readmissions, LOS, and complications rates. CHF patients benefited from order sets in terms of mortality and LOS, while there was no sufficient data to display results for readmissions and complications. Utilization of AMI order sets was insufficient to produce statistically significant results. Results will (1) empower health providers with evidence to justify implementation of order sets due to their effectiveness in driving improvements in health outcomes and efficiency of care and (2) provide researchers with new ideas to conduct health outcomes research.

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Chapter 1

Introduction

Background and Problem Statement

In the medical field, order set is a product that utilizes standard combinations of drugs and procedures for treating typical clinical cases. Multidisciplinary teams of professionals represented by physicians, pharmacists, nurses, and other clinicians approve these sets. Paper-based order sets have existed for over two decades but lack popularity among physicians due to inefficient access and excessive processing routines. Medical information technology, in particular computerized physician order entry (CPOE) systems, have made order sets more popular through easy access, knowledge database support, and a perceived probability of reducing medication error rates. Consequently the study of order sets is related closely to three major research subjects: (1) CPOE systems implementation and resulting health outcomes, (2) adverse drug effects (ADE) and their effect on quality of care, and (3) standardization of patient care and application of the evidence-based medicine methods to achieve consistency and quality of health outcomes.

CPOE is a relatively new information technology concept that is not only costly but also is politically charged to implement, particularly given that health care professionals have demonstrated long-standing aversion to technological change in many areas. Order set is one element of CPOE, with few studies of its effect on health outcomes reported.

Yet, order sets promise great potential in improving quality of care, reducing the health and financial effects of ADE, and standardize medication prescription practices to achieve consistent patient care outcomes (Zafar & Dixon, 2009).

Clinical informatics professionals believe that electronic medication order sets: (1) improve health outcomes, (2) reduce preventable adverse drug effects and their impact on quality of care, and (3) lower cost of care (Zafar & Dixon, 2009). However, despite growing reliance on order sets to standardize care and improve safety, little quantitative evidence of effects on care has been documented and published in the literature. This study was aimed at contributing to a better understanding of the effects of the practices. Specifically, *despite ongoing heavy utilization of evidence-based treatment methods in hospitals, there is a lack of quantitative evidence of the impact of CPOE-based medication order sets on patients' health outcomes*. In other words, no scientifically proven link between utilization of standardized evidence-based medication sets and quality of care has been established.

Both positive and negative effects determined in such a study add value in the clinical information systems domain, pointing multidisciplinary teams involved with different aspects of clinical informatics to the most and least effective ways to offer CPOE products to customers. Consequently, this research study warrants follow-up studies to determine effects of specific evidence-based methods on treatment of illnesses that fall outside of the scope of this dissertation.

Dissertation Goal

Based on the problem statement, the principal goal of this dissertation was to *quantitatively to determine the effectiveness of evidence-based medication order sets using specific health outcomes from experimental and control groups in CPOE application, utilizing several types of order sets adjusted to varied clinical settings and patient demographics*.

Physicians' skills, experience, and actions vary, especially considering time pressures in a high-volume clinical environment. Evidence-based order sets enable standardization of care for certain common situations based on feedback from interdisciplinary teams of professionals who compile these sets (Payne, Hoey, Nichol, & Lovis, 2003). However, while several organizations, worldwide, have adopted utilization of the order sets, few research studies have gone as far as determining health outcomes in situations when voluntary use of order sets was/was not executed. Physicians are typically not accustomed to requirements for mandatory utilization of order sets, outside of situations when doctors are recruited for experimental studies. The latter are covered as part of the literature review. The detailed outline of the goals of this project is as follows: (1) to determine the effect of several common order sets on quality of care based on actual health outcomes for patients who received/did not receive evidence-based medications, (2) to determine variability between different types of sets and illnesses and whether order set utilization is a positive solution under all or only some clinical circumstances, (3) to explore effectiveness of the order sets based on some intervening variables, such as clinical settings (teaching vs. non-teaching facilities), age of a patient, and disease complications, (4) to recommend/not recommend utilization of order sets by healthcare

facilities worldwide, and (5) to identify recommendations for further research based on results of this study.

Research Site

The research was performed at Advocate Health Care, the large integrated healthcare provider in Illinois. Advocate's extensive network includes ten hospitals, home care services, rehabilitation facilities, outpatient imaging centers, consolidated labs, hospice care, pharmacies, and thousands of employed and partner physicians. The research did not involve any experiments with patients at sites and focused on utilization of electronic medical records and physician orders to mine a wealth of history data to answer the research questions outlined for this study. Select inpatient facilities with the longest history of electronic medical records utilization were the main sources of patient data. Advocate began early adoption of clinical information systems in 2001 and rolled out dozens of different clinical applications from Cerner, Inc. under the internal project name Care Connection. The rollout included computerized physician order entry functionality that enabled utilization of electronic order sets for prescribing and standardizing procedures and medications to treat well-known patient conditions. A decade of electronic records maintenance, coupled with introduction of the Enterprise Data Warehouse in 2007, enabled collection of sufficient data to conduct quantitative research on the effectiveness of order sets in improving quality of patient care. Specific hospitals that participated in the study are introduced as part of the research methodology in Chapter 3.

Overview of the Research Questions and Hypotheses

This report is split into four sections, each providing quantitative coverage and analysis for one of the patient conditions listed below. This section contains high-level questions and hypotheses, with a complete detailed listing available in Chapter 3. The main independent variable applicable to all four studies is utilization of the order sets. This variable sets up experimental (utilization = yes) and control (utilization = no) groups. There are four dependent variables representing health outcomes to measure effectiveness of the order sets: mortality, readmissions, complications/comorbidity, and length of stay. Not all of these variables are applicable to each condition. There are also independent variables of secondary importance to examine external influences on patient conditions and health outcomes: age, sex, and race. These are descriptive pre-existing conditions that might be important in predicting health outcomes of the patients and/or interfere with the role of order sets in ensuring effectiveness of the evidence-based practices.

Venous Thromboembolism (VTE)

Questions were aimed at (1) investigating whether utilization of the VTE medication order sets will be effective in preventing acute VTE among eligible inpatients; (2) exploring the relationship between utilization of the order sets and length of hospital stay, determining whether complications or pre-existing medical conditions contributed to this relationship; and (3) analyzing and comparing several factors such as race, sex, and age in terms of their influence on acute VTE. Among health outcomes utilized for the overall study of order sets, mortality and readmissions are not considered directly linked to VTE, so these dependent variables were dropped from the list of VTE health outcomes.

Questions (1) and (3) represent relationships between independent variables in the study, while question (2) examines relationship between independent and dependent variables.

VTE study has a unique setup consisting of two main independent variables, outside of the ones representing pre-existing conditions – utilization of the order sets and acute VTE. While in the cases of pneumonia, CHF, and AMI the patient condition is a given (patient diagnosed before treatment occurred), acute VTE is typically a secondary condition that may or may not occur among various categories of patients. This situation presents a challenge of accounting for the presence or the lack of one for potential VTE patients, as well as exclusion of the chronic VTE patients with principal diagnosis of VTE from the study - focusing on prophylaxis instead. Therefore, there is an opportunity to examine the relationship between independent variables of utilization of the order sets and acute VTE, as well as a complex relationship between all independent and dependent variables involved in the study.

Hypotheses derived from these questions took the form of null statements. Statistical manipulations reported in the final stage of the dissertation process either accept or reject the null hypotheses, thus answering the research questions outlined in Chapter 3. More research questions and hypotheses emerged from further categorization of medical records into smaller categories based on sex and surgical qualification of the patients.

Pneumonia

Pneumonia study has a simpler setup compared to VTE, with one independent variable of utilization of the order sets and four dependent ones, adding mortality and readmissions to the list of health outcomes. Investigation of the effects of pre-existing factors of age, sex, and race still applies to pneumonia, as well as all four of the patient

conditions. Surgical qualifications do not apply to pneumonia cases, and data samples are too small to afford categorization of patients by sex, as evident from monthly utilization of the pneumonia order sets provided in Appendix B.

Congestive Heart Failure (CHF) and Acute Myocardial Infarction (AMI)

Questions and hypotheses for these two patient conditions are identical to pneumonia, with unique differences in setup, inclusions, and exclusions for each of these two studies. As in the case of pneumonia, data samples are too small compared to VTE to enable categorization, other than reporting results by individual hospital.

Relevance and Significance

Due to minimal research performed on order sets using actual CPOE data and their possible effect on health outcomes, this study was timely and relevant. As the literature review revealed, the need for such foundational research has been established in professional and academic circles. Results of this study have potential to influence decisions to promote evidence-based medicine utilization among physicians, both at healthcare facilities with established CPOE systems and culture, as well as those planning migration to electronic medical records (EMR) and upgrade to incorporate CPOE component.

Between 2010 and 2012 several articles on medication order sets appeared in journals and conferences, compared to none or order sets being secondary subjects in articles covering other aspects of healthcare in the past - indicating growing interest in care practice standardization among researchers. In particular, these recent studies were conducted by Formea, Picha, Griffin, Schaller, and Lee (2010) at Mayo Clinic, Khanna, Vittinghoff, Maselli, and Auerbach (2011) at University of California at San Francisco,

Wright et al. (2010) at Harvard Medical School, and Ballard et al. (2010) at Baylor Health. However, comprehensive quantitative research necessary to back claims of the evidence-based approach health outcomes requires extensive electronic data collected with significant level of detail after implementation of CPOE systems. Once implemented, clinical committees must create, review, and test medication order sets before releasing for general use. After release, data should accumulate for a number of years (longer for smaller healthcare facilities) in order to generate a sufficiently large sample for quantitative study using statistical methodology and techniques. Majority of the aforementioned articles recently published by well-known and highly regarded research institutions cover order sets through either qualitative methods of assessment (i.e. physician surveys), investigation of efficiency of the medication order entry (usability and/or graphical user interface study), or utilization and quality of the order sets. A few studies have approached analyzing health benefits and unintended effects of the medication order sets by performing small experiments with relatively few participants among physicians and patients. Most of these studies returned positive results in favor of the order sets and serve as encouragement for greater effort and more comprehensive studies, such as the one proposed as part of this dissertation research.

Any clinical study that targets patient care outcomes deserves attention due to its potential to save and/or improve more lives. The literature indicates potential for evidence-based medicine to improve health outcomes, and any evidence of improvement would be welcomed by providers and patients alike. Even a small percentage of improvement in outcomes leads to saved lives, one patient at a time. A larger percentage of improvement also carries significant financial implications through shorter lengths of

hospital stay and fewer procedures performed on patients – at a time when the nation struggles to contain escalating health care costs that already represent a large and growing portion of the gross domestic product.

This study represents the application of knowledge management in a specialized niche. Years of clinical research and experience, enhanced by communication and collaboration among clinical professionals and scientists, combine forces to produce evidence-based standards for treating known and well-defined patient cases. This knowledge, once digitized and leveraged through computer technology, provides professionals in the field with easy access to medication orders that are verified against databases containing medication doses, side effects, impact on care, and more. The effectiveness of order sets to improve quality of care is well suited to strengthen the use of knowledge management to drive change in a field that has trailed many others in terms of technology adoption and interdisciplinary approaches.

Barriers and Issues

Conducting this study required human interaction with members of multiple technical teams managing EMR, billing, data warehousing, and other systems. It also required challenging manual and computer programming efforts to extract data from several disparate information sources. Since few similar studies of this scope have been published, conducting this research involved charting complex methodology and performing many trial and error steps before the study took logical form and shape that is generalizable to many clinical settings and was ready for presentation as a completed dissertation.

While this study did not require human subjects, it entailed mining several years of patient data from historical CPOE databases. Thus, patient data was utilized, which required obtaining the IRB approval. Such process took time. Since all hospitals within the scope of this study belong to one healthcare system, only one IRB authorization is necessary in order to obtain permission to access, manipulate, and analyze data. Advocate Health Care's corporate policy requires IRB approval for any studies that involve patient data, regardless of clinical involvement, risk to the patient, and historical nature of the analysis. In this case, an exception was requested and granted under the expedited review category. Such review required the same paperwork as the full review but expedited the process by skipping board review and allowing the IRB leader to sign off on paperwork. Advocate's IRB approval has been obtained in January 2011 for 12 months and required application for extension beyond the allocated period of time. Any further extensions require a review and submission of the research project status. The NSU IRB committee had its own unique requirements in this case. The NSU IRB application was submitted and approved in the exempt status in conjunction with the Research Proposal document.

As already mentioned, EMR data for this research was scattered among several computer systems that have not always had interfaces between them. For example, patient records must be obtained initially from a patient billing/accounting system because this is the only system that maintains chief complaint and/or primary diagnosis for billing purposes. Patient records were then inserted into a data query from a CPOE system to obtain data such as order set utilization, age, and hospital name/location. Only then could the same patient record number be utilized to obtain corresponding health outcomes data. Such inter-system complexities complicated the study but did not result in

an inability to obtain valid data. Extracted from multiple sources, such data had to be sorted and categorized for validity and verified to match, before proceeding with statistical analysis. This was another time-consuming process. To address this concern, data was obtained from the Enterprise Data Warehouse (EDW). The EDW has existing interfaces piping data into one repository that maintains it in its original form without further manipulations. Obtaining data from the EDW led to creation of the "raw" Excel data files suitable for editing and statistical analysis in SPSS.

Every hospital in the system uses its own order sets for each of the studied patient conditions. These sets look similar by title but contain different medications, requiring splitting the study into several individual cases by hospital. Due to differences in the order set content, effect on health outcomes differed as well and was consequently explained by different variables, especially when the analysis led to differences in the cases where variances were detected between hospitals within the Advocate's healthcare system. However, a case-based approach helped meet one of the goals of this study to identify differences in medication order set utilization between teaching and non-teaching hospitals, without performing additional data manipulations.

There is also no common identifier for sets listed in various records and computer systems. All sets selected for the study had to be moved into individual worksheets and manually verified with clinicians for validity. The multitude of order sets available in the EMR had to be sorted by preventive and treatment goals, with no single standard for the four categories contained in this research study. More specifically, only prophylaxis VTE order sets were selected for the study, with prevention being the principal and most valid utilization goal. Treatment effectiveness can produce varied results that may be difficult

to verify for validity. All other sets must be in the treatment category due to their purpose of responding to symptoms in patients. Health outcomes are contained in yet another system and were displayed in a variety of spreadsheets that had to be organized and translated into a common data language for use in queries.

Due to lack of corporate policy enforcing rules of medication order set utilization, experimental group samples were much smaller compared to control groups. Statistical tests for significance validated results of the study and shed light into the quantitative validity of the study. At the same time, the summary report from this study has the potential to catalyze change toward greater utilization of order sets and standardization of processes around evidence-based medicine practices. Dealing with small samples required workarounds, including elimination of splits into more groups of patients among population selected for this research. For example, based on monthly utilization figures for VTE order sets and patient volumes, the initial data sample for this study was expected to exceed 100,000 – making it a candidate for splits into groups and several manipulations to determine impact of multiple variables on health outcomes. However, in the case of pneumonia, the total number of patient encounters pulled for the study just barely exceeded 5,000 – suggesting that statistically significant results could come from a combination of all patients from all hospitals and not splits into multiple groups to study additional factors influencing health outcomes. Further adoption of the order sets over time may enable a more effective follow-up study within several years of completing this dissertation. Scarcity of data also explained why so little research is published on the subject – it requires a significant buildup of data in CPOE systems which are too new,

immature, and expensive to implement. Few organizations possess sufficient data to undertake such a study.

Data contained in CPOE does not yet contain sufficient detail to perform comprehensive cause-and-effect analysis of all factors influencing patient health outcomes. Statistical links between utilization of the order sets to treat pneumonia and the Charlson Comorbidity Index representing the rate of complications, are not as direct as this research study originally assumed. If the Index is compiled of serious illnesses like diabetes, cancer, and heart disease – pneumonia might be just one of the factors that contribute to change in this score. There is not sufficient detail in the patient records to date to account for all possible factors. Again, further maturity of CPOE software will help address this issue in the future. For now, establishing statistical evidence of a relationship between variables in this study will at least point to order sets making a positive/negative difference in patient care, and at this point it is a significant step forward for clinical informatics and knowledge management fields.

The Charlson Comorbidity Index is a debatable subject among researchers and clinicians in terms of its meaning and cause/effect relationship with complications. This debate has not been addressed in literature to date and remains internal discussion among academics and professionals involved with clinical quality assessment, data analysis, and design of quality metrics. Much of the discussion below represents informal feedback from individuals involved with clinical quality data analysis rather than a mature published study. Comorbidity might be used to interchangeably to serve as a rate of patient complications and a barometer of the effect of pre-existing conditions on patient outcomes. In this study, comorbidity was utilized to explore the relationship between

utilization of the order sets and complications as a measure of health outcomes. On the other hand, comorbidity may explain other relationships between health outcomes and application of the order sets to prescribe medications. For example, lower rate of acute VTE occurrence coupled with longer hospital stay could be a confusing benefit of the order sets (improved result for the independent variable and undesired effect on the dependent variable of health outcomes), until comorbidity enters the picture. In this case, higher comorbidity would explain longer hospital stay due to pre-existing conditions that are unrelated to the VTE order set study. The same applies to a completely positive outcome in favor of the order sets: shorter hospital stay could be explained by utilization of the order sets or the fact that a healthier patient was treated and required shorter recovery due to better general state of health. The dual role of comorbidity is also analyzed in Chapters 4 and 5, where results and their implications on patient care are discussed.

Data in some fields in the Excel files that were extracted from EDW had missing values. This was due to either lack of requirements for physicians to complete all fields in the record or other factors leading to missing data. To address this issue the researcher performed initial cleanup to ensure that only valid data entered SPSS for analysis and then set proper cases within SPSS to include only valid sets of data. Missing values were the cause for differences between descriptive statistics provided for each case study that is based on the total number of entries in each column and population listed as parts of output from statistical manipulations that take only valid data from each column that satisfy the entire set of conditions for the case. The safety net is that summary reports are based on statistics coming out of the actual SPSS cases that contain valid data

combinations, so slight differences with descriptive statistics are not important relative to goals of the study.

Order sets are configured in CPOE in such a way that physicians can either click on the entire medication set to prescribe to a patient or deselect any of the medications/orders from the set. While there are logs maintained in the CPOE indicating whether entire or custom set of medications was selected as part of the order, there are no reliable data structures retrievable from EDW or SQL database behind CPOE to match order set utilization statistics with the actual content of each incomplete custom set order. Accordingly, there are no records indicating what was selected within the set. There was no remediation for this issue, so one of the assumptions for this study is that all or most of the entries within medication order sets are selected by physicians when they choose to utilize sets. Otherwise no set selection is recorded in CPOE, triggering a change in the value of independent variable managing set utilization in the study to 0 (none). Future generations of CPOE software will come with more mature data structures that better address research needs for manipulating extracted data. At this point, the researchers have to resort to utilizing data structures currently available to them, despite the fact that logs are generally available for manual review of each particular order. Such manual review could grow into a follow-up study with narrower scope and aim to analyze certain restricted conditions within each data subset using fewer patient records.

While not directly related to the study, it is important to note that some physicians still utilize paper-based order forms for medication sets. The percentage of these paper orders relative to CPOE has recently shrunk to 5%-10%, due to CPOE utilization growth and preference of physicians who are trained to place orders via CPOE to utilize electronic

sets. While the study could be enhanced through inclusion of all applicable and available orders, accounting for paper sets was not technically feasible due to a short retention history and a manual analysis process, except for rare cases when utilization of paper sets is reliably documented. Majority of the paper-based sets were excluded from the study, with the exception of select AMI and CHF sets initiated from outpatient facilities that did a good job providing order entry information to Clinical Informatics department for documentation purposes. These exceptions are noted where applicable in the Methodology chapter of this report. The organization where this dissertation research was conducted has made headway in pushing higher utilization of CPOE among its affiliated physicians, leading to much higher order placements in electronic format relative to paper-based ones. This means that the majority (90% - 95%) of the most recent orders were captured through database queries, reducing the impact of eliminating paper forms from the study.

A general concern was that the organization where the research was planned is not a research organization by culture. Persuading people to assist took time and patience. Some of the tasks were not high on the data owners', project managers', and application analysts' to-do lists, so additional time had to be allocated for data extraction projects. Despite this lack of academic research support, all data owners took interest in the study that was well outside the realm of their normal day-to-day responsibilities and cooperated in the most collaborative manner during most stages of this study. The study was sponsored at the executive level (Chief Information Officer and Vice President of Clinical Informatics) in the organization. These leaders were interested in addressing

some of the major concerns, such as quality of care, health outcomes, and key result areas established by the executive management team.

While not a serious concern relative to outcomes of the study, it is noted that some references required for the literature review are rare and may come from sources that are over a decade old. However, the quality of literature used for this study is high, because longitudinal studies associated with adverse drug effects (representing the vast majority of the outdated references selected for the dissertation) have been conducted for some time with good outcomes, except for lack of solutions to the problems. Taken from high-quality professionally regarded journals, these studies satisfy the need for justifying existing problems with medication errors and potential role of the medication order sets in standardization of care. A majority of the literature associated with CPOE and order sets came from recent publications, yet ADE-related studies can be obtained from older sources without compromise in terms of quality or relevancy.

The sources of references utilized for the literature review also require an explanation, as most come from medical or clinical IT journals, as opposed to the more traditional choices in the field of information systems. This is due to the fact that majority of the clinical IT research is sponsored and/or performed under medical leadership in both academic and industry/community organizations, where technology functions report to executives with clinical focus. The latter group prefers reading and publishing in clinically oriented journals. One particular publication, the *Journal of the American Medical Informatics Association* frequently cited in this paper, happens to be a well-established authority in the field of clinical IT, despite being just a little over a decade

old. The newness of the field calls for exploration and the use of journal titles that appeared relatively recently and is an outgrowth of a new research area.

Assumptions, Limitations, Delimitations

Assumptions

As far as VTE cases are concerned, the main focus of this study was prevention rather than treatment. In general, only minority of the VTE cases are chronic and require treatment, while majority are expected negative clinical outcomes from many surgical and non-surgical procedures routinely performed at hospitals. Among non-chronic VTE cases where order sets are applied, there are treatment cases when a patient experienced VTE condition and required VTE medications and non-treatment (preventive) cases, when a patient received VTE medications aimed at preventing a potential VTE condition. The focus of this VTE study was on the latter cases. It was assumed that setting a limit on the query of VTE medications ordered within 48 hours of admission would, in a majority of cases, indicate that the order was placed for preventive reasons to address a potential VTE problem rather than treat an existing condition. No documented borderline exists for the method of differentiating between treatment and prophylaxis order sets, so the researcher made an assumption for the purposes of this dissertation study, after discussing with clinicians and specialists who analyze clinical data at Advocate. However, as a second line of defense from error, all chronic VTE cases were excluded from the study, as another way to ensure patients who require VTE treatment were not mixed in with prophylaxis population. This exclusion is listed in the detailed VTE methodology in Chapter 3.

The researcher conducting this study skipped running queries against disparate CPOE, billing, and other systems containing necessary data in favor of utilizing the Enterprise Data Warehouse that maintains daily data interfaces with all necessary data sources. It was assumed, based on actual verification and meetings with data owners, that there is no missing data that arrives to EDW through the numerous data interfaces.

The study assumed that entire order set was utilized in case where order set = 1 (yes). The Limitations section below contains additional information on the physician ability to deselect certain items in the set – without a record indicating what was altered.

Charlson Comorbidity Index was assumed to be a good indicator of the overall patient complications score that is widely accepted in the healthcare industry. The Index contains a number of serious conditions indicative of the patients' outcomes and/or pre-existing health issues. There is a number of ongoing initiatives in clinical informatics to design better complications measures, but none is currently available to utilize for the purposes of this study. Literature confirms that the Charlson Comorbidity Index is the current standard for measuring complications and comorbidities as part of similar quantitative studies utilizing health data from clinical information systems.

Limitations

The study used data available in CPOE at the time of running database queries and could not investigate finer detail, such as all reasons that led to patient complications, mortality, or increased length of stay. This means that reasons other than order sets and existence of the documented patient condition are likely in play, but it will take years before CPOE systems become sufficiently mature to offer a level of detail necessary to enhance this research study with additional data.

The study aimed to analyze several descriptive variables beyond order set utilization in terms of their impact on patient conditions and health outcomes. However, other factors not readily available in CPOE are likely at play that could not be made part of this study due to lack of data.

The study could only delineate use or lack of use of the order sets among physicians, assigning binary indicators to each case. In reality, physicians have an ability to deselect certain medications or procedures from the sets. However, CPOE does not currently keep track of records of the customized orders made via sets, so only two assumptions could be made: order set was utilized and order set was not utilized. Logs of all orders are, in fact, maintained in CPOE for the audit and history purposes, yet there is no reliable way to match them to other order set utilization documentation and health outcomes in order to reliably draw parallels between disparate pieces of information supplied to the EDW from various data sources. This problem is related to one of the barriers mentioned in the study – availability of a wealth of data contained in multiple repositories that do not link and are not verified against each other.

While a majority of physicians affiliated with the healthcare system that serves as the site for study shifted to utilization of CPOE, there is a small number of medication orders still placed via paper. These orders are difficult and time consuming to analyze, representing a 5%-10% fraction of all medication orders. Majority of these paper-based orders were excluded from the study, with the exception of some CHF and AMI records that have been documented by outpatient offices and entered into the database by Clinical Informatics departments. These select orders are documented where appropriate in Chapter 3.

Delimitations

The study utilized industry-standard definitions of patient conditions, surgical status, discharges, principal and secondary diagnosis, along with other variables. Therefore, results of this study are generalizable to other US hospitals. Researchers in international locations will need to pay attention to the AHRQ codes listed within the text and as part of the appendices and compare methodology utilized in this study to the one commonly used within their clinical settings.

Definition of Terms

ADE: Adverse Drug Effect

AHRQ: Agency for Healthcare Research and Quality, a federal government agency charged with definitions of health-related standards, codes, and methods of treatment

AMI: Acute Myocardial Infarction, one of the patient conditions selected for this study

CHF: Congestive Heart Failure, one of the patient conditions selected for this study

CCI: Charlson Comorbidity Index of patient complications

CPOE: Computerized Physician Order Entry System, used interchangeably with EMR in this study. Advocate Health Care has gone through several stages of EMR and CPOE adoption, adding new modules and capabilities with each implementation phase. At this time application combines documentation and order entry features, bringing together EMR and CPOE as part of one software solution from Cerner, Inc. While EMR and CPOE are not the same, data extracted for the purposes of this study came from a universal source. In order to avoid confusion and maintain consistency throughout the document, the CPOE term is used in situations that specifically refer to physician order entry, such as when order sets are utilized to prescribe medications. In all other instances,

EMR serves the purpose of identifying software application that electronically maintains medical records and other clinical documentation.

DRG: Diagnosis Related Group, frequently used with preceding letters appended for identification of principal and secondary diagnoses

DVT: Deep Vein Thrombosis, used interchangeably with VTE in this study, older definition of the same/similar patient condition relative to VTE

EDW: Enterprise Data Warehouse, a data repository that receives feeds from multiple sources, eliminating the need for many queries against several disparate databases.

EMR: Electronic Medical Record, used interchangeably with CPOE in this study. Explanation and delineation of the two terms is available under the CPOE paragraph.

HL7: Health Level 7, international standard for clinical interfaces used to ensure interoperability of software used for storage and maintenance of patient information. Programming in HL7 ensures that data can be exchanged between any of the clinical systems and is one of the very few data standards in existence that enable integration of clinical software applications.

ICD: International Classification of Diseases, an industry standard identification of patient conditions governed by alpha-numeric codes

LOS: Length of Stay

Medication Order Set: collection of medications and order aimed at treating one common patient condition

MSDRG: Medicare Diagnosis Related Group, a group defined for Medicare medical billing purposes

OB: Obstetrics

GYN: Gynecology

PSI: Patient Safety Indicator, used by AHRQ to define categories of patient conditions

Psych: psychiatric/psychiatry

SQL: Structured Query Language

VTE: Venous Thromboembolism, one of the patient conditions selected for this study

Summary

CPOE/EMR computer applications remain in the early stages of development and implementation, along with documentation of medical procedures that goes through its own development cycle managed by federal healthcare governing agencies. It is currently difficult to perform quantitative studies that involve health outcomes and quality of patient care using history data from electronic medical records. Many of the data sources lack consistency, integration, and frequently suffer from tendency by healthcare IT organization to computerize everything by implementing poorly communicating applications addressing varieties of clinical needs and specialties. The lack of standards for healthcare data, outside of the Health Level 7 (HL7) programming interface that is typically desired but not required of software vendors, forces hospitals to either take charge of their own integration efforts or enter local alliances complicated by competitive and political differences – effectively contributing to even greater disarray when it comes to data driven clinical research. Due to newness of the field, many assumptions not backed by documentation and literature must be made by researchers in order to move their efforts along.

As the following literature review reveals, there is interest among researchers to begin mining the data in the growing medical records systems. The latter includes the potential

ability to examine effects of evidence-based medicine and standardization of medication prescribing methods on patient health outcomes. Despite issues and barriers associated with lack of detailed data and requirements to make certain assumptions about patients and treatment, the research outlined in this dissertation study is the next big step in quantifying the benefits of standardization of care and setting a new baseline for health outcomes analysis utilizing statistics and clinical information systems within this knowledge management domain.

The study aimed at some of the most frequently researched patient conditions that are tracked from quality perspective by the majority of hospitals and healthcare systems across the United States. These conditions – VTE, CHF, AMI, and pneumonia – affect millions of patients annually and contribute to population health overall, as well as national healthcare expense. Prescribing medications via order sets is one of the myriad options available in modern CPOE applications that have not been tested for outcomes due to newness, lack of data and resources to perform studies, as well as ever-changing priorities in clinical research. Yet, there are opportunities to prove validity of existing practices and to encourage increased adoption, discontinue current practices, or make changes – based on results of a study that utilizes quantitative data to analyze patient outcomes as part of a longitudinal ex post facto study utilizing existing historical patient data. The introduction, literature review, and quantitative methods outlined below were aimed at answering several important questions with the potential to improve lives of thousands of patients who may receive more consistent health outcomes as results of their treatment in hospitals worldwide.

Chapter 2

Review of the Literature

Context

The literature review addresses two major research areas closely related to a study of order sets: (1) effectiveness of CPOE applications in a clinical setting and (2) impact of adverse drug effects (ADE) on quality of care. The review concludes with a summary of the latest research related to evidence-based medicine, medication order sets, and their effects on patient care. As previously stated, due to lack of research on effects of the evidence-based medicine on quality of care, the latter review includes a strong foundation supporting the existence of a potential problem due to the lack of analysis rather than coverage of related studies that offer a wealth of qualitative analysis to support the cause.

CPOE Literature

Several research studies point out advantages and disadvantages of CPOE. Bates and Gawande (2003) highlighted standardization of care and records, along with instant verification against possible adverse drug effects as advantages, while pointing to cultural mismatches between programming logic and clinical decision making. Bates and Gawande warned of the lack of standards among CPOE software applications, leading to recent challenges in the processes of clinical systems integration and information exchange. Such standards prevent easy identification and comparison of data between

individual modules of the same EMR application, as well as data exchange between various applications utilizing medical records. A typical large healthcare system uses more than one application, taking advantage of the data contained in an EMR. In cases when the lack of standards prevents data owners from effectively exchanging and identifying records between systems, any research that involves a variety of disparate sources of information becomes difficult and costly to conduct. In addition, few organizations in the process of EMR development and expansion have a population of sufficient size to support quantitative research. This may be the primary reason for a lack of published research on effects of evidence-based medicine on health outcomes and patient care.

Ash et al. (2003) discussed CPOE in light of organizational effects that promote teamwork, responsibility, and accountability, while also introducing more effective and formal ways of communication to reduce chances for errors in verbal and written orders. Yet, Ash et al. also noted difficulty in adapting large CPOE rollouts to divergent local practices that vary by department and physician, and the mismatch between restrictive programming logic of CPOE applications and broader thinking patterns of physicians. Part of the problem is the programming of CPOE applications that uses the logic of central application management and universal standards. This makes adaptations to varied local practices difficult. Another problem is a lack of effective human intelligence mechanisms built into CPOE applications, calling for inclusion of the latest artificial intelligence breakthroughs with future versions of the CPOE software. However, such research may significantly increase already high software development costs, driving

major CPOE application vendors away from practice/content localization efforts aimed to incorporate individual physician preferences as a way to increase usability and adoption.

In a follow-up study of the unintentional consequences of information technology in healthcare, Ash, Berg, and Coiera (2004) revealed productivity loss among physicians and nurses resulting from additional cognitive overhead as a result of numerous order entry menus in CPOE applications, errors in keyboard data entry, ineffective graphical user interfaces delivered by some of the application vendors, and modification of the workflow established through years of practice and experience. Linearizing complex medical decisions has been highlighted as the single greatest dissatisfaction and productivity loss factor, causing some physicians to oppose further computerization of clinical settings (Ash et al., 2003).

Chan (2002) blamed low CPOE adoption rates on the failure of project managers in charge of vendor selection and project rollout to account for cultural, contextual, and cognitive factors as part of the social reengineering effort that must be included in the process of CPOE planning in addition to typical technology challenges. Such factors may range from small interface issues to entire, improperly designed modules of the application. For example, a number of recently interviewed physicians indicated that electronic patient charts should come up with a general status/condition screen rather than medication orders and vitals that need to be documented and reviewed later. While seemingly a minor issue, physicians believe that such wrong sequences of screens/events programmed into CPOE applications erase physician logic by modifying a typical clinical workflow. Another example is the absence of a copy/paste feature for chart updates, which was designed as an additional safety measure by requiring an update on patients

every time the chart is opened. However, a typical patient's condition does not change drastically between two chart reviews, thus requiring physicians to reenter almost everything recorded previously. In paper-based records, physicians have to enter notes on the patient's condition but not go through the entire logic of reviewing a patient file. Some physicians view such software performance as an invasion into their workflow, leading to decreased utilization of CPOE at facilities where business cultures still allow using paper. Examples like these are many.

Han et al. (2005) presented evidence of the negative effect CPOE can have on clinical outcomes by measuring mortality rate increases from 2.8% to 6.57% after CPOE implementation at one healthcare facility. While Han et al. (2005) admitted that many factors likely played a role in this mortality rate increase, the lesson to measure more than just ADE as an outcome of CPOE implementation is clear. Longhurst et al. (2010) quantified the impact of CPOE on patient mortality in a historical data study performed at a 303-bed freestanding quaternary care academic children's hospital, with a total of 80,063 discharges analyzed before intervention on November 1, 2007 and 17,432 discharges after implementation of CPOE. In the latter case, the mean monthly adjusted mortality rate decreased by 20% (1.008 – 0.716 deaths per 100 discharges/month, 0.8% & 40%, $p = 0.03$).

Poissant, Pereira, Tamblyn, and Kawasumi (2005) quantitatively explained productivity loss by physicians, measuring clinical case documentation efficiency among nurses (24% time reduction) and physicians (17.5% time increase). Returning the focus of this review to qualitative, Sittig, Krall, Kaalaas-Sittig, and Ash (2005) interviewed physicians to study the emotional side of CPOE implementations and found that the

majority of positive emotions were related to rewards through system alerts, acceptance of correct order entries, and instant access to vast knowledge databases behind order entry applications. A majority of the negative emotions were associated with doubts over physicians' ability to make correct decisions as primary reasons for bringing CPOE to the clinical setting. A more recent study by McAlearney, Chisolm, Veneris, Rich, and Kelleher (2007) encompassed interviews with 10 focus groups and 71 physicians. This study discovered additional application design concerns (people serving technology rather than the opposite) and the cost of implementation in terms of modification of responsibilities and the workflow (physicians taking on data entry responsibilities that were previously shared among nurses and clerks in the past).

Concluding the study of CPOE advantages and disadvantages, Gross and Bates (2007) summarized success factors in implementation into 10 commandments: (1) speed, (2) real time information delivery, (3) fit to the workflow, (4) attention to details in usability studies, (5) recognition of resistance and the reasons behind this resistance, as well as remedial actions, (6) flexibility to change direction as a result of resistance study, (7) having simple guidelines and effective help available to users, (8) asking for additional data entry and tasks only when absolutely necessary, (9) monitoring impact and feedback as part of a continuous quality improvement process, and (10) managing and maintaining currency of the knowledge systems. Looking to the future, Rothschild and Lehmann (2005) proposed building problem-specific CPOE pick-lists from a database of explicitly linked orders and problems taken from actual clinical cases. The latter study explains the link between CPOE success and taking next steps in clinical knowledge management and integration as leading in two directions: (1) standardization of care through evidence

based medicine in the form of hundreds of ready-to-order sets of medications and (2) packaging entire clinical cases as bases for decision making by utilizing vast data and knowledge resources entered in CPOE over the years. Both future directions rest upon successful implementation of CPOE to build electronic databases of knowledge to be converted into multiple forms and shapes for further enhancement of health outcomes.

ADE Literature

While CPOE establishes a base for enhanced electronic order set implementation, there is a need to describe the influence of adverse drug effects on quality and cost of care in order to discover the need for evidence-based care standardization as part of the health outcomes improvement effort. Walsh et al. (2006) described negative CPOE effects in the ADE language. In a study of 6,916 medication orders among 352 randomly selected pediatric admissions over 1,930 patient days, Walsh et al. discovered 104 medication errors, 71 of them serious, with 19% computer data entry related. While the latter is a small rate of 3.6 errors per 1,000 orders compared to reasons unrelated to computers of 10 errors per 1,000 orders, it is important to remember that while CPOE helps reduce medication error rate, it is unable to eliminate it. A majority of the articles on ADE and CPOE published in the past several years are more upbeat about the future of CPOE and standardized care helping to reduce error rates. In an early study by Chertow et al. (2001), the researchers compared differences between “basic” CPOE (control group) and CPOE enhanced with decision-making capability (experimental group) over a period of four consecutive two-month intervals in 1997 and 1998. A total of 7,490 patients, 97,151 orders, and 14,440 orders modified by the decision support program (15% of the total) were evaluated, resulting in a 4.5 patient days mean stay in

intervention versus 4.8 days in control group hospital stays, pointing to a slight improvement in quality and cost of care in cases modified by the decision support system. This particular study does not account for other factors beyond decision support that might have influenced the outcome, yet points to a possibility of the computer-enhanced workflow positively affecting health outcomes.

Teich et al. (2000) found that CPOE utilization resulted in an increase in use of nizatidine from 15.6% of all histamine blocker orders to 81.3%, with a decrease in the SD of drug doses by 11%. Increased use of nizatidine, if prescribed properly, leads to more effective treatment of the gastroesophageal reflux disease (GERD), as well as duodenal and gastric ulcers. In the same study, display of a recommended frequency for ondansetron hydrochloride administration resulted in an increase in use of approved frequency from 6% of all ondansetron orders to 75%. Finally, use of subcutaneous heparin sodium to prevent thrombosis increased from 24% to 47%. These changes persisted throughout the 1-2 years of the analysis.

Bates et al. (1997) analyzed 4108 admissions to a stratified random sample of 11 medical and surgical units in two tertiary care hospitals over a six-month period. Post-event length of stay and total costs of ADE were measured using chart and billing records review methods. There were 190 ADE, 60 of them preventable, from 207 admissions. An average additional length of stay was 2.2 days at an average cost of $3244. Among preventable ADE, there was a 4.6 average additional length of stay that resulted in $5857 total cost. After sampling adjustment, the cost comparison between all ADE and preventable ones was $2595 vs. $4685, leading to the conclusion that preventable ADE carried extra cost and represented a good cause for investment into research with a goal

of reduction and elimination. Due to its primary focus on cost rather than quality of care, this study encompassed multiple departments and categories of illnesses without classification by disease.

Classen, Pestotnik, Evans, Lloyd, and Burke (1997) performed a study to determine excess length of stay, extra costs, and mortality from ADE at the Latter-Day Saints (LDS) hospital in Salt Lake City, Utah. ADE affected 2.43 of every 100 admissions resulting in extra stay of 1.74 days for an extra cost of $2,013. The data also revealed a roughly two-fold increase in probability of death from ADE compared to non-ADE cases. King, Paice, Rangrej, Forestell, and Swarz (2003) conducted a study at a tertiary care pediatric hospital with patients in three medical and two surgery wards. Six years of data, 804 medication errors with 18 ADE among 36,103 discharges and 179,183 patient days were analyzed. Before CPOE implementation, the error rate was 4.49 per 1,000 patient days, with the after-CPOE rate down 40%. This pointed to a huge health benefit from the CPOE rollout. In yet another study, Bates et al. (1999) determined a rate of 1 per 100 medication errors resulting in ADE. Their study consisted of patients admitted to three medical units over a period of seven to ten weeks and over four different years, split between pre-CPOE (control group) and post-CPOE (experimental group) categories. The error rate fell 81% from 142 per 1,000 to 26.6 per 1,000 patient days – another health benefit of CPOE relative to ADE.

Kaushal et al. (2001) performed an ADE effects study with 1120 patients at two academic institutions during six weeks in 1999. Researchers analyzed 10,778 orders, with 616 (5.7%) medication errors, 115 (1.1%) potential ADE cases, 26 (0.24%) actual ADE cases, with 19% of the cases preventable based on detailed review by pharmacists and

availability of standard medication practices to replace custom orders. ADE rates were significantly higher in neonatal and neonatal intensive care units. Most cases (79%) occurred at the stage of ordering and involved incorrect dosing (34%), anti-infective drugs (28%), and intravenous (IV) medications (54%). Physician reviewers, asked to comment on retrieved data, judged CPOE could prevent 93% of errors, and pharmacy reviewers came up with a 94% figure, ultimately agreeing that most ADE are preventable cases.

Evidence-Based Medicine and Order Set Literature

Standardization of care through ADE prevention by using evidence-based medicine methods appears that it can help further reduce error rates and improve health outcomes. Only a handful of studies have been conducted using actual data analysis, and all these studies were based on isolated configurations such as alerts or decision support applications built for the purposes of conducting research, as opposed to standard CPOE-based order sets routinely utilized in thousands of patient care cases for a period of several years - as proposed for this dissertation. The review also revealed that evidence-based medicine is still in its initial discovery phases, with numerous challenges remaining.

Medication allergy checking, dose calculations, and drug interactions are some of the most common actions physicians perform when ordering medications, and these also happen to be some of the most common ordering stages when errors are made, especially in fast-paced community hospital environments (Del Fiol, Rocha, Bradshaw, Hulse, & Roemer, 2005). Implementation of CPOE-based electronic order sets at the 21 hospitals of Intermountain Health Care have had positive effects through simplification of the

thought process for some of the standard patient cases, but challenges identified as part of the study by Del Fiol et al. include the need for consistent change management exacerbated by the cost of maintaining a permanent panel of professionals representing multiple disciplines and a hierarchical structure of maintenance by different professionals utilizing CPOE. Yet, many medical professionals are interested in utilizing standardized sets, based on a study of early paper-based forms posted on an Intranet site for printing, when the utilization rate increased from 0 to 6400 hits for the form per month over the 24-month period (Heffner, Brower, Ellis, & Brown, 2004). Early decision support-based programs administered at the end of the 1980s and in the mid-1990s at the 520-bed LDS hospital in Salt Lake City, Utah, used an antibiotic management program based on local clinician derived guidelines embedded in the software application. This helped decrease the cost of drug administration per patient from $122.66 in 1988 to $78.37 in 1994, despite an overall increase in antibiotic drug administration during the same period (Pestotnik, Classen, Evans, & Burke, 1996).

Brigham and Women's hospital in Boston performed a more sophisticated study based on computer alerts in CPOE. The program encouraged prophylaxis as a way to reduce frequency of deep-vein thrombosis (DVT) among high-risk hospitalized patients (Kucher, Koo, Quiroz, Cooper, Paterno, Soukonnikov, & Goldhaber, 2005). There were 1,255 patients in the intervention group and 1,251 in the control group. Acute DVT occurred in 4.9% of patients in the intervention and 8.2% in control groups. This constituted a 41% reduction in the deep-vein thrombosis or pulmonary embolism rates at 90 days. In the most recent cluster-randomized controlled trial of 179 diabetes mellitus and inpatient hyperglycemia patients at an academic hospital, primary mean percent of the glucose

readings per patient were reduced to 60-180 mg/dL (Schnipper, Liang, Ndumele, & Pendergrass, 2010). The result of this experimentally categorized study, based on a custom medication order (control group) and a CPOE admission order set (intervention group), indicated a positive outcome from use of the standard medication order sets.

Payne, Hoey, Nichol, and Lovis (2003) performed a study at the Veterans Administration (VA) Puget Sound hospital in Washington with two medical centers, 500,000 annual outpatient visits, and 10,000 discharges. While admitting a painful and time-consuming process of creating order sets, the study recorded order set utilization rates of 50% for order dialogs, 57% for quick orders, and 13% for full order sets used within six months of implementation. There was also a further 26% increase in use recorded over two years following the initial study. McAlearney, Chisolm, Veneris, Rich, and Kelleher (2006) analyzed rates of utilization of order sets by physicians among 529 asthma patients (88.1% use), 277 appendectomy patients (79.4% use), and 210 CAP patients (21.1% use) between November 2001 and November 2003. The study indicates generally high, but variable, use among various types of order sets.

Dinning, Branowicki, O'Neill, Marino, and Billett (2005) found that 48,000 cancer-diagnosed patients can expect ADE, 20% of them drug-related, but two-thirds of the cases should be preventable. Such improvement may come from utilization of order sets with the benefits of improved order legibility, time savings, standardization, and low percent of necessary adjustment in template set (given the quality of an order set). In the study, the use of templated sets increased from 1% in 1998 to 70% in 2005, with a 0% physician adjustment rate for CPOE sets and 5% to handwritten ones (Dinning et al., 2005). Cowden, Barbacioru, Kahwash, and Saltz (2003) published an order set quality

improvement study with the goal of combining two orders and evaluating a combined chi-squared to predict order set correspondence to an ordering pattern. The study was performed using 3.06 million records from the Ohio State University (OSU) Medical Center with statistically significant patterns identified in 9762 records, corresponding to 904 orders – a number leading to the conclusion that a large portion of medication orders qualifies for an order set. Chisolm et al. (2006) performed a quantitative study with 790 pediatric asthma patients at Columbus Children's Hospital, dividing patients into three groups: pre-set, set, and no set. Set patients were more likely to receive SCS and PulseOx than pre-set and no set patients, resulting in better health outcomes. There were no statistically significant differences found between no set and pre-set patients.

A number of qualitative studies have been performed to assess effects of evidence-based medicine on patient care. Bobb, Payne, and Gross (2007) identified several controversies with order sets, while confirming excellent decision support opportunities from electronic CPOE-based implementations: (1) voluntary use by physicians creating variability in ADE and utilization rates, (2) typical CPOE sets versus locally used ones produced significant variability, (3) modification of some drugs in a set proved to be difficult despite the available option, and (4) order sets tend to go quickly out of date, requiring costly change and knowledge management efforts. Zafar and Dixon (2009) confirmed costly collaboration of multidisciplinary teams. However, they described as an advantage enhanced teamwork and collaboration among professionals who may otherwise be acting on their own, advancing quality of care and promoting more effective knowledge management practices in healthcare organizations. Zafar and Dixon saw 40% to 50% mortality rate reduction through such collaboration and higher utilization and

buy-in through participation among medical professionals. Yet, they identified time constraints as barriers to participation (typical order set creation project requires six to eight weeks of physician participation).

Rosenal et al. (2009) performed a comprehensive study on utilizing blood culture order sets among 2000 patients and 2000 physicians, encompassing 61,000 orders. They found mixed results due to communication and collaboration, as well as training, issues – concluding the report with quantitative data to back the claim that collaboration and knowledge management efforts to maintain currency of information in CPOE are keys to getting results described in the studies of evidence-based approaches to medical treatment. Lee, Teich, Spurr, and Bates (1996) found one satisfaction factor for physicians – ability to customize order sets – turn into a disadvantage by taking a toll on patient safety due to variable error rates after customization and confusion among technicians charged with following physician orders. Yet, Peitzman (2009) highlighted automation benefits of the order sets as the ones solving communication problems and helping to avoid errors in ordering under situations when multiple priorities may alter an otherwise standard procedure set.

Ahmad et al. (2002) documented a tendency of physicians to request custom sets, which increased availability and variability among order sets in CPOE, thus negatively affecting safety rates through lack of focus and effective communication with people in charge of execution. Ozdas et al. (2006) described another tendency of physicians to ignore medication sets even in cases perfectly matching established standards, with physician independence and different decision-making, potentially affecting quality of care. Rules to require consideration of order sets would represent a culture change that

many healthcare facilities are not ready to undertake. Adventist Health System in Florida undertook such transformation and cited physician engagement as the biggest reason for success of a 2.5-year project to address 80% of the diagnosis-related cases with an order set approach (Herring, 2009). Resistance to change was listed as the biggest challenge on an eventually successful initiative that led to quality of care improvement through reduction of the ADE rates. Hulse et al. (2005) summarized strategic advantages of evidence-based medicine as (1) support for clinical knowledge management, (2) frequent updates to the best drug practices, (3) true evidence-based medicine supported by review of the latest medical and pharmaceutical advances, and (4) health outcomes improvement. Yet, there is at least one argument against evidence-based medicine published in the scholarly literature by Maynard (2009), who argues that prevention of the deep vein thrombosis through implementation of standardized drug sets is a measure of mediocrity that should not replace physician analysis. However, this study is not of a quantitative nature and represents an expert opinion. In fact, Giuse, Williams, and Giuse (2010) recently published an article describing effectiveness of the Vanderbilt University Eskind Biomedical Library's knowledge management team in utilizing multidisciplinary approach to evidence-based medicine to construct 225 evidence packets since 2004, many of which have been implemented electronically as part of CPOE and were well received by members of the clinical staff. The library team utilizes its data for more than just building medication sets and provides input for several quality management and standardization initiatives at the university medical center.

Interest in evidence-based medicine has been on the rise over the past couple of years, as insurance, government agencies, and healthcare organizations have renewed focus on

safety and quality in patient care. Due to this renewed interest, several research studies on medication order sets were conducted under various conditions, including experimental setups, with some just recently published. Afessa, Mullon, Badley, and Gajic (2007) conducted a study of the paper order set effects among 168 severe sepsis and 373 septic shock ICU patients. Health outcomes were selected using Acute Physiology and Chronic Health Evaluation (APACHE) III guidelines that require compliance with the following six elements of early goal-directed therapy and hospital mortality: (1) use of central venous pressure, (2) central venous oxygen saturation measurement, (3) adequate fluid resuscitation, (4) appropriate use of vasopressors, (5) inotropes, and (6) transfusion of red blood cells. The order set was utilized in 61.9% of the patient cases, with no statistically different outcomes relative to the non-set patients, but compliance with standards has increased from 24.8% to 39.6% of the patient cases. In a smaller, experimental study of 120 patients with septic shock diagnosis performed at the Emergency Department (ED) of a 1,200-bed academic medical center, 60 patients in the experimental group were more likely to receive intravenous fluids while in the emergency department (ED) than patients in the control group (2825 +/- 1624 mL vs. 3789 +/- 1730 mL, $p = 0.002$), more likely to receive fluids of >20 mL/kg body weight before vasopressor administration (58.3% vs. 88.3%, $p < 0.001$), and more likely to be treated with an appropriate initial antimicrobial regimen (71.7% vs. 86.7%, $p = 0.043$) (Micek, Roubinian, Heuring, Bode, Williams, Harrison, Murphy, Prentice, Ruoff, & Kollef, 2006). Overall, using order sets for administering drugs in treating septic patients was associated with statistically more rigorous fluid resuscitation of patients, more effective use of appropriate antibiotics, and lower 30-day mortality.

Thiel, Asghar, Micek, Reichley, Doherty, and Kollef (2009) performed a follow-up severe sepsis study at the 1,200-bed academic Jewish-Barnes Hospital, this time among 200 bacteremic patients with severe sepsis for 18 months prior to the order set implementation and 200 in the 18 months after. As with the earlier study, patients in the experimental group received more intravenous fluids in the first 12 hours after onset of the hypotension (1627 +/- 1862 mL vs. 2054 +/- 2237 mL; $p = 0.04$) and were more likely to receive an appropriate dose of the antibiotic therapy (53% vs. 65.5%, $p = 0.01$). Mortality has statistically decreased in the experimental group (55% vs. 39.5%, $p < 0.01$), along with the hospital stay (28.7 +/- 30.1 days vs. 22.4 +/- 20.9 days, $p = 0.02$). The experimental group also experienced other positive effects through reduction in complications, as follows: renal failure (70.5% vs. 57%, $p < 0.01$), cardiovascular failure (70.5% vs. 57%, $p<0.01$), and less likelihood of the vasopressor administration after fluid resuscitation (68.5% vs. 52.5%, $p<0.01$). In their own study of severe sepsis order set implementation, Rivers, Coba, and Rudis (2009) showed relative risk reduction of 0.34 and absolute risk reduction of 16% with a corresponding cost reduction in results of an experiment performed at the Emergency Department (ED) of a university medical center. This translates into the saved life of one out of every six severe sepsis patients – a strong case for insisting on evidence-based medicine implementation in both academic and community hospital settings.[1]

[1] While there are many types of hospital designations depending on their purpose, scope, outreach, access to research, residency slots, etc – this study delineates between teaching and community hospitals as these relate to the dissertation subject. There are

Bekmezian, Chung, and Yazdami (2009) quantitatively measured perceived benefits of the pediatric admission order sets (PAOS) among 97 medical residents at the University of California Los Angeles Children's Hospital using a 5-point Likert scale. Eighty-nine percent of residents approved PAOS and 58% admitted using it all the time. Eighty-eight percent reported that PAOS saved time, 93% thought it was convenient, and most reported less need for communication and clarification with nurses and secretaries. Broussard, Bass, and Arnold (2007) conducted a pediatric sedation drug dosing study at Louisiana State University Health Sciences Center in Shreveport using paper order sets to compare the 26 patient intervention group to the control group of 42 sedations. The average age of patients in the groups was 45 and 71 months respectively. One hundred percent of documentation compliance cases increased from 32% in the control group to 69% in the experimental one. Ordering of resuscitation equipment, American Society of Anesthesiologists (ASA) class, listing of allergies, and post-sedation orders all increased (93% to 100%, 0% to 81%, 64% to 100%, and 43% to 100% respectively). Medication dosages for Versed, Fentanyl, and Ketamine that fell within the recommended dosage range per Lexis-Comp's Pediatric Dosage Handbook (+/- 10%) varied between control

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expected differences between teaching hospitals, where students and residents enter medication orders in addition to physicians, and community hospitals where minimal research is performed and all medication orders are entered by attending physicians. These are also the only two types of hospitals managed by Advocate Health Care where this study is conducted. Other types of hospitals may include academic, regional, tertiary care, etc.

and intervention groups as follows: 68% versus 100%, 100% versus 95%, 71% versus 100%, and 67% versus 100%. Reversal agents ordered, using mg/kg, were 56% in the control group and 100% in the experimental one. Overall, and with a few exceptions, preprinted orders made a dramatic difference in the quality of pediatric sedation care.

Ballard, Ogola, Fleming, Heck, Gunderson, Mehta, Khetan, and Kerr (2008) conducted an observational study to examine order set use by hospital, discharge month, severity of illness, and risk of mortality for pneumonia patients between March 2006 and September 2007. They assessed the impact on in-hospital mortality and 30-day readmission rates using the following four measures: (1) Cox proportional hazards regression, (2) Joint Commission Core Measures compliance using logistic regression, (3) length of stay, and (4) financial indicators using robust regression methods for highly skewed data. Among 3,301 patient cases, order set use increased by 55 percent and significantly improved in-hospital mortality [95 percent confidence interval: 0.66 (0.45; 0.97) or 0.67 (0.46; 0.98)] and Core Measures compliance [95 percent confidence interval: 1.24 (1.04; 1.48) or 1.22 (1.02; 1.45)], without affecting 30-day readmission rate.

Wright et al. (2010) analyzed order sets adoption and utilization among seven hospitals in a mix of community and academic type settings: Brigham and Women's in Boston, Faulkner Hospital in Boston, Kaiser Permanente Northwest in Oregon/Washington, Massachusetts General Hospital in Boston, Sugar Land Hospital in Sugar Land, Texas, NSMC Union Hospital in Lynn, Massachusetts, and Providence Portlar Medical Center in Portland, Oregon. There was no commonality among these hospitals in terms of the CPOE systems they use, size (number of beds ranged from 77 to

750), and scope. The researchers searched for common trends in utilization of the order sets. They found a general increase in utilization, but no patterns in the types of sets. The most common ones among the top 10 at every site were emergency department admission sets, stroke admission orders, pediatric admission sets, general detoxication, and pre/post surgery sets. Other sets included patient controlled analgesia, post-cardiac catheterization, labor admission, insulin, dialysis, blood transfusion, neonatal circumcision, obstetrics admission, expedited admission, zosyn advisor (medication set used to treat or prevent drug-resistant infections, recommended by clinical decision support systems under certain medical conditions), rehabilitation orders, peripheral nerve block, chest pain nursing orders, intensive care unit admission, and psychiatry admission sets. Total availability of the order sets in CPOE ranged between 35 at Faulkner Hospital and 535 at Kaiser Permanente Northwest. Percentage of utilization was higher among health systems and academic hospitals versus smaller community centers. Overall, a growing trend towards utilization of the sets to standardize care practices and to improve efficiencies was identified, but no specific patterns of utilization were revealed.

Another indirect study around order sets that was intended to reveal health outcomes benefits was performed by Khajouei, Peek, Wierenga, Kersten, and Jaspers (2010). They researched efficiency of ordering medications via sets versus custom selection methods in CPOE and found the median excess number of mouse clicks and keystrokes needed by physicians in order to complete medication prescribing tasks was 6.2 times lower in the method with predefined order sets ($P < 0.01$). The excess number of mouse clicks and keystrokes was increased by erroneous messages with a factor of 2.62 (2.24 & 3.07 at

95% CI), use of unfamiliar terminology by a factor of 1.28 (1.14 & 1.43 at 95% CI), and non-informative system feedback by 1.15 (1.03 & 1.29 at 95% CI).

Fleming, Ogola, and Ballard (2009) measured utilization and health outcomes after an implementation of community-acquired pneumonia order set at the Baylor Health Care System, with 4,454 patients meeting the Joint Commission's definition of pneumonia selected for the study between March 2006 and August 2008. After risk adjustment, analysis showed significant reduction in the following areas: in-hospital stay, 30-day mortality, and direct cost, with a 75% increase in compliance. The difference in core measure compliance was statistically significant at 1.08. Mortality reductions approached significance at 0.73 for in-hospital measures and 0.79 for 30-day mortality. The mean benefits of order set use in in-hospital mortality and costs were 1.67. The incremental cost-effectiveness ratio point estimate was -$22,882 per life saved, with an upper 95% confidence limit of $1,278 per life saved. [2]

Braxton, Gerstenberger, and Cox (2010) demonstrated that use of medication order sets can improve compliance with Surgical Care Improvement Project (SCIP) guidelines developed by the US National Institute of Medicine. They utilized a tailored antibiotic

[2] Amount per life saved is a standard clinical case terminology, when savings from clinical quality initiatives are calculated. Terminology refers to savings per patient or patient case, relative to healthcare expenses for treating this same patient without the mentioned clinical innovation. In other words, it is a financial expression/measure of clinical success.

prophylaxis form to help standardize perioperative antimicrobial use, with 90% compliance and an estimated $8,500 annual pharmacy savings through standardization. Wren, Martin, Yoon, and Beck (2010) demonstrated through EMR data mining that electronic orders sets, coupled with education for medical professionals utilizing EMR, can decrease risk of the post-surgery hospital-acquired pneumonia. In their study conducted at the Veterans Administration Palo Alto Health Care System, 13 out of 1,668 patients were admitted with post-operative pneumonia in the pre-intervention period, while only 3 of 1,651 patients were admitted after intervention.

Seattle Children's Hospital implemented a number of quality improvement measures to establish governance over peripherally inserted central catheters, medication order sets included (Migita, Postetter, Heath, Hagan, & Beccaro, 2009). After implementation, insertion volume of the devices decreased by 33.4% and physician satisfaction with the ordering process increased from 2.68 to 3.55 based on a 5-point Likert scale. Improvements were sustained over 19 months, when observation for the purposes of the study concluded. Results were achieved through standardization of practices using evidence-based approaches to treat patients. O'Connor, Adhikari, DeCaire, and Friedrich (2009) conducted a deep venous thrombosis (DVT) prophylaxis quality improvement study at the 750-bed community hospital in Mississauga, Ontario using paper medication order sets for voluntary use by internists without prior education on benefits of the evidence-based approaches to medicine. Order sets were used to prescribe admission medications to 10.9% of the patients, who were 23.4% more likely to receive DVT prophylaxis than patients in the control group. Follow-up experiments showed improvements in other areas where medication order sets were made available, including

allied health consultations (62.8% vs. 12.7%), application of the standardized diabetic diet (17% vs. 5.1%), insulin sliding scale (19.1% vs. 7.6%), potassium replacement protocol (63.8% vs. 0.51%), documentation of allergies (54.3% vs. 9.6%), and resuscitation status (57.4% vs. 10.2%). This study repeated success of the earlier one performed at the same hospital, when results were tracked based on Heparin SC usage for DVT prophylaxis. The number of patients receiving this medication order increased from 10.2% to 22.3% at that time, leading to improved DVT prevention results (O'Connor, DeCaire, & Friedrich, 2005).

Albert, Sherman, and Backus (2010) performed a comprehensive Six Sigma based experiment using a combination of medication order sets, standardization of practice methods, and prioritization for left-ventricular congestive heart failure (CHF) patients to determine impact of evidence-based practices on the length of hospital stay among CHF patients. Turnaround time was reduced from a mean of 2.2 days to a mean of 0.78 days for the left-ventricular CHF patients, while the length of stay was reduced from 7 days to 4 days ($P < 0.05$), and utilization of the order sets by physicians rose from 25% to 72.6%. The study was performed at a medium-sized 265-bed community hospital and points to benefit of the order sets to treat CHF patients but stops short of providing quantitative evidence for the sets outside of the overall array of measures that, in addition to introduction of the sets, included factors such as a new rounding policy, safety checks, and prioritization of patients. However, the study does point out growing interest among researchers to investigate impact of clinical process standardization on CHF health outcomes.

While few recently published studies attempted to link utilization of electronic order sets to quality indicators and patient care directly, a few came close to suggesting such a link without quantitative evidence to support the claim. For example, Ahmad et al. (2002) and Payne, Hoey, Nichol, and Lovis (2003) agreed that the measure of CPOE success is represented by (1) the percentage of orders entered into CPOE directly by providers and (2) the overall utilization of the order sets. Peshek, Cubera, and Gleespan (2010) measured the impact of CPOE implementation on order set utilization and compared the percentage of orders placed using paper sets versus electronic ones at Summa Health System in Ohio. The difference was an astonishing 46%, between 37% prior to CPOE (paper version) and 83% after CPOE (electronic version). Payne et al. (2003) supported the CPOE success measures and their close relationship to order sets and health outcomes by referring to the report by Mehta et al. (2002), which credited evidence-based medicine as a proven quality improvement measure resulting in better health outcomes for patients with acute myocardial infarction – without a direct reference to the order sets that happen to be the core element of the evidence-based medicine implementation as part of the CPOE. When studies of ADE, CPOE, and evidence-based medicine are reviewed and summarized, it is apparent that authors emphasized the positive impact of a CPOE and medication order set as its core element on health outcomes, with references to past studies of the evidence-based medicine that were not performed at healthcare facilities with strong CPOE culture. Moreover, the success of CPOE implementation was widely linked to utilization of its core elements, including medication order sets constructed by teams of clinicians. The missing piece is a quantitative study with the potential to claim a

direct effect of evidence-based medicine on quality of care, using order set data from EMR as a basis to form experimental groups of patients.

The Mayo Clinic introduced a comprehensive order set review process that includes formal committee evaluation, approval process, and mid-term progress checks on utilization and patient outcomes (Formea, Picha, Griffin, Schaller, & Lee, 2010). The only quantitative data provided in the study cites convenience surveys distributed among physicians, with 105 staff members surveyed, 56% responses returned, 65% reporting positive impact on hospital intrateam communications, 71% citing improvement in participant safety, 65% more satisfied with new process compared to the old one (more sporadic introduction of the order sets without formal committee review and progress checks), and 19% indicating no difference in efficiency. The study primarily took on process improvement benefits of the sets rather than direct impact on care, or at least no statistics is provided for the claims of patient safety improvements.

A couple of promising studies on direct medication order set benefits have been recently published. One is on congestive heart failure medication order set that closely resembles an attempt to explore quantitatively the relationship between evidence-based medicine and health outcomes. Another one is on impact of order sets to treat adult febrile neutropenia by antibiotics (not subject of this dissertation).

Ballard, Ogola, Fleming, Stauffer, Leonard, Khetan, and Yancy (2010) performed an observational study on the effects of a standardized heart failure order set on mortality, readmission, and cost of care. Patient population was adults (>18 years old) discharged between December 2007 and March 2009, with a length of stay shorter than 120 days, who had not undergone heart transplant and who did not have a left ventricular assistance

device. Order set utilization reached 73.1% by March 2009 and resulted in increased compliance with core measures (1.51 & 1.08; 2.12 at the 95% confidence level) and reduced in-patient mortality (0.49 & 0.28; 0.88 at the 95% confidence level). Reductions in 30-day readmissions and mortality approached significance. The study also analyzed factors influencing the physician's decision to utilize order sets for prescribing medications. While this observational study is smaller, relative to the proposed study (fewer medication sets, conditions, illnesses, and variables), it represents a serious step forward in identifying quantitative support for evidence-based medicine and indicates documented significance of the dissertation topic.

Best et al. (2011) evaluated the impact of standardized medication order sets on the time interval in initiation of antibiotic therapy for adult patients with cancer and febrile neutropenia at the oncology unit of an urban community hospital in the southeastern United States. A small population sample of 53 cancer patients included a control group of 30 patients admitted in the six months prior to implementation of the order set and 23 patients in the experimental group admitted in the three months after implementation. Order set use was the independent variable, and initial antibiotic times and length of stay were the dependent variables, analyzed in SPSS using One-Way ANOVA and logistic regression methods. An overall reduction of time intervals for initiation of antibiotic therapy was observed among the experimental group of patients – presentation ($t = 2.25$, $df = 37$, $p = 0.031$) and antibiotic administration ($t = 2.67$, $df = 40.17$, $p = 0.012$). Order set usage was 31% in the inpatient unit and 71% in the emergency department.

It is noteworthy that Khanna, Vittinghoff, Maselli, and Auerbach (2011) performed a quantitative study of the unintended consequences of a standard prophylaxis venous

thromboembolism (VTE) admission order set on patient outcomes, thus opening a new chapter in the evidence-based practices research. They argued that administration of prophylaxis sets may worsen outcomes among some patients who should not have received medications, even while improving outcomes among a majority of others who may have benefitted from evidence-based practices. The setting of their experiment was University of California at San Francisco Medical Center, a 790-bed academic hospital. The experiment was based on analysis of data from the pharmacy charge database between July 1, 2005 and December 31, 2008. The primary outcome was use of the VTE order sets among patients with likely benefit, unclear benefit, and potential harm. The sample size was 8429 control and 17635 experimental patients prior to and after implementation of the VTE order set. There was an overall rise in VTE cases after implementation at 58% after versus 51% before, $p < 0.001$, while patients with potential harm from the sets exhibited larger increase in VTE – odds ratio = 1.58 (1.12 & 2.22 at 95% CI). While the overall increase in VTE was small, the higher odds ratio among patients with potential harm from the sets is of concern. Investigation of the harm from administration of the medication order sets to some groups of patients is outside of the scope of this study, but in case it reveals that majority of the patients could benefit from prophylaxis medications ordered via sets, a follow-up study for smaller groups of potentially harmed patients would be warranted before adjusting hospital policy on utilization of the sets and promoting them for all patients.

In their qualitative study on designing and implementing VTE protocols aimed at improving effectiveness of the prophylaxis methods, Maynard and Stein (2010) confirmed that failure to revise and manage order sets, including revisions based on

impact on certain groups of patients, may lead to unintended consequences of standardization. Among other influencing factors, complexity, no guidance for application of sets, failure to adjust risk levels, and lack of situational awareness are listed as contributors to higher VTE rates and failures of the evidence-based sets to increase compliance and reduce acute VTE occurrences. The latter factor has to do with building another line of defense in identification of patients eligible for prophylaxis sets who have not received them by building CPOE alerts recommending use of the sets and leading to potentially higher utilization by physicians.

Summary

Based on this literature review, interest in evidence-based medicine, in general, and utilization of the medication order sets, specifically, to improve quality of care and increase compliance is likely to grow. Coupled with regulatory and industry focus on standardization and outcomes, evidence-based medicine appears poised to be the next big step to raise the quality bar. While few hospitals may have the resources available for implementation at this time, there is interest in exploring the subject among researchers and practitioners alike.

Chapter 3

Methodology

Overview of the Research Methodology

Analysis of the effectiveness of medication order sets measured by health outcomes was a quantitative ex post facto research study using a simple design and purposive sampling methodology. It was based on data extracted from a combination of computerized physician order entry (CPOE), patient accounting, and care quality sources. Full data sets were available beginning in 2007 for most hospitals but Trinity that went live with CPOE in April, 2010. Therefore, a majority of the data contained over four years of patient history. This translated into over 126,000 applicable venous thromboembolism (VTE) records, 5,000 pneumonia encounters, 11,000 congestive heart failure (CHF) cases, and 1,300 acute myocardial infarction (AMI) ones. The VTE study allowed for greater flexibility in terms of splitting patients into groups to perform additional discoveries, such as studying patient sex differences on outcomes and examining data on surgical and non-surgical patients separately. Hospital splits were attempted in VTE and pneumonia studies, while samples were too small to perform any categorizations and hospital splits for AMI and CHF – due to lower utilization of the order sets system-wide. In the pneumonia case, hospital splits could not produce

statistically significant results, but data was collected due to initial expectation that results had the potential to be significant.

Literature, national health problem prevention, cost of care, and actual Advocate Health Care key result areas comprised the basis for selection of the four patient conditions that affect millions of patients. Ultimately, effectiveness of any and all medication order sets must be explored as part of several quantitative studies. Due to lack of such data overall, some of the most common and serious patient conditions were selected for this particular study. Researchers have a chance to review input, content, and methodology behind this study, which is determined to be generalizable to any US-based hospital and, after adjustments to foreign standards of quality measures, any hospital worldwide.

Most of the data sources have existing inbound interfaces into the enterprise data warehouse (EDW), so a series of queries against one database reduced time and complexity necessary to extract data. Every patient encounter contains one principal diagnosis and up to 30 secondary ones. All were pulled and searched for the four patient conditions identified for this study. VTE represents secondary diagnosis only due to the prophylaxis focus of the study that explicitly excluded chronic VTE patients with a principal diagnosis of VTE. The latter category is too small to include as part of extensive study, at least until larger population samples are explored. All of the VTE patients would acquire or have the potential to acquire VTE as part of another treatment, making the diagnosis secondary. In contrast, a majority of the pneumonia patients have their diagnosis listed as principal for community acquired cases, with a minority acquired as hospital-born (nosocomial). A majority of the AMI patients were admitted with AMI as a

principal diagnosis, while CHF can be discovered both as part of the admission process or as part of treatment for a different chief complaint.

The patient encounter number was a unique patient identifier that made it possible to run complex queries against multiple computer applications, ensure proper comparisons between multiple spreadsheets and summary tables, and eliminate patient identity from the study, streamlining the IRB approval procedure. Due to disparity in records, lack of unique identifier for medication order sets, and differences in content among sets with similar titles, manual order set selection was performed on a spreadsheet broken down by hospital, with matching order set content for verification purposes, implementation date, statistical utilization average to ensure acceptable data sample size, and matching health outcomes to ensure validity of complex data queries. Each methodology case below contains detailed information on the order sets selected for the study, as well as lists utilization statistics. The high-level summary of the order sets is presented in Table 15, Appendix A.

There are ten hospitals within Advocate Health Care's network, seven of which will appear as part of this dissertation study. Others are not included, as newer members of the network have not accumulated sufficient electronic patient data under the same computer databases utilized for this study. Table 1 lists all hospitals that participated in the study, along with abbreviated codes that are referenced in the methodology and results sections of this report.

Table 1. Advocate Health Care Hospital Reference Codes

Hospital Code	**Description**
CMC	Christ Medical Center, Chicago, IL
GSAM	Good Samaritan Hospital, Downers Grove, IL
GSHP	Good Shepherd Hospital, Barrington, IL
IMMC	Illinois Masonic Medical Center, Chicago, IL
LGH	Lutheran General Hospital, Park Ridge, IL
SSUB	South Suburban Hospital, Hazel Crest, IL
TRIN	Trinity Hospital, Chicago, IL

The paragraphs below explain sources and basic nature of the dependent variables in the study. These variables represent health outcomes as measurement instruments for quantitative evaluation of effectiveness of the order sets. Further information on specific criteria for these instruments is provided under specific case methodology sections of this chapter, under each patient condition.

Readmission rate stored in EDW came from Thomson-Reuters. It is available in the form of a yes/no binary value, with an added benefit of a reason for readmission that was linked to one or more of the diagnoses in patient encounter records to validate that readmission was a follow-up to a previous hospital stay.

Complications stored in the EDW are represented by the Charlson Comorbidity Index. It is a calculated score based on a list of complications that produce an expected/statistical complications index when added up. While seemingly not the most reliable method of calculating complications, it is the only industry standard widely

accepted by researchers who utilize medical records for historical data studies. Thomson Reuters is in the process of developing a new methodology, but it was not available in time to be utilized for the purposes of this research. Future use would also depend on the degree of acceptance of the new methodology among researchers, as it is best to refer to the most trusted sources in cases when no fully reliable research methods have been developed to analyze complications.

Mortality stored in the EDW was initially represented as a discharge code with matching description. It was converted to a yes/no binary format, based on selection methodology that is detailed within each study that uses mortality as a dependent variable. While projections based on diagnoses are available in the EDW, such data was irrelevant to this study.

Length of stay is stored in the EDW in actual and projected variants. Actual variant is the most relevant use for this variable, as it can tell researchers how long exactly the patient stayed and how medications were prescribed to result in this length of stay, rather than rely on predicted value that would be useful for other kinds of studies not involving historical data.

Overall, the study was split into four independent cases based on specific patient conditions. Results are reported independently as well, but with an overall summary linking all patient conditions to goals of this research study, culminating in recommendations for follow-up quantitative and (potentially) qualitative investigations.

Case I: VTE Methodology

Overview

The study encompassed creation of several cases, split by hospitals chosen from among the heaviest users of the order sets based on EMR utilization statistics, marked by common factors delineating VTE, constrained by timing of the medication orders to filter out treatment sets, and linked to applicable health outcomes as follows:

1. Reviewed one of the monthly medication order set utilization statistics reports to determine applicable sets for the VTE study and to choose hospitals offering the largest data samples. A summary of the August 2010 VTE statistics is presented in Table 130, Appendix B.
2. Reviewed content of each order set in order to verify its validity to use for VTE prevention purposes and to make sure it actually contained medications and not just non-medication orders such as nurse communications or medical devices. The latter two comprised a different study but did not apply to the one examining medication order sets. The complete listing of each set selected for this study is presented in Table 134, Appendix B.
3. Extracted patient encounters with VTE coded as diagnosis, where physicians utilized pre-defined EMR sets to order medications, to form experimental groups. The Enterprise Data Warehouse contains all patient data interfaced by the EMR, billing, and financial systems – necessary to perform extracts and conduct the study, eliminating the need for querying several systems. Data interfaces into the EDW were created as part of a different business need unrelated to this study.

4. Formed control groups of comparable patients who were eligible to receive VTE order sets based on their history expressed as ICD codes. Split cases by hospital (IMMC and LGH only), surgical/non-surgical patient status, and sex.
5. Queried the length of stay and complications for both experimental and control groups.
6. Accounted for factors outlined in the Inclusions and Exclusions sections of this document.
7. Produced a spreadsheet with "raw" data extracted from the EDW.
8. Analyzed the spreadsheet and further excluded unnecessary items that did not conform to requirements of the study, i.e. all chronic VTE encounters, orders placed outside of the 48-hour window from the time of admission, etc.
9. Loaded the resulting "clean" data set into SPSS v. 19 for detailed statistical analysis.
10. Performed case analysis, employing such methods as "if" case definition; group definition; crosstabs; chi-squared Fisher's Exact; Pearson Chi-Squared tests to determine statistical significance of the results; One-Way ANOVA with Bonferroni, Tukey, Dunnett post hoc tests to compare means among independent variable groups and effect on the dependent variables; Mann-Whitney Non-Parametric test of independent samples to test null hypotheses and compare means; and binary logistic regression to calculate the odds ratio among independent variables and between independent and dependent variables in the study.

Goal

The goal was to develop methodology for a causal comparative study analyzing the differences between health outcomes among groups of patients whose VTE medications were ordered via sets and using the "traditional" custom order method. Results indicate the effects of standardization of the medication ordering on quality of care. More specifically, the study was aimed at determining effectiveness of the VTE/DVT order sets in preventing occurrence of acute VTE among surgical and non-surgical inpatients at Advocate Lutheran General Hospital (LGH) and Advocate Illinois Masonic Medical Center (IMMC), as well as to establish any statistical relationships between utilization of the order sets, cases of diagnosed VTE, and two dependent variables most applicable to this illness: patient complications index and length of hospital stay.

Research Questions and Hypotheses

Question 1: Do VTE/DVT medication order sets help prevent occurrence of acute VTE among adult non-surgical patients?

Hypothesis 1 (null): VTE/DVT medication order sets do not help prevent occurrence of acute VTE among adult non-surgical patients.

Question 2: Do VTE/DVT medication order sets help prevent occurrence of acute VTE among adult surgical patients?

Hypothesis 2 (null): VTE/DVT medication order sets do not help prevent occurrence of acute VTE among adult surgical patients.

Question 3: Does patient sex play a role in this study and alter answers to Questions 1 and 2?

Hypothesis 3 (null): Patient sex does not make a difference in the relationship between utilization of the medication order sets to prevent VTE and occurrence of acute VTE.

Question 4: What effect does utilization of the VTE medication order sets have on surgical patient complications index expressed as a calculated Charlson Comorbidity Index?

Hypothesis 4 (null): VTE medication order sets have no effect on surgical patient complications as expressed by the Charlson Comorbidity Index.

Question 5: What effect does utilization of the VTE medication order sets have on non-surgical patient complications index expressed as a calculated Charlson Comorbidity Index?

Hypothesis 5 (null): VTE medication order sets have no effect on non-surgical patient complications as expressed by the Charlson Comorbidity Index.

Question 6: What effect does utilization of the VTE medication order sets have on the length of surgical patients' hospital stays?

Hypothesis 6 (null): Utilization of the VTE medication order sets has no effect on the length of surgical patients' hospital stay.

Question 7: What effect does utilization of the VTE medication order sets have on the length of non-surgical patients' hospital stays?

Hypothesis 7 (null): Utilization of the VTE medication order sets has no effect on the length of non-surgical patients' hospital stay.

Question 8: Which among independent variables of order set utilization, patient age, patient sex, patient race, and surgery status has most influence on the independent variable of acute VTE?

Hypothesis 8 (null): None of the independent variables of order set utilization, patient age, patient sex, patient race, and surgery status has any effect on acute VTE, or all of these variables have equal influence on acute VTE.

High Level Overview of Elements and Outcomes of the Study

The study aimed to compare between identical groups of patients that received and did not receive medication order sets as prophylaxis for VTE. In order to ensure the prophylaxis purpose of the medications, as opposed to treatment, the study was limited to medications ordered within 48 hours of patients' admission. Chronic VTE cases that were listed under a different ICD code were filtered out to ensure further compliance with the prophylaxis requirement. Due to potential differences in characteristics of the VTE conditions among groups differentiated by treatment facility, surgical status, and sex, the final report is split into eight major categories, as follows:

1. Relationship between utilization of the order sets and acute VTE – split by hospital and surgery categories, a total of 4 cases as follows:
    a. IMMC Surgical Calculations
    b. IMMC Non-Surgical Calculations
    c. LGH Surgical Calculations
    d. LGH Non-Surgical Calculations
2. Relationship between utilization of the order sets and acute VTE – split by hospital, surgery, and sex of the patients categories, a total of 8 cases as follows:
    a. IMMC Surgical Calculations – Female

   b. IMMC Surgical Calculations – Male
   c. IMMC Non-Surgical Calculations – Female
   d. IMMC Non-Surgical Calculations – Male
   e. LGH Surgical Calculations – Female
   f. LGH Surgical Calculations – Male
   g. LGH Non-Surgical Calculations – Female
   h. LGH Non-Surgical Calculations – Male
3. Relationship between utilization of the order sets, acute VTE, and Charlson Comorbidity Index as follows:
   a. IMMC Surgical Calculations
   b. IMMC Non-Surgical Calculations
   c. LGH Surgical Calculations
   d. LGH Non-Surgical Calculations
4. Relationship between utilization of the order sets, acute VTE, and length of stay, as follows:
   a. IMMC Surgical Calculations
   b. IMMC Non-Surgical Calculations
   c. LGH Surgical Calculations
   d. LGH Non-Surgical Calculations
5. Direct relationship between utilization of the order sets and length of stay, as follows:
   a. IMMC Surgical Calculations
   b. IMMC Non-Surgical Calculations

   c. LGH Surgical Calculations
   d. LGH Non-Surgical Calculations

6. Direct relationship between utilization of the order sets and Charlson Comorbidity Index, as follows:
   a. IMMC Surgical Calculations
   b. IMMC Non-Surgical Calculations
   c. LGH Surgical Calculations
   d. LGH Non-Surgical Calculations
7. Analysis of statistical significance of several independent variables on occurrence of acute VTE, as follows:
   a. Acute VTE as affected by utilization of the order sets, patient age, patient sex, patient race, and surgical/non-surgical status – LGH and IMMC combined.
   b. Acute VTE as affected by utilization of the order sets, patient age, patient sex, patient race, and surgical/non-surgical status – IMMC.
   c. Acute VTE as affected by utilization of the order sets, patient age, patient sex, patient race, and surgical/non-surgical status – LGH.
8. Descriptive statistics, as follows:
   a. Patient Sex, by order set utilization - IMMC
   b. Patient Sex, by order set utilization - LGH
   c. Patient Race, by order set utilization - IMMC

d. Patient Race, by order set utilization – LGH

e. Study Race Codes

The surgical vs. non-surgical distinction was made via the Agency for Healthcare Research and Quality (AHRQ) industry standard, commonly available as PSI-12 Postoperative Pulmonary Embolism or Deep Vein Thrombosis.

Study Inclusions

a. Acute VTE patients.

b. Adult patients 18 years of age or older.

c. VTE order sets available via EMR at LGH and IMMC hospitals.

d. Surgical and Non-Surgical cases delineated (AHRQ ICD-9, PSI-12).

e. Encounters with use of the order set and none (experimental vs. control groups).

f. Sex of the patients.

g. Age of the patients.

h. Race of the patients.

i. Length of stay (dependent variable).

j. Charlson Comorbidity Index as rate of complications (Table 132, Appendix B).

k. Full list of inclusions is presented in Table 2. Some elements are for the follow-up study use but included as part of the extract for efficiency purposes.

Table 2. Data Elements for Inclusion in the VTE Study

Data Elements (Set 1)	**Data Elements (Set 2)**
Encounter number	Discharge disposition code
Patient key	Length of stay
Site	Observed complications
VTE (yes or no)	Expected complications
Order set (yes or no)	Charlson Comorbidity Index score
Order set (title)	Patient age
Order set catalog number	Patient sex
Surgery (yes or no), AHRQ ICD-9 basis	Patient race
PSI-12 table	
Admit date	VTE Type (acute vs. chronic)
Discharge date	Attending physician name

Study Exclusions

a. OB patients.

b. Psych patients.

c. Pediatric patients under the age of 18.

d. Medication sets ordered after 48 hours from the time of admission.

e. Chronic VTE encounters to focus on prophylaxis only.

Initial Data Processing Steps

The steps outlined in this section were required in order to get the raw data properly organized in Excel and loaded into SPSS, in accordance with inclusions and exclusions of

the study. First, it was necessary to extract data from the EDW database to receive a raw file suitable for analysis and data categorization. For this purpose, a query had to be built against EDW SQL Server database for all patient encounters available since inception of the data repository in 2007, so over four years of data within the 2007 – 2011 date range, using the list of variables provided in Table 2. Results of the query were converted to Excel format in order to be useful for statistical manipulations, including loading into SPSS. Table 131, Appendix B lists values assigned to variables in this study. The Excel file had variables listed as columns and patient encounters corresponding to these variables listed as rows. The query excluded patients under 18 years of age, obstetrics patients, and psych patients – as indicated by the list of exclusions produced for the VTE study. Other exclusions were taken care of via SPSS groups and filtering.

The "raw" file extracted out of the EDW database and saved in Excel produced a large listing with over 126,000 patient encounters, based on the monthly medication order set utilization statistics provided in Table 130, Appendix B. For encounters where medication order sets were utilized, a special column that displays time in days between admission and physician order set timestamp was necessary in order to comply with the policy of adhering to prophylaxis sets ordered within 48 hours of admission. Both variables were available via data extract. The valid time to include in the study was an integer that varied between negative range (pre-admitted patients from nursing homes or other outpatient facilities) and positive number not exceeding 1 (within 48 hours of admission). Zero is a valid value in the range, because days within admission is a calculated field where number of days is converted from hours, so if a medication order

was placed shortly before or after admission, it would have a non-zero value in hours but might have a zero-value in days when rounded.

A table of race codes was necessary in order to turn string format of the race description data coming from the warehouse into numerical field suitable for quantitative analysis of the race's influence as an independent variable on the dependent variables in the study. This conversion of format was accomplished using "Search" function in Excel, building a table of race codes utilized in the data file, and assigning random numbers in logical order to each race type. The race codes for the VTE study are summarized in Table 133, Appendix B. The "Replace" function in Excel was utilized to assign numeric codes in the race column, replacing corresponding string values that cannot be used for statistical purposes.

Any unnecessary fields that arrived from raw data as results of extensive data entry for the study had to be removed, leaving only the following columns:

- VTE Order Set Used
- Facility Key (Table 1)
- Admit Date
- Patient Sex
- Age
- Race
- Length of Stay
- VTE Order Set Date
- Days Admit to VTE Order Set (calculated in Excel)

- MAXDX (unnecessary field but required to load surgery status)
- PSI 12 Denominator – categorical delineation between surgical and non-surgical patients based on AHRQ PSI-12, Appendix A standards, Operating Room Procedure Codes - listed in Table 135, Appendix B. Value of 0 is displayed when procedure code for the patient does not produce a match in the PSI table, otherwise a value of 1 is displayed indicating surgery – true. AHRQ codes are healthcare industry standards that providers and insurers refer to when reviewing services delivered to patients
- Acute VTE
- Chronic VTE
- Charlson Comorbidity Index.

The resulting Excel file was ready for shifting work into SPSS and contained only data identified as required for the study. The initial full data set before cleanup can be utilized for follow-up studies that are proposed in Chapter 5. It was also important to account for any remaining study exclusions by deleting corresponding rows with patient encounters in SPSS using the Data Split File function for sorting, as follows:

- Delete all cases with Chronic VTE = 1
- Delete any rows containing encounters with the Days Admit variable value > 1.

Variable Setup for CCI and LOS cases

The One-Way ANOVA test was applied to examine complex relationship between utilization of the order sets, acute VTE (both independent variables), and length of stay or Charlson Comorbidity Index (both dependent variables). In this setup, it was important to not only account for the experimental factor of application of the order sets but also for the known fact of occurrence of the VTE before examining the overall effect of the VTE order set on health outcomes. In other words, whether the order set was applied and whether acute VTE occurred were facts known from medical records, creating four possible combinations that could influence LOS and CCI in four different ways. However, One-Way ANOVA is only effective in comparing categories of variables selected for experimental study but not examining complex relationships within this structure. Therefore, additional assumptions were necessary to simplify structure for ANOVA, with relationships between independent variables documented for analysis of the results. In order to properly configure One-Way ANOVA, a new field in SPSS, called VTE_Category, served the purpose of comparison of means between two independent variables of VTEOrderSetUsed and AcuteVTE, and the dependent variables of the length of stay and CharlsonComorbidityIndex. This was accomplished in SPSS in the following order:

- Ensured that VTEOrderSet Used and AcuteVTE columns appeared next to each other for convenience
- Inserted a new field called VTE_Combination next to AcuteVTE
- Sorted VTEOrderSetUsed column in descending order

- Called the first combination of 1/1 (VTEOrderSetUsed=1/AcuteVTE=1) as 1 and entered the value on the first row in the VTE_Combination column
- Formatted the new field to integer with no decimal places
- Copied and pasted the number for all rows next to the 1/1 combination rows
- Labeled and documented all cases in the same fashion, as follows:
    a. 1->1 = 1
    b. 1->0 = 2
    c. 0->1 = 3
    d. 0->0 = 4

The above cases served as input for the One-Way ANOVA analysis of the relationship between independent and dependent variables (LOS and CCI).

Case Separation by Hospital, Sex, and Surgical Status – Repetitive Process

The *High Level Overview of Elements and Outcomes of the Study* section outlined several cases split by hospital and surgical status that must be run separately in SPSS. This was accomplished using Data -> Select Cases functionality in SPSS. Examples are as follows:

- IMMC Surgical calculations case: “Facility Code = 7 AND PSI12DENOM = 1”
- LGH Non-Surgical Female calculations case: “Facility Code = 10 AND PSI12DENOM = 0 AND Sex = 1”

- IMMC Surgical Male calculations case: “Facility Code = 7 AND PSI12DENOM = 1 AND Sex = 0”

Conditions for the first studies in the list can be defined as a single setup per case with resetting all conditions back to original state and defining conditions again, capturing data for each scenario. Repeating data select and reset operations helped in running all statistical manipulations on all identified hospital, surgical status, and sex condition combinations.

Relationship Between Order Set Utilization and Acute VTE Independent Variables

For each of the cases, Analyze -> Descriptive Statistics -> Crosstab SPSS function was utilized to display VTE Order Set Used and Acute VTE columns with corresponding statistics in a table. Additionally, Statistics sub-menu contained the option to request chi-squared data for each case. Statistics for the first two cases were obtained in the following format:

Table 3. Format for Displaying Relationships Between Order Set Utilization and Acute VTE Independent Variables

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher’s Exact**	**1-sided Fisher’s Exact**	**EXP (B) – Binary Logistic Regression**
VTE = yes						
VTE = no						
Percent (VTE=yes) / total						

VTE outcomes, coupled with Control Group and Experimental Group patient encounters, represented four scenarios with VTE outcomes equal 0 or 1 and utilization of order sets equals 0 (control group) or 1 (experimental group). For each of the four groups, a within group ratio of acute VTE cases relative to the group total was reported, together with applicable statistics for the entire scenario that included Pearson Chi-Squared, 2-sided Fisher's Exact, 1-sided Fisher's Exact, and the odds ratio from the binary logistic regression calculations. Lower percent of patients who acquired VTE always indicated the benefit for whatever group such lower ratio was recorded for, i.e. if lower percentage of VTE = yes was reported for the experimental group, the result indicated the benefit of ordering VTE medications via sets.

It made no sense to perform Pearson correlation testing for dichotomous variables expected to display low correlation values. Smaller ratio on the right side of the statistics reporting format above suggested that fewer cases when order sets were applied led to VTE, compared to cases when physicians did not utilize sets. This scenario indicated a benefit of the VTE order sets. Smaller ratio on the left of the statistics reporting format above suggested that fewer cases when order sets were not applied led to VTE, indicating negative impact of the sets. However, the best conclusion from this statistic was that factors other than medications were involved.

Two-sided Fisher's Exact was used to measure significance in each case. Standard expectation is for $p =< 0.05$ in order for differences to be significant. These steps concluded studies (a) and (b). The 1-sided Fisher's Exact, if significantly different from the 2-sided number, might indicate a larger spread of values within distribution or smaller

data samples. It was not used in the study as an indicator of significance but had the potential to contribute to summary and analysis.

Binary logistic regression was employed to define the relationship between two independent categorical variables, AcuteVTE and VTEOrderSetUsed. The binary regression formula is specifically designed in SPSS in order to compare two variables with dichotomous rather than continuous values. The following steps were followed in SPSS in order to run binary logistic regression and derive the value of the odds ratio (EXP(B)). For each case, Analyze -> Regression -> Binary Logistic function of SPSS was utilized. Setup was as follows:

- Dependent: AcuteVTE
- Covariate: VTEOrderSetUSed (categorical)
- Methods: Enter and Backward LR
- Options: CI for EXP(B)

Two of the following results are reported: odds ratio EXP(B) and the lower/upper boundaries at the 95% confidence level, followed by summary of the relationship between independent variables for all cases.

Relationship Between Order Set Utilization and LOS/CCI

For the studies of establishing relationships between independent variables and dependent variables of length of stay and complications (LOS and CCI), the same case selection as in the earlier studies applied, but crosstabs listed the number of patient encounters corresponding to these variables – resulting in the following table templates that were filled with data when it became available as part of the Final Report stage of the dissertation process:

Table 4**.** Relationship Between Charlson Comorbidity Index (CCI), Order Set Utilization, and Acute VTE

CCI	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						

Table 5**.** Relationship Between Length of Stay, Order Set Utilization, and Acute VTE

Length	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
1 - 5						
6 - 10						
11 - 15						
16 - 20						
21 - 25						
26 - 30						
31 - 35						
36 - 40						
41 - 45						

The length of stay was grouped due to excessive number of categories, with values above 45 days dropped due to small data samples and extreme statistically insignificant

ratios produced as a result. Smaller ratios on the right side of the template tables 4 and 5 indicated fewer patients with VTE in cases where medication order sets were utilized, indicating statistical benefit of the sets. Larger number on the right side of the template tables 4 and 5 led to the opposite conclusion.

Each one of the 16 Charlson Comorbidity categories were analyzed for surgical and non-surgical patients at each of the two hospitals selected for the study. Each one of the length of stay groups were analyzed for surgical and non-surgical patients at each of the two hospitals selected for the study. Same categories from each study were compared to determine consistency.

The categorical column created at the outset of the SPSS manipulations process for the purposes of setting up the One-Way ANOVA study was then put in use. The test was executed in SPSS in the following fashion:

- Analyze -> Compare Means -> One-Way ANOVA
- LOS and CCI for dependent variables in two separate runs
- VTE_Category as Factor
- Options -> Descriptive
- Post Hoc: Bonferroni, Tukey, Dunnett (Control Category = Last)

For all cases, the value of F, degrees of freedom, and significance were reported as basic One-Way ANOVA outcomes. Additionally, tables of means, standard deviation, significance, and 95% confidence intervals were reported for all cases. Group comparison tables for Bonferroni and Tukey post hoc tests have shed more light on relationships between experimental categories. Comparisons of means were performed between groups

of 1:2 (application of sets) and 3:4 (no application of sets). In order to qualify, SPSS must mark results statistically significant. For all significant results, means were compared to determine longer/shorter hospital stay for patients under all categories and higher/fewer number of complications.

Dunnett *t*-test is an alternative post-hoc method to Bonferroni and Tukey. It analyzes results for all groups against the control group. Dunnett results were reported for each of the cases. Control group was 4 (no order set and no VTE), and experimental group was 2 (order set and no VTE). Other groups were disregarded as irrelevant for the study. This test revealed the relationship between utilization of the order sets and CCI/LOS, comparing experimental group with order sets applied and no VTE against control group with no order sets applied and no VTE.

Examining the direct relationship between utilization of the order sets and length of stay was accomplished by running the Mann-Whitney Independent Samples comparison of means aimed at testing the null hypotheses and comparing mean ranks among values for the categorical variable of VTEOrderSetUsed. Independent samples were utilized due to a mix of categorical and continuous variables. SPSS steps to run this test were as follows:

- Analyze -> Nonparametric Tests -> Independent Samples
- Test Field: LOS
- Groups: VTEOrderSetUsed
- Settings -> Customize Tests -> Mann-Whitney U (2)
- Run

The following was reported in order to document Mann-Whitney results: N for each category of the VTEOrderSetUsed variable, Total N, Mean Ranks, Mann-Whitney U, Wilcoxon W, Test Statistic, Standard Error, Standardized Test Statistic, and Significance. Final Mann-Whitney test results were reported as simply accepting/rejecting null hypothesis and outlining the differences between mean ranks for the VTEOrderSetUsed variable.

Similar setup is applicable for examining the relationship between utilization of the order sets and Charlson Comorbidity Index. SPSS setup steps were as follows:

- Analyze -> Nonparametric Tests -> Independent Samples
- Test Field: CharlsonComorbidityIndex
- Groups: VTEOrderSetUsed
- Settings -> Customize Tests -> Mann-Whitney U (2)
- Run

At this point, cases were summarized and conclusions were drawn based on data provided in all tables used for the dependent variable studies. One-Way ANOVA and Mann-Whitney tests are two alternative methods for testing the same relationships between variables. Differences and similarities shed light on results of the study: same outcomes served as verification of validity of the results and differences indicated discrepancies that were analyzed before jumping to conclusions.

Relationship Between Independent Variables of Order Set Utilization, Age, Sex, Race, and Surgical Status

This last VTE study examined significance/effect of several independent variables on the value of independent variable Acute VTE. The test was accomplished using binary logistic regression function of SPSS, invoked by selecting Analyze -> Regression -> Binary Logistic, and utilizing the following setup:

- Dependent: AcuteVTE
- Covariates: Patient Sex (categorical), Patient Age, Race_Code, PSI12DENOM (categorical), VTEOrderSetUsed (categorical)
- Method: Enter

Results for all hospitals and by hospital separately were reported in the following table template:

Table 6. Acute VTE as Affected by Utilization of the Order Sets, Patient Age, Patient Sex, Patient Race, Surgical/Non-Surgical Status

Independent Variable	**Significance, 95% conf. level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)		
Patient Age		
Patient Sex		
Patient Race		
Surgery Status		
Constant		

Descriptive Statistics and Patient Demographics

It was helpful to conclude the VTE study by reporting descriptive statistics for all cases. This was accomplished by invoking the Crosstabs functionality of SPSS and selecting various cases, as described earlier in the methodology. Totals broken down by patient sex, race, order set utilization, and acute VTE occurrence were reported. The complete list is as follows:

- Patient Sex, Order Sets – IMMC
- Patient Sex, Order Sets – LGH
- Patient Sex, Acute VTE – IMMC
- Patient Sex, Acute VTE – LGH
- Patient Race - IMMC
- Patient Race – LGH

The final step in the VTE study was bringing together all statistics to answer the research questions and test hypotheses outlined for each of the questions.

Case II: Pneumonia Methodology

Overview

The study involved statistical comparison between experimental groups of patients who received medications via order sets available in EMR and control groups of patients who received medications via "traditional" custom electronic physician orders. Building the case, obtaining data, and performing analysis processes included the following high-level steps:

1. Reviewed one of the recent monthly mediation order set utilization reports to compile to determine applicable Pneumonia sets for this study and choose hospitals offering the best utilization with the largest samples. Summary of the August 2010 statistics is presented in Table 137, Appendix C. Pneumonia order set content is listed in Table 138, Appendix C.
2. Due to relatively low utilization of Pneumonia order sets at many Advocate facilities, considered inclusion of all facilities in case individual ones did not

produce statistically significant results due to small populations. This was actually the case, but due to availability of data all results were reported: the combination of facilities and each facility individually.

3. Formed experimental and control groups of patients by extracting from EDW all patient data with Pneumonia as principal diagnosis. Patient encounters without medication orders placed via sets constituted a control group, and those encounters where medications were ordered via sets constituted an experimental group. Given small utilization of the sets, control group was significantly larger than experimental group.
4. Ensured that dependent variables of mortality, 30-day readmission, length of stay, and comorbidity appeared on the spreadsheet, along with other independent variables of age, sex, and race that will also serve for the purposes of listing descriptive statistics for control and experimental groups.
5. Accounted for factors outlined in the Inclusions and Exclusions sections of this document.
6. Reviewed the spreadsheet, cleaned up cases that did not appear to meet criteria for the study, and loaded into SPSS v. 19 for statistical analysis.
7. Performed case analysis in SPSS, including methods such as Pearson Chi-Squared, Fisher's Exact significance, binary logistic regression to determine odds ratios for the relationships between independent and dependent variables, and Mann-Whitney independent samples test to reject/accept null hypothesis to determine the relationship between utilization of the order sets and length of stay and complications.

Goal

The goal was to develop methodology for a causal comparative study analyzing the differences in health outcomes among groups of patients whose medications were ordered via sets and using the “traditional” custom order method. Results indicated the effects of standardization of the medication ordering on quality of care. More specifically, the study was aimed at determining effectiveness of the pneumonia medication order sets in treating this illness, as evidenced by mortality, 30-day readmission, length of stay, and patient complications health outcomes data collected at Advocate Good Samaritan, Illinois Masonic, and South Suburban, and Trinity hospitals.

Research Questions and Hypotheses

Question 1: Do pneumonia medication order sets help decrease mortality among pneumonia patients?

Hypothesis 1 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and in-hospital mortality among pneumonia patients.

Question 2: Is there a difference in the relationship between utilization of the pneumonia medication order sets and in-hospital mortality when patients with hospice discharge code are excluded from the study?

Hypothesis 2 (null): There is no statistical difference in mortality health outcomes relative to utilization of the pneumonia medication order sets when hospice patients are excluded from the study.

Question 3: Do pneumonia medication order sets help prevent and/or decrease 30-day readmission rate among pneumonia patients?

Hypothesis 3 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and 30-day readmission rates among pneumonia patients.

Question 4: Is there a statistical relationship between utilization of the pneumonia medication order sets and in-hospital length of stay?

Hypothesis 4 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and length of stay among pneumonia patients.

Question 5: Is there a statistical relationship between utilization of the pneumonia medication order sets and patient complications represented by Charlson Comorbidity Index?

Hypothesis 5 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and patient complications.

Question 6: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of 30-day hospital readmission among pneumonia patients?

Hypothesis 6 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict 30-day hospital readmission among pneumonia patients.

Question 7: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of in-hospital mortality among pneumonia patients?

Hypothesis 7 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict in-hospital mortality among pneumonia patients.

High Level Overview of Elements and Outcomes of the Study

The study aimed at comparison between identical groups of patients who received and did not receive medication order sets as treatment for pneumonia. It resulted into seven different reports, as follows:

a. Relationship between utilization of the order sets and mortality, with discharge codes for hospice patients excluded for the purposes of this study.
b. Relationship between utilization of the order sets and mortality, with only Expired discharge codes marked as mortality = yes. The differences between these cases with different classification of mortality were analyzed and reported.
c. Relationship between utilization of the order sets and 30-day readmission.
d. Relationship between utilization of the order sets and length hospital stay.
e. Relationship between utilization of the order sets and patient complications represented by Charlson Comorbidity Index (CCI).

f. Analysis of significance among independent variables of utilization of the order sets, patient sex, patient race, and patient age in predicting the value of the dependent variables of readmissions and mortality.
g. Descriptive statistics on patients reported in the study, including race and sex of patients distributed across control and experimental groups.

Cases of mortality from pneumonia, in addition to discharge codes appearing in the discharge summary in EMR, are governed by table of ICD-9-CM Diagnosis codes, listed as part of the industry-standard AHRQ IQI-20 Pneumonia Mortality Definitions. In other words, all cases with Expired and/or Hospice discharge codes must also match entries on the table of diagnosis codes in order to be mortality from pneumonia specifically. The ICD-9 codes pertaining to pneumonia cases are listed in Table 136, Appendix C.

Study Inclusions

a. Patients with primary diagnosis of pneumonia (community acquired, chief complaint on admission) and secondary diagnosis of pneumonia (nosocomial infection, hospital acquired, not chief complaint on admission).
b. Adults over 18 years of age.
c. Full list of variables pulled from EDW is provided in Table 7:

Table 7: Data Elements Pulled as Part of the "Raw" Pneumonia EDW File

Data Elements (Set 1)	**Data Elements (Set 2)**
Encounter Key	MSDRG Description
Encounter Number	MSDRGMDC

Medical Record Number	Discharge Location Code
Facility Abbreviation Name	Principal Diagnosis Code
Admit Date	Principal Diagnosis Description
Discharge Date	Principal Diagnosis POA
Discharge Fiscal Year	PN Order Set Indicator
Discharge Fiscal Period	Order Key
Patient Age Year	Catalog Code
Patient Race Code	Catalog Synonym Code
Patient Race Description	Final Order Status Description
Patient Sex Code	Order Original Date
Financial Class Code	Facility Key
Financial Class Description	Readmits Encounter Key
Discharge Disposition Code	Readmits Encounter Number
Discharge Disposition Description	Readmits Discharge Location Code
Admit Source Date	Readmits Financial Class Code
Admit Source Description	Has Readmit Indicator
Length of Stay (LOS)	Midas Readmit Index
MSDRG	Readmit Encounter Key
Charlson Comorbidity Index	

d. Final list of variables loaded into SPSS for the purposes of this dissertation study (Table 8). Other variables can be utilized for follow-up studies, such as investigation of why patients without use of the order sets were readmitted

within 30 days and their corresponding discharge codes, financial impact of readmissions and longer length of stay, advanced effects of complications and how the influence the overall future state of the patient's health outcomes beyond pneumonia case treatment, etc.

Table 8. Final List of Variables Selected for the Pneumonia Study

Data Elements	**Notes and Values**
Facility Abbreviation Name	GSAM = 4 IMMC = 7 SSUB = 9 TRIN = 8
Facility Key	See codes above
PN Order Set Indicator	Order Set = no = 0 Order Set = yes = 1
Has Readmit Indicator	Readmission = no = 0 Readmission = yes = 1
Length of Stay (LOS)	Number of days
Discharge Disposition Code	Converted field, final form as follows: No Mortality = 0 Mortality = 1
Discharge Disposition Description	FYI field for discharge disposition code
Patient Age Year	Age in years
Patient Sex Code	Male = 0 Female = 1
Patient Race Code	Converted field, final form as follows See Table 139, Appendix C
Patient Race Description	FYI field for patient race code
MSDRG (admit code)	Values not used in calculations, but can be reviewed to confirm all patients are pneumonia patients
MSDRG Description	FYI field for MSDRG
Principal Diagnosis Code	Values not used in calculations, but can be reviewed to confirm all patients are pneumonia patients
Principal Diagnosis Description	FYI field for Principal Diagnosis Code
Principal Diagnosis POA	Easy verification for pneumonia patients:

	Pneumonia = Y Other = N
Charlson Comorbidity Index	Calculated Total Index Values 0 - 16

e. Patient discharge code 20 for the study that assumed mortality as Expired patient only. For mortality study that excludes hospice patients, excluded discharge codes were 50 (hospice/facility) and 51 (hospice/home).
f. Admit and Diagnosis values that appear in the spreadsheet were already filtered for inclusion of pneumonia patients only – reason why these codes are displayed FYI for verification only.
g. Order sets selected for each hospital, along with their detailed content, appear in Table 138, Appendix C.

Study Exclusions

a. Psych and OB patients.
b. Pediatric patients (under 18 years of age).
c. Trinity hospital discharges before April 2010 – these came from paper records before EMR was implemented, so no order set patients in the experimental group would match, thus forming invalid control group prior to that date.

Detailed Review of the Steps and Elements of the Study

As with the VTE case, the data obtained from the EDW database was saved in Excel and cleaned up, leaving only columns/elements outlined in Table 8. The resulting Excel file was used for performing further numerical manipulations in SPSS.

Initial Data Processing Steps

Every discharge reason has corresponding code. This variety of codes is unnecessary for the study. The preference is to leave dichotomous values in the discharge code field. For the first of the two mortality studies, “Find” and “Replace” functions of Excel were utilized to convert all codes to 0 (no mortality), except the following: 20 (Expired), 50 (Hospice/Facility), and 51 (Hospice/Home). The Expired values (20) were replaced with 1. The other two values were left for later cleanup in SPSS. Result was a binary representation of mortality suitable for quantitative analysis. Other mortality differences had no value for this study. The new Excel file was saved separately for the study that assumed exclusion of the hospice patients as a way to examine differences between variables as related to the hospice cases specifically. The descriptive file name chosen for filing of these intermediate results was ‘Required + Mortality + Hospice Excluded” to indicate which study the file covered. For the study that only listed Expired patients as mortality = yes, another file was saved with a discharge code of 20 converted to 1 and other values converted to 0.

Using “Find” and “Replace” functions of Excel, the string race code values were converted to randomly assigned codes listed in Table 139, Appendix C. These numeric codes were more suitable for a quantitative study.

Excel files only contained required data at this point and were loaded into SPSS for further analysis. It was only required to work with two files for the purposes of conducting research on the dependent variable of mortality. For other variables, there was no difference, and any of the two SPSS/Excel files could be used. For study that excludes hospice patients from mortality, the Split File function of SPSS was utilized to sort the

DischargeDisposition field and delete all rows with values of 50 and 51. These rows were at the bottom.

Relationship Between Order Set Utilization and Mortality

The Descriptive Statistics -> Crosstabs function of SPSS was invoked with PNOrderSetIndicator and DischargeDisposition fields and Pearson Chi-Squared calculation as the sole option. Pearson Chi-Squared and Fisher's Exact values were used to determine significance of statistical relationship between the independent variable of order set utilization and the dependent variable of mortality. The number of entries for experimental and control group formed the following report:

0 -> 1: X	1 -> 1: X
0 -> 0: Y	1 -> 0: Y
% (X/(X+Y))	% (X/(X+Y))

These values represented percentage of orders with no medication order sets that resulted in mortality as a ratio of all orders with no medication order sets – left side. On the right side, there was comparison of orders where medication sets were utilized and resulted in mortality as a ratio of all orders with utilization of sets. Smaller number on the right means that fewer orders with medication sets led to mortality, while smaller number on the left skewed results towards benefit of the custom orders without utilization of the sets. The number above could and was also obtained as the odds ratio via binary logistic regression, as follows:

- Analyze -> Regression -> Binary Logistic
- Dependent: DischargeDispositionCode
- Covariate: PNOrderSetIndicator (categorical)

- Option: CI for EXP(B)

The odds ratio was obtained via both Enter and Backward LR methods in order to determine whether differences in methods exist. Ratios over 1 indicated benefit of the sets (as represented by smaller percentage on the right side); ratios smaller than 1 indicated the benefit of custom medication orders versus sets. It is also necessary to report lower and upper boundaries of the odds ratio, at the 95% confidence level.

Relationship Between Order Set Utilization and Readmissions

All of the above SPSS steps were repeated using PNOrderSetIndicator as independent (covariate) variable and HasReadmit_Indicator variable as dependent to define relationship between these variables. So two tests were performed: (1) crosstabs with Pearson Chi-Squared and Fisher's Exact and (2) binary logistic regression with odds ratio and upper/lower boundaries at the 95% confidence level.

All SPSS manipulations were repeatedly performed for all cases, split by hospital and sex using Select Cases functionality of the application. In all individual cases, the population size was too small to produce statistically significant results, but the data was reported for the combined and individual facility cases – without testing the split by patient sex that was obviously destined to produce statistically insignificant results.

All calculations were repeated for the separate data file representing scenario where hospice patients were not excluded and instead accounted for as mortality = no. Any differences and corresponding conclusions were reported, along with summary of the benefits of medication order sets based on the health outcomes of mortality and readmission.

Relationship Between Order Set Utilization and LOS/CCI

Due to a mix of continuous values for the LOS and CCI variables and dichotomous ones for the PNOrderSetIndicator variables, the best test for the LOS and CCI relationships was a Non-Parametric one designed for independent samples. It helped with testing the null hypothesis and determining which way results were skewed in case the null hypothesis was rejected.

The Non-Parametric tests were performed using the Analyze -> Nonparametric Tests -> Independent Samples function of SPSS. In the Variable View, both variables were set to the Scale type. Other options were as follows:

- Automatically Compare
- Fields Tab -> LOS variable for the Test field
- PNOrderSetIndicator will be a group variable with binary values of 1 and 0
- Settings -> Customize Fields, and select Mann-Whitney U (2 samples) tests – the most appropriate comparison of the two samples with one dependent variable. This test can use categorical and continuous variables to produce results.

Results were summarized to make a verdict on acceptance or rejection of the null hypothesis – based on which direction results on the distribution were skewed in. The Non-Parametric tests were also repeated using Charlson Comorbidity Index as a dependent variable. Due to a relatively small data sample size, it only made sense to perform calculations for all hospitals selected for the study and skip individual calculations that were unlikely to produce statistically significant outcomes.

A One-Way ANOVA helped double-checking results of the Non-Parametric tests from the comparison of means perspective, comparing the means for the two order set utilization binary values and testing for statistical significance. The following steps were necessary in order to run One-Way ANOVA tests in SPSS:

a. Analyze -> Compare Means -> One-Way ANOVA
b. Chose LOS as a dependent variable
c. Chose PNOrderSetIndicator as a Factor
d. Requested Descriptive from the Options list
e. Ran the test
f. Reported the F value, degrees of freedom, and the P value
g. Repeated the same steps using CharlsonComorbidityIndex as a dependent variable.

Conclusions regarding relationship between utilization of the order sets and LOS, and utilization of the order sets and CCI were ready for documentation at this point, noting any discrepancies between One-Way ANOVA and Non-Parametric Mann-Whitney tests. The latter did not produce any significant differences, leading to sound conclusions proven by two different statistical methods.

Relationship Between Independent Variables of Order Set Utilization, Age, Sex, & Race and Dependent Variables of LOS/CCI

The last study proposed for the pneumonia case was an explanation of the dependent variables of mortality and readmission by several independent variables of order set indicator, race code, sex, and age. Binary logistic regression was the most suitable method of running this study, because this statistical method used significance as a way

to indicate strength of the relationship and influence of the independent variables on health outcomes represented by the dependent variables of readmissions and mortality. This method also uses odds ratio to quantify the relationship between variables, leading to conclusions regarding significance of the independent variables in analysis of the outcomes and comparison between those variables hospitals/researchers cannot control (age, sex, race) and the ones they can (application of the order sets to request medications). Two tests, for the DischargeDispositionCode and HasReadmit_Indicator dependent variables, were reported separately. The PatientSexCode variable was defined as categorical. Table 9 represents format for the results of this test.

Table 9. Pneumonia <Readmissions or Mortality> as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)		
Patient Age		
Patient Sex		
Patient Race		
Constant		

It was determined by analyzing results reported in Table 9 which independent variables best and better predict dependent ones, and which independent variables were statistically insignificant.

Summary

The final report incorporates overall analysis and recommendations regarding utilization of the medication order sets to treat pneumonia, and how these sets influence/predict the health outcomes of length of stay, mortality, 30-day readmission,

and comorbidity. The report provides grounds for answering the research questions outlined in the pneumonia study and accepting/rejecting the research hypotheses.

Case III: Congestive Heart Failure (CHF) Methodology

Overview

The study involved statistical comparison between experimental groups of patients who received medications via order sets available in EMR or on paper and control groups of patients who received medications via "traditional" custom electronic or paper physician orders. Building the case, obtaining data, and performing analysis processes included the following high-level steps:

1. Reviewed one of the recent monthly mediation order set utilization reports to determine applicable CHF sets for this study and choose hospitals offering the best utilization with the largest samples. Summary of the August 2010 statistics is presented in Table 141, Appendix D.
2. Due to very low utilization of CHF order sets at many Advocate facilities, considered inclusion of all facilities in case individual ones did not produce statistically significant results due to small populations. This was actually the case, so it only made sense to work with the totals for all facilities participating in the CHF study.
3. CHF is unique among other patient conditions in terms of the prescription medium: many physicians still utilize paper forms, in part because some sets are ordered ahead of time from outpatient offices or are used for outpatient treatment of CHF by doctors who have no direct access to in-hospital EMR. Due to

significant number of CHF sets ordered via paper and tracking of these sets in EDW, paper sets were included for the purposes of CHF study only.

4. CHF study was also unique because outpatient and inpatient treatments were mixed: CHF can be treated both ways depending on circumstances of the case and its severity. Splitting the two and reporting separately was not possible due to small data samples leading to lack of statistical significance, although once utilization increases separate reporting would represent a nice follow-up study.
5. Formed experimental and control groups of patients by extracting from EDW all patient data with CHF as principal diagnosis. Patient encounters without medication orders placed via sets constituted a control group, and those encounters where medications were ordered via sets constituted an experimental group. Given small utilization of the sets, control group was expected to be significantly larger than experimental group.
6. Ensured that dependent variables of mortality, 30-day readmission, length of stay, and Charlson Comorbidity Index appeared on the spreadsheet, along with other independent variables of age, sex, and race that also served the purposes of listing descriptive statistics for control and experimental groups.
7. Accounted for factors outlined in the Inclusions and Exclusions sections of this document.
8. Reviewed the spreadsheet, cleaned up any cases that did not appear to meet criteria for the study, and loaded into SPSS v. 19 for statistical analysis.
9. Performed case analysis in SPSS, including methods such as Pearson Chi-Squared; Fisher's Exact significance; binary logistic regression to determine odds

ratios for the relationships between independent and dependent variables; Mann-Whitney independent samples test to reject/accept null hypothesis to determine the relationship between utilization of the order sets and length of stay, and between utilization of the order sets and complications; and One-Way ANOVA test to confirm Mann-Whitney test results.

10. Some fields contained null values for the readmissions and CCI variables, so complete data samples were small, and consequently not all studies produced statistically significant results.

Goal

The goal was to develop methodology for a causal comparative study analyzing the differences between health outcomes among groups of patients whose medications were ordered via sets and using the "traditional" custom order method. Results indicated effects of standardization of the medication ordering on quality of care. More specifically, the study was aimed at determining effectiveness of the congestive heart failure medication order sets in treating this condition, as evidenced by mortality, 30-day readmission, length of stay, and complications health outcomes data collected at Advocate Christ, Illinois Masonic, South Suburban, Good Shepherd, and Lutheran General hospitals.

Research Questions and Hypotheses

Question 1: Do CHF medication order sets help decrease mortality among CHF patients?

Hypothesis 1 (null): There is no statistically significant relationship between utilization of CHF medication order sets and in-hospital mortality among CHF patients.

Question 2: Is there a difference in the relationship between utilization of the CHF medication order sets and in-hospital mortality when patients with hospice discharge code are excluded from the study?

Hypothesis 2 (null): There is no statistical difference in mortality health outcomes relative to utilization of the CHF medication order sets when hospice patients are excluded from the study.

Question 3: Do CHF medication order sets help prevent and/or decrease 30-day readmission rate among CHF patients?

Hypothesis 3 (null): There is no statistically significant relationship between utilization of CHF medication order sets and 30-day readmission rates among CHF patients.

Question 4: Is there a statistical relationship between utilization of the CHF medication order sets and in-hospital length of stay?

Hypothesis 4 (null): There is no statistically significant relationship between utilization of CHF medication order sets and length of stay among CHF patients.

Question 5: Is there a statistical relationship between utilization of the CHF medication order sets and complications quantified via Charlson Comorbidity Index?

Hypothesis 5 (null): There is no statistically significant relationship between utilization of CHF medication order sets and complications among CHF patients.

Question 6: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of 30-day hospital readmission among CHF patients?

Hypothesis 6 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict 30-day hospital readmission among CHF patients.

Question 7: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of in-hospital mortality among CHF patients?

Hypothesis 7 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict in-hospital mortality among CHF patients.

High Level Overview of Elements and Outcomes of the Study

1. The study aimed at comparison between identical groups of patients who received and did not receive medication order sets as treatment for CHF.
2. The study resulted into 7 different reports, as follows:
    a. Relationship between utilization of the order sets and mortality, with discharge codes for hospice patients excluded for the purposes of this study.
    b. Relationship between utilization of the order sets and mortality, with only Expired discharge codes marked as mortality = yes. The differences between these cases with different classification of mortality will be analyzed and reported.
    c. Relationship between utilization of the order sets and 30-day readmission.

d. Relationship between utilization of the order sets and length hospital stay.
e. Relationship between utilization of the order sets and complications
f. Analysis of significance among independent variables of utilization of the order sets, patient sex, patient race, and patient age in predicting the value of the dependent variables of readmissions and mortality.
g. Descriptive statistics on patients reported in the study, including race and sex of patients distributed across control and experimental groups.

3. Cases of mortality from CHF, in addition to discharge codes appearing in the discharge summary in EMR, are governed by table of ICD-9-CM Diagnosis codes, listed as part of the industry-standard AHRQ IQI-16 CHF Mortality Definitions. In other words, all cases with Expired and/or Hospice discharge codes must also match entries on the table of diagnosis codes in order to be mortality from CHF specifically. The ICD-9 codes pertaining to CHF cases are listed in Table 140, Appendix D.

Study Inclusions

a. Patients with primary and secondary diagnosis of CHF.
b. Adults over 18 years of age.
c. CPOE and Written CHF order sets (content provided in Table 142, Appendix D).
d. Full list of variables pulled from EDW is provided in Table 10.

Table 10. Data Elements Pulled as Part of the "Raw" CHF EDW File

Data Elements (Set 1)	**Data Elements (Set 2)**
Encounter Key	MSDRG Description
Encounter Number	MSDRGMDC
Medical Record Number	Discharge Location Code
Facility Abbreviation Name	Principal Diagnosis Code
Admit Date	Principal Diagnosis Description
Admit Time	Admit Type Description
Admit Source	Admit Source Description
Admitting Diagnosis Code	Admitting Diagnosis Proof
Discharge Date	Principal Diagnosis POA
Discharge Fiscal Year	Has Order Set
Discharge Fiscal Period	Order Key
Order Method	Order Method Description
Order Date	Order Time
Patient Age Year	Catalog Code
Patient Race Code	Catalog Synonym Code
Patient Race Description	Final Order Status Description
Patient Sex Code	Order Original Date
Financial Class Code	Facility Key
Financial Class Description	Readmits Encounter Key
Discharge Disposition Code	Readmits Encounter Number

Discharge Location Code	Discharge Location Description
Discharge Disposition Description	Readmits Discharge Location Code
Admit Source Date	Readmits Financial Class Code
Admit Source Description	Has Readmit Indicator
Readmit Type	Readmit Encounter Number
Length of Stay (LOS)	Midas Readmit Index
MSDRG	Readmit Encounter Key
Secondary Diagnosis	Charlson Comorbidity Index
Attending Physician Last Name	Attending Physician First Name
Attending Physician Key	Attending Physician Specialty Key

e. Final list of variables loaded into SPSS for the purposes of this dissertation study. Other variables can be utilized for follow-up studies, such as investigation of why patients without use of the order sets were readmitted within 30 days and their corresponding discharge codes, financial impact of readmissions and longer length of stay, ratio of handwritten orders versus electronic, etc.

Table 11. Final List of Variables Selected for the CHF Study

Data Elements	**Notes and Values**
Facility Abbreviation Name	LGH = 10 IMMC = 7 SSUB = 9 CMC = 3 GSHP=5
Facility Key	See codes above

Has Order Set	Order Set = no = 0 Order Set = yes = 1
Catalog Code	FYI field for the order set catalog number
Order Method Description	FYI field for descriptive statistics, values: WRITTEN CPOE
Has Readmit	Readmission = no = 0 Readmission = yes = 1
Length of Stay (LOS)	Number of days
Discharge Disposition Code	Converted field, final form as follows: No Mortality = 0 Mortality = 1 Hospice: 50, 51
Discharge Disposition Description	FYI field for discharge disposition code
Patient Age Year	Age in years
Patient Sex Code	Converted field, final values below: Male = 0 Female = 1
Patient Race Code	Converted field, final form as follows See Table 143, Appendix D
Patient Race Description	FYI field for patient race code
MSDRG (admit code)	Values not used in calculations, but can be reviewed to confirm all patients are CHF patients
MSDRG Description	FYI field for MSDRG
Principal Diagnosis Code	Values not used in calculations, but can be reviewed to confirm all patients are CHF patients
Principal Diagnosis Description	FYI field for Principal Diagnosis Code
Principal Diagnosis POA	Easy verification for CHF patients: CHF = Y Other = N
Principal Diagnosis POA Int	Converted integer field for numeric representation of the values above: CHF = 1 Other = 0
Admit Type Description	FYI field to verify inpatient admission fact
Charlson Comorbidity Index	Calculated field, values 0 - 16

f. Patient discharge code 20 for the study that assumed mortality as Expired patient only. For mortality study that excluded hospice patients, excluded discharge codes were 50 (hospice/facility) and 51 (hospice/home).
g. Admit and Diagnosis values that appeared in the spreadsheet were already filtered for inclusion of CHF patients only – reason why these codes were displayed FYI for verification only.
h. CMC, GSHP, IMMC, and SSUB orders for 2008, 2009, 2010, and 2011. LGH orders for 2009, 2010, and 2011.

Exclusions

a. Psych and OB patients.
b. Pediatric patients (under 18 years of age).

Detailed Review of the Steps and Elements of the Study

As with the VTE and pneumonia cases, the data obtained from the EDW database was saved in Excel and cleaned up, leaving only columns/elements outlined in Table 11. The resulting Excel file was used for performing further numerical manipulations in SPSS.

Initial Data Processing Steps

Drawing similarity to the pneumonia study, discharge descriptions were replaced with discharge codes suitable for quantitative analysis in SPSS, producing two Excel files with (1) hospice patients excluded from the study and (2) hospice patients accounted for with mortality set to 0 (no). Using “Find” and “Replace” functions of Excel, the string race

code values were converted to randomly assigned codes listed in Table 143, Appendix D. These numeric codes were more suitable for a quantitative study.

Excel files only contained required data at this point and could be loaded into SPSS for further analysis. It was only required to work with two files for the purposes of conducting research on the dependent variable of mortality. For other variables, there is no difference, and any of the two SPSS/Excel files can be used. For the study that excludes hospice patients from mortality, the Split File function of SPSS was utilized to sort the DischargeDisposition field and delete all rows with values of 50 and 51. These rows were at the bottom.

Relationship Between Utilization of Order Sets and Mortality

The Descriptive Statistics -> Crosstabs function of SPSS was invoked with HasOrderSet and DischargeDisposition fields and Pearson Chi-Squared calculation as the sole option. Pearson Chi-Squared and Fisher's Exact values were used to determine significance of statistical relationship between the independent variable of order set utilization and the dependent variable of mortality. The number of entries for experimental and control group formed the following report:

0 -> 1: X	1 -> 1: X
0 -> 0: Y	1 -> 0: Y
% (X/(X+Y))	% (X/(X+Y))

These values represented percentage of orders with no medication order sets that resulted in mortality as a ratio of all orders with no medication order sets – left side. On the right side, there was a comparison of orders where medication sets were utilized and resulted in mortality as a ratio of all orders with utilization of sets. Smaller number on the

right meant that fewer orders with medication sets led to mortality, while smaller number on the left skewed results towards benefit of the custom orders without utilization of the sets. The number above was also obtained as the odds ratio via binary logistic regression, as follows:

- Analyze -> Regression -> Binary Logistic
- Dependent: DischargeDispositionCode
- Covariate: HasOrderSet (categorical)
- Option: CI for EXP(B).

The odds ratio was obtained via both Enter and Backward LR methods in order to determine whether differences in methods exist. Ratios over 1 indicated benefit of the sets (as represented by smaller percentage on the right side); ratios smaller than 1 indicated the benefit of custom medication orders versus sets. It was also necessary to report lower and upper boundaries of the odds ratio, at the 95% confidence level.

Relationship Between Utilization of Order Sets and Readmissions

All of the above SPSS steps were repeated using HasOrderSet as independent (covariate) variable and HasReadmit variable as dependent to define relationship between these variables. So two tests were performed: (1) crosstabs with Pearson Chi-Squared and Fisher's Exact and (2) binary logistic regression with odds ratio and upper/lower boundaries at the 95% confidence level.

All SPSS manipulations were repeatedly performed for all cases, split by hospital and sex using Select Cases functionality of the application. In all cases, the population size was too small to produce statistically significant results, so the odds ratio EXP(B) was only be reported for the first case of all facilities combined. The latter scenario was more

likely for the CHF study compared to VTE and pneumonia, provided that most facilities utilize no more than a few hundred sets a year, resulting in a small overall sample when it is split by hospital. CHF utilization trends are evident from Table 141, Appendix D.

All calculations were repeated for the separate data file representing scenario where hospice patients were not excluded and instead accounted for as mortality = no. Any differences and corresponding conclusions should be reported, along with summary of the benefits of medication order sets based on the health outcomes of mortality and readmission.

Relationship Between Utilization of Order Sets and LOS/CCI

Due to a mix of continuous values for the LOS and CCI variables and dichotomous ones for the HasOrderSet variable, the best test for the LOS and CCI relationships was a Non-Parametric one designed for independent samples. It helped with testing of the null hypothesis and determining which way results were skewed in case the null hypothesis was rejected.

The Non-Parametric tests were performed using Analyze -> Nonparametric Tests -> Independent Samples function of SPSS. In the Variable View, both variables were set to the Scale type. Other options were as follows:

- Automatically Compare
- Fields Tab -> LOS variable for the Test field
- PNOrderSetIndicator was a group variable with binary values of 1 and 0
- Settings -> Customize Fields, and select Mann-Whitney U (2 samples) tests – the most appropriate comparison of the two

samples with one dependent variable. This test can use categorical and continuous variables to produce results.

Results were summarized to make a verdict on acceptance or rejection of the null hypothesis – based on which direction results on the distribution were skewed in. The Non-Parametric tests were also repeated using Charlson Comorbidity Index as a dependent variable. Due to a relatively small expected data sample size, it only made sense to perform calculations for all hospitals selected for the study and skip individual calculations that were likely to produce statistically insignificant outcomes.

A One-Way ANOVA helped double-checking results of the Non-Parametric tests from the comparison of means perspective, comparing the means for the two order set utilization binary values and testing for statistical significance. The following steps were necessary in order to run One-Way ANOVA tests in SPSS:

a. Analyze -> Compare Means -> One-Way ANOVA
b. Chose LOS as a dependent variable
c. Chose HasOrderSet as a Factor
d. Requested Descriptive from the Options list
e. Ran the test
f. Reported the F value, degrees of freedom, and the P value
g. Repeated the same steps using CharlsonComorbidityIndex as a dependent variable.

Conclusions regarding relationship between utilization of the order sets and LOS, and utilization of the order sets and CCI were ready for documentation at this point, noting any discrepancies between One-Way ANOVA and Non-Parametric Mann-Whitney tests.

The latter did not produce any significant differences, leading to sound conclusions proven by two different statistical methods.

Relationship Between Independent Variables of Order Set Utilization, Age, Sex, & Race and Dependent Variables of LOS/CCI

The last study proposed for the CHF case was an explanation of the dependent variables of mortality and readmission by several independent variables of order set indicator, race code, sex, and age. Binary logistic regression was the most suitable method of running this study. Two tests, for the DischargeDispositionCode and HasReadmit dependent variables, were reported separately. The PatientSexCode variable was defined as categorical. Table 12 represents format for the results of this test.

Table 12. CHF <Readmissions or Mortality> as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)		
Patient Age		
Patient Sex		
Patient Race		
Constant		

It was determined by analyzing results reported in Table 12 which independent variables best and better predicted dependent ones, and which independent variables were statistically insignificant.

Summary

The final report incorporates overall analysis and recommendations regarding utilization of the medication order sets to treat CHF, and how these sets influence/predict

the health outcomes of length of stay, mortality, 30-day readmission, and comorbidity. The report provides grounds for answering the research questions outlined in the CHF study and accepting/rejecting the research hypotheses.

Case IV: Acute Myocardial Infarction (AMI) Methodology

Overview

The study involved statistical comparison between experimental groups of patients who received medications via order sets and control groups of patients who received medications via "traditional" custom electronic physician orders. Building the case, obtaining data, and performing analysis processes included the following high-level steps:

1. Reviewed one of the recent monthly mediation order set utilization reports to determine applicable AMI sets for this study and choose hospitals offering the best utilization with the largest samples. Summary of the August 2010 statistics is presented in Table 145, Appendix E.
2. Due to relatively low utilization of AMI order sets at many Advocate facilities, considered inclusion of all facilities in case individual ones did not produce statistically significant results due to small populations. As was already evident from earlier review of the order set content prepared for the preliminary work as part of the dissertation process, only two hospitals (GSHP and TRIN) qualified for the study, thus introducing the risk of low samples and statistically insignificant results. Low utilization, couple with missing data in some patient

encounters, made it clear that only one case with all participating facilities included could stand a chance to produce statistically significant results.

3. Formed experimental and control groups of patients by extracting from EDW all patient data with AMI as principal diagnosis. Patient encounters without medication orders placed via sets constituted a control group, and those encounters where medications were ordered via sets constituted an experimental group. Given small utilization of the sets, control group was significantly larger than experimental group.
4. Ensured that dependent variables of mortality, 30-day readmission, length of stay, and Charlson Comorbidity Index appeared on the spreadsheet, along with other independent variables of age, sex, and race that also served the purposes of listing descriptive statistics for control and experimental groups.
5. Accounted for factors outlined in the Inclusions and Exclusions sections of this document.
6. Reviewed the spreadsheet, cleaned up any cases that do not appear to meet criteria for the study, and loaded into SPSS v. 19 for statistical analysis.
7. Performed case analysis in SPSS, including methods such as Pearson Chi-Squared; Fisher's Exact significance; binary logistic regression to determine odds ratios for the relationships between independent and dependent variables; Mann-Whitney independent samples test to reject/accept null hypothesis to determine the relationship between utilization of the order sets and length of stay, and between utilization of the order sets and complications; and One-Way ANOVA test to confirm Mann-Whitney test results.

Goal

The goal was to develop methodology for a causal comparative study analyzing the differences between health outcomes among groups of patients whose medications were ordered via sets and using the "traditional" custom order method. Results indicated effects of standardization of the medication ordering on quality of care. More specifically, the study was aimed at determining effectiveness of the acute myocardial infarction (AMI) medication order sets in treating this condition, as evidenced by mortality, 30-day readmission, length of stay, and complications health outcomes data collected at Advocate Good Shepherd and Trinity hospitals.

Research Questions and Hypotheses

Question 1: Do AMI medication order sets help decrease mortality among AMI patients?

Hypothesis 1 (null): There is no statistically significant relationship between utilization of AMI medication order sets and in-hospital mortality among AMI patients.

Question 2: Is there a difference in the relationship between utilization of the AMI medication order sets and in-hospital mortality when patients with hospice discharge code are excluded from the study?

Hypothesis 2 (null): There is no statistical difference in mortality health outcomes relative to utilization of the AMI medication order sets when hospice patients are excluded from the study.

Question 3: Do AMI medication order sets help prevent and/or decrease 30-day readmission rate among AMI patients?

Hypothesis 3 (null): There is no statistically significant relationship between utilization of AMI medication order sets and 30-day readmission rates among AMI patients.

Question 4: Is there a statistical relationship between utilization of the AMI medication order sets and in-hospital length of stay?

Hypothesis 4 (null): There is no statistically significant relationship between utilization of AMI medication order sets and length of stay among AMI patients.

Question 5: Is there a statistical relationship between utilization of the AMI medication order sets and complications quantified via Charlson Comorbidity Index?

Hypothesis 5 (null): There is no statistically significant relationship between utilization of AMI medication order sets and complications among AMI patients.

Question 6: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of 30-day hospital readmission among AMI patients?

Hypothesis 6 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict 30-day hospital readmission among AMI patients.

Question 7: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of in-hospital mortality among AMI patients?

Hypothesis 7 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict in-hospital mortality among AMI patients.

High Level Overview of Elements and Outcomes of the Study

1. The study aimed at comparison between identical groups of patients who received and did not receive medication order sets as treatment for AMI.
2. The study resulted into 7 different reports, as follows:
    a. Relationship between utilization of the order sets and mortality, with discharge codes for hospice patients excluded for the purposes of this study.
    b. Relationship between utilization of the order sets and mortality, with only Expired discharge codes marked as mortality = yes. The differences between these cases with different classification of mortality were analyzed and reported.
    c. Relationship between utilization of the order sets and 30-day readmission.
    d. Relationship between utilization of the order sets and length hospital stay.
    e. Relationship between utilization of the order sets and complications
    f. Analysis of significance among independent variables of utilization of the order sets, patient sex, patient race, and patient age in predicting the value of the dependent variables of readmissions and mortality.
    g. Descriptive statistics on patients reported in the study, including race and sex of patients distributed across control and experimental groups.
3. Cases of mortality from AMI, in addition to discharge codes appearing in the discharge summary in EMR, are governed by table of ICD-9-CM Diagnosis codes, listed as part of the industry-standard AHRQ IQI-15 AMI Mortality Definitions. In other words, all cases with Expired and/or Hospice discharge

codes must also match entries on the table of diagnosis codes in order to be mortality from AMI specifically. The ICD-9 codes pertaining to AMI cases are listed in Table 144, Appendix E.

Study Inclusions

a. Patients with primary and secondary diagnosis of AMI.
b. Adults over 18 years of age.
c. AMI order sets (content provided in Table 146, Appendix E).
d. Full list of variables pulled from EDW is provided in Table 13:

Table 13. Data Elements Pulled as Part of the "Raw" AMI EDW file

Data Elements (Set 1)	**Data Elements (Set 2)**
Encounter Key	MSDRG Description
Encounter Number	MSDRGMDC
Medical Record Number	Discharge Location Code
Facility Abbreviation Name	Principal Diagnosis Code
Admit Date	Principal Diagnosis Description
Admit Time	Admit Type Description
Admit Source	Admit Source Description
Admitting Diagnosis Code	Admitting Diagnosis Proof
Discharge Date	Principal Diagnosis POA
Discharge Fiscal Year	Has Order Set
Discharge Fiscal Period	Order Key

Order Method	Order Method Description
Order Date	Order Time
Patient Age Year	Catalog Code
Patient Race Code	Catalog Synonym Code
Patient Race Description	Final Order Status Description
Patient Sex Code	Order Original Date
Financial Class Code	Facility Key
Financial Class Description	Readmits Encounter Key
Discharge Disposition Code	Readmits Encounter Number
Discharge Location Code	Discharge Location Description
Discharge Disposition Description	Readmits Discharge Location Code
Admit Source Date	Readmits Financial Class Code
Admit Source Description	Has Readmit Indicator
Readmit Type	Readmit Encounter Number
Length of Stay (LOS)	Midas Readmit Index
MSDRG	Readmit Encounter Key
Secondary Diagnosis	Charlson Comorbidity Index
Attending Physician Last Name	Attending Physician First Name
Attending Physician Key	Attending Physician Specialty Key

e. The final list of variables loaded into SPSS for the purposes of this dissertation study is outlined in Table 14. Other variables can be utilized for follow-up studies, such as investigation of why patients without use of the

order sets were readmitted within 30 days and their corresponding discharge codes, financial impact of readmissions and longer length of stay, ratio of handwritten orders versus electronic, etc.

Table 14. Final List of Variables Selected for the AMI Study

Data Elements	**Notes and Values**
Facility Abbreviation Name	TRIN=8 GSHP=5
Facility Key	See codes above
Has Order Set	Order Set = no = 0 Order Set = yes = 1
Catalog Code	FYI field for the order set catalog number
Has Readmit	Readmission = no = 0 Readmission = yes = 1
Length of Stay (LOS)	Number of days
Discharge Disposition Code	Converted field, final form as follows: No Mortality = 0 Mortality = 1 Hospice: 50, 51
Discharge Disposition Description	FYI field for discharge disposition code
Patient Age Year	Age in years
Patient Sex Code	Converted field, final values below: Male = 0 Female = 1
Patient Race Code	Converted field, final form as follows See Table 147, Appendix E
Patient Race Description	FYI field for patient race code
MSDRG (admit code)	Values not used in calculations, but can be reviewed to confirm all patients are AMI patients
MSDRG Description	FYI field for MSDRG
Principal Diagnosis Code	Values not used in calculations, but can be reviewed to confirm all patients are AMI patients
Principal Diagnosis Description	FYI field for Principal Diagnosis Code

Principal Diagnosis POA	Easy verification for AMI patients: AMI = Y Other = N
Principal Diagnosis POA Int	Converted integer field for numeric representation of the values above: AMI = 1 Other = 0
Admit Type Description	FYI field to verify inpatient admission fact
Charlson Comorbidity Index	Calculated field, values 0 - 16

f. Patient discharge code 20 for the study that assumed mortality as Expired patient only. For mortality study that excluded hospice patients, excluded discharge codes were 50 (hospice/facility) and 51 (hospice/home).

g. Admit and Diagnosis values that appear in the spreadsheet were already filtered for inclusion of AMI patients only – reason why these codes were displayed FYI for verification only.

h. GSHP orders for 2008, 2009, 2010, and 2011. Trinity orders for (November, December) 2009, 2010, and 2011. Trinity orders are only available since CPOE application has gone live at this facility.

Exclusions

a. Psych and OB patients

b. Pediatric patients (under 18 years of age).

Detailed Review of the Steps and Elements of the Study

There are many similarities between CHF and AMI cases, with main differences being in the variables, exclusions, and inclusions in the study outlined at the outset of the case

methodology descriptions. Many of the quantitative analysis steps below are applicable to both CHF and AMI studies.

Initial Data Processing Steps

As with VTE, pneumonia, and CHF cases, the data obtained from the EDW database was saved in Excel and cleaned up, leaving only columns/elements outlined in Table 14. The resulting Excel file was used for performing further numerical manipulations in SPSS. Discharge descriptions were replaced with discharge codes suitable for quantitative analysis in SPSS, producing two Excel files with (1) hospice patients excluded from the study and (2) hospice patients accounted for with mortality set to 0 (no). Using “Find” and “Replace” functions of Excel, the string race code values were converted to randomly assigned codes listed in Table 147, Appendix E. These numeric codes were more suitable for a quantitative study.

Excel files only contained required data at this point and were loaded into SPSS for further analysis. It was only required to work with two files for the purposes of conducting research on the dependent variable of mortality. For other variables, there was no difference, and any of the two SPSS/Excel files could be used. For the study that excluded hospice patients from mortality, the Split File function of SPSS was utilized to sort the DischargeDisposition field and delete all rows with values of 50 and 51. These rows were expected to be on the bottom.

Relationship Between Utilization of Order Sets and Mortality

The Descriptive Statistics -> Crosstabs function of SPSS was invoked with HasOrderSet and DischargeDisposition fields and Pearson Chi-Squared calculation as the sole option. Pearson Chi-Squared and Fisher’s Exact values were used to determine

significance of statistical relationship between the independent variable of order set utilization and the dependent variable of mortality. The number of entries for experimental and control group formed the following report:

0 -> 1: X	1 -> 1: X
0 -> 0: Y	1 -> 0: Y
% (X/(X+Y))	% (X/(X+Y))

These values represented percentage of orders with no medication order sets that resulted in mortality as a ratio of all orders with no medication order sets – left side. On the right side, there was comparison of orders where medication sets were utilized and resulted in mortality as a ratio of all orders with utilization of sets. Smaller number on the right meant that fewer orders with medication sets led to mortality, while smaller number on the left skewed results towards benefit of the custom orders without utilization of the sets. The number above was also obtained as the odds ratio via binary logistic regression, as follows:

- Analyze -> Regression -> Binary Logistic
- Dependent: DischargeDispositionCode
- Covariate: HasOrderSet (categorical)
- Option: CI for EXP(B)

The odds ratio was obtained via both Enter and Backward LR methods in order to determine whether differences in methods exist. Ratios over 1 indicated benefit of the sets (as represented by smaller percentage on the right side); ratios smaller than 1 indicated the benefit of custom medication orders versus sets. It is also necessary to report lower and upper boundaries of the odds ratio, at the 95% confidence level.

Relationship Between Utilization of Order Sets and LOS/CCI

All of the above SPSS steps were repeated using HasOrderSet as independent (covariate) variable and HasReadmit variable as dependent to define relationship between these variables. So, two tests were performed: (1) crosstabs with Pearson Chi-Squared and Fisher's Exact and (2) binary logistic regression with odds ratio and upper/lower boundaries at the 95% confidence level.

All SPSS manipulations were repeatedly performed for all cases, split by hospital and sex using Select Cases functionality of the application. In all individual hospital cases, the population size was too small to produce statistically significant results, so the odds ratio EXP(B) was only reported for the first cases of all facilities combined. The latter scenario was more likely for the AMI and CHF studies compared to VTE and pneumonia, provided that most facilities utilize no more than a few hundred sets a year, resulting in a small overall sample when it is split by hospital. AMI utilization trends are evident from Table 145, Appendix E.

All calculations were repeated for the separate data file representing scenario where hospice patients were not excluded and instead accounted for as mortality = no. Any differences and corresponding conclusions were reported, along with summary of the benefits of medication order sets based on the health outcomes of mortality and readmission.

Due to a mix of continuous values for the LOS and CCI variables and dichotomous ones for the HasOrderSet variables, the best test for the LOS and CCI relationships was a Non-Parametric one designed for independent samples. It helped with testing the null

hypothesis and determining which way results were skewed in case the null hypothesis was rejected.

The Non-Parametric tests were performed using Analyze -> Nonparametric Tests -> Independent Samples function of SPSS. In the Variable View, both variables must be set to the Scale type. Other options were as follows:

- Automatically Compare
- Fields Tab -> LOS variable for the Test field
- PNOrderSetIndicator was a group variable with binary values of 1 and 0
- Settings -> Customize Fields, and selected Mann-Whitney U (2 samples) tests – the most appropriate comparison of the two samples with one dependent variable. This test can use categorical and continuous variables to produce results.

Results were summarized to make a verdict on acceptance or rejection of the null hypothesis – based on which direction results on the distribution are skewed in. The Non-Parametric tests were also repeated using Charlson Comorbidity Index as a dependent variable. Due to a very small data sample size, it only made sense to perform calculations for the total of all hospitals selected for the study and skip individual calculations that were unlikely to produce statistically significant outcomes.

A One-Way ANOVA helped double-checking results of the Non-Parametric tests from the comparison of means perspective, comparing the means for the two order set utilization binary values and testing for statistical significance. The following steps were necessary in order to run One-Way ANOVA tests in SPSS:

a. Analyze -> Compare Means -> One-Way ANOVA
b. Chose LOS as a dependent variable
c. Chose HasOrderSet as a Factor
d. Requested Descriptive from the Options list
e. Ran the test
f. Reported the F value, degrees of freedom, and the P value
g. Repeated steps “a” through “f” using CharlsonComorbidityIndex as a dependent variable.

Conclusions regarding relationship between utilization of the order sets and LOS, and utilization of the order sets and CCI were ready for documentation at this point, noting any discrepancies between One-Way ANOVA and Non-Parametric Mann-Whitney tests. The latter did not produce any significant differences, leading to sound conclusions proven by two different statistical methods.

Relationship Between Independent Variables of Order Set Utilization, Age, Sex, & Race and Dependent Variables of LOS/CCI

The last study proposed for the AMI case was an explanation of the dependent variables of mortality and readmission by several independent variables of order set indicator, race code, sex, and age. Binary logistic regression was the most suitable method of running this study. Two tests, for the DischargeDispositionCode and HasReadmit dependent variables, were reported separately. The PatientSexCode variable was defined as categorical. Table 15 represents format for the results of this test.

Table 15. AMI <Readmissions or Mortality> as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)		
Patient Age		
Patient Sex		
Patient Race		
Constant		

It was determined by analyzing results reported in Table 15 which independent variables best and better predicted dependent ones, and which of the independent variables were statistically insignificant.

Summary

The final report will incorporates overall analysis and recommendations regarding utilization of the medication order sets to treat AMI, and how these sets influence/predict the health outcomes of length of stay, mortality, 30-day readmission, and comorbidity. The report provides grounds for answering the research questions outlined in the CHF study and accepting/rejecting the research hypotheses.

Resource Requirements

Since all of the data needed for this research is interfaced with EDW database, it is the only data source required to complete data queries. The data comes to EDW from multiple sources: CareConnection EMR/CPOE, Allegra patient accounting, TSI decision support, Thompson Reuters research, MIDAS quality (falls/incidents), AHRQ government healthcare standards, and NDNQI nursing quality applications. The latter two are government sources referenced in the healthcare industry. The CareConnection

EMR/CPOE team, led by Laurie Gift, Director of Clinical Applications at Advocate, was initially involved with supplying data to build the case and compile an idea paper. Their spreadsheets were invaluable in identifying current state of order set utilization at Advocate, content of the sets, running comparisons between the sets, and identifying data gaps and initial barriers to conducting the research. Beyond Research Proposal stage, only data from EDW was utilized to perform database queries, followed by statistical analysis in Excel (initial) and SPSS (advanced).

The Executive Sponsor for this research at Advocate, Dr. Joel Shoolin, provided clinical expertise to analyze outcomes of the research for each proposed patient condition. Dr. Shoolin also helped identify ways to implement recommendations from Final Report in the organization. He also helped identify the research problem, formulate the goals, select measurement criteria for outcomes, and identify resources available for the project. Mary Gagen from the EDW team assisted in performing initial extracts from the database before data is available for analysis based on methodology proposed for the study. Her help was also necessary to understand the content of raw data, agency sources governing healthcare data and quality standards, and methodologies behind clinical data analysis. Due to data security restrictions, only members of the EDW team can have direct access to raw data.

Executive support for the project was also ensured via Chief Information Officer, who signed IRB paperwork for the Advocate IRB office and received periodic updates on progress of the project. The Information Systems Leadership Team (ISLT), comprised of five Vice Presidents over several Information Systems organizations, also received periodic updates and presentations but was ultimately interested in final outcomes of the

study. Records of interactions with these individuals were maintained by the student researcher working on this dissertation.

NSU required following its own IRB process. The IRB paperwork for NSU was filed prior to the data collection phase of the research project, with Advocate's IRB approvals attached, as the site where collection of the patient information took place. Advocate required for the IRB paperwork to be filed at the outset of the project in the idea stage before the overall project could be approved, while NSU required filing of the IRB forms prior to collecting data and with assumption that the hospital network had necessary signatures in place.

Summary

Research methodology outlined in this chapter was aimed at analyzing effectiveness of evidence-based medication order sets on health outcomes, based on theoretical assumption that standardization of care for certain patient conditions could lead to improved quality, greater safety, and better health of the patients. The following statistical methods were utilized in the study: Pearson Chi-Squared, Fisher's Exact, cross-tabs, binary logistic regression, One-Way ANOVA comparison of means with Bonferroni, Tukey, and Dunnett add-ons, and Mann-Whitney non-parametric test of independent samples.

Due to differences in the unique setup of each case and circumstances of each patient condition, there were differences in health outcomes considered for examination in each case and research methods selected to analyze corresponding data. There were two distinct categories of cases: (1) VTE and (2) pneumonia, CHF, and AMI. The latter three were similar in the kinds of available data, setup, statistical analysis methods, and

variables. All three cases were analyzed using all four health outcomes: mortality, length of stay, readmissions, and complications. All three cases emphasized treatment of the conditions. VTE case emphasized prevention, used constraints to identify cases of prevention, and utilized two health outcomes from the general list of four – length of stay and complications. Mortality and readmissions were not applicable, as those were likely results of the chief and/or secondary complaints that patients are admitted to the hospital with. VTE case was also unique because it tracked patient progress from chief complaint to medical procedure to potential VTE suspicion to actual VTE outcome. This combination introduced one extra independent variable of acute VTE, enabling analysis of the relationship between two independent variables of order set utilization and acute VTE. There were further possibilities of both examining direct relationship between these variables, as well as more complex relationships controlled by the dependent variables of length of stay and complications/comorbidity – resulting in series of One-Way ANOVA setups.

Despite assumptions and barriers listed for the study, it represents a major leap in the analysis of order set effectiveness and the overall case of evidence-based medicine in the inpatient settings. The study utilized a wealth of data from large samples that few institutions possess in electronic EMR/CPOE format(s), thus making serious case for the first comprehensive review of the medication order set impact in clinical settings. Table 16 is aimed at avoiding confusion regarding content and goals of each of the four studies. It lists each patient condition and corresponding measurements. The variables of sex, age, and race do not appear below, as the study of their influence is common and applicable to all patient conditions.

Table 16. Summary of Patient Conditions, Variables, and Health Outcomes

Condition	**Mortality**	**Readmission**	**Length of Stay**	**Complications**	**Acute VTE**
VTE	N/A	N/A	Analyze	Analyze	Analyze
Pneumonia	Analyze	Analyze	Analyze	Analyze	N/A
CHF	Analyze	Analyze	Analyze	Analyze	N/A
AMI	Analyze	Analyze	Analyze	Analyze	N/A

Chapter 4

Results

Introduction

Similar to Chapter 3, results sections are split into four categories by patient condition examined as part of this dissertation study: VTE, pneumonia, CHF, and AMI. Subsequently, there are several sub-sections under each section describing independent and dependent variables. Each quantitative summary outlined as part of these subsections is followed by a discussion of the findings before moving on to the next variable relationship analysis. The overall summary is provided at the end of this chapter in response to the research questions and hypotheses.

VTE Study Results

Case 1: Relationship Between Utilization of VTE Order Sets and Acute VTE (Independent vs. Independent Variables) – Split by Hospital and Surgery Categories

Table 17. IMMC Hospital Surgical Calculations – VTE, by Hospital

Outcomes and Measures	Control Group	Experi-mental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
VTE = yes	85	35				
VTE = no	7884	2200				

Percent (VTE=yes) / total	**1.07%**	1.57%	3.745 (p=0.044)	0.045	0.028	0.670 [0.452 & 0.992]

Table 18. IMMC Hospital Non-Surgical Calculations – VTE, by Hospital

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
VTE = yes	488	299				
VTE = no	13980	13456				
Percent (VTE=yes) / total	3.37%	**2.17%**	37.483 (p<0.01)	0.000 (p<0.01)	0.000 (p<0.01)	1.566 [1.354 & 1.812]

Table 19. LGH Hospital Surgical Calculations – VTE, by Hospital

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
VTE = yes	262	60				
VTE = no	14878	1932				
Percent (VTE=yes) / total	**1.73%**	3.1%	16.817 (p<0.01)	0.000 (p<0.01)	0.000 (p<0.01)	0.497 [0.383 & 0.645]

Table 20. LGH Hospital Non-Surgical Calculations – VTE, by Hospital

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
VTE = yes	967	208				
VTE = no	29093	8248				
Percent (VTE=yes) / total	3.22%	**2.46%**	12.915 (*p*=0.011)	0.012	0.006	1.205 [1.043 & 1.393]

VTE Case 1 Findings

The VTE study begins with a case that represents the most basic but quite powerful view of the collected data. The case provides comparative data for the control and experimental groups, listing VTE cases for each of the groups and percentages of VTE cases relative to the group totals. The smallest percentage of positive acute VTE cases indicates the benefit of one of the medication prescribing methods utilized in the research. Comparative data is strengthened with more advanced statistical views represented by significance at the 95% confidence level and logistic regression.

Details outlined above are subdivided by hospital and surgical status of the patients. Results presented in the tables show comparisons between percentages of patients who acquired VTE within control and experimental groups, relative to the total patient population in each group. The smaller percentage of patients who acquired VTE indicates the benefit of VTE medications administered via order sets. Person and Fisher's Exact chi-squared tests indicate statistical significance in each table. Binary logistic regression

is another measure of the relationship between control and experimental groups that was employed.

The differences between the control and experimental groups must be statistically significant in order to ascertain valid conclusions from the study (Pearson Chi-Squared $p =< 0.05$). Fisher's Exact statistic is provided as confirmation of significance indicated by Pearson Chi-Squared. While a 2-sided Fisher's Exact is necessary to report on testing two-tailed null hypotheses utilized in this case, the 1-sided number is provided to indicate highly skewed results in cases where there is significant difference between the 2-sided and 1-sided numbers. The EXP(B) binary logistic regression odds ratio indicates the odds of acute VTE occurrence for every application of the order set. The binary logistic regression odds ratio is presented as a number followed by upper and lower bounds at the 95% confidence level. All odds ratios indicative of the benefits of the order sets in preventing VTE are greater than 1. Higher numbers indicate higher odds of preventing VTE using medication order sets, while lower numbers indicate lower odds, with all ratios below 1 indicating lack of the medication order set benefit. Ultimately, all results provided as part of this sub-case are aimed at identifying cases where medication order sets were effective in preventing acute VTE.

Based on results presented in Tables 17 through 20, it is clear that non-surgical patients at both LGH and IMMC hospitals benefited from application of the order sets, while surgical patients did not benefit. Given the number of patients analyzed as part of this case, even a 0.5% difference indicates that many patients' health outcomes could be improved through utilization of evidence-based medicine practices. In healthcare, small percentages and differences matter because of the impact on human lives and well being;

every gain in quality, health outcomes, and ability to save lives counts as positive impact, one human life at a time. All results were statistically significant. In all cases, binary logistic regression was obtained by using Enter and Backward LR methods in SPSS. Both methods returned identical results.

Case 2: Relationship Between Utilization of VTE Order Sets and Acute VTE (Independent vs. Independent Variables) – Split by Hospital, Surgery, and Sex of the Patients

Categories

Table 21. IMMC Hospital Surgical Calculations – VTE, by Hospital and Sex

Sex	**Outcomes and Measures**	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Fe-male	VTE = yes	29	17				
	VTE = no	4048	1042				
	Percent (VTE=yes) / total	**0.71%**	1.6%	7.569 (*p*=0.006)	0.010	0.008	0.439 [0.240 & 0.802]
Male	VTE = yes	56	18				
	VTE = no	3836	1158				
	Percent (VTE=yes) / total	**1.49%**	1.53%	0.053 (*p*=0.818)	0.783	0.454	0.939 [0.550 & 1.604]

Table 22. IMMC Hospital Non-Surgical Calculations – VTE, by Hospital and Sex

Sex	Outcomes and Measures	Control Group	Experi-mental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
Fe-male	VTE = yes	242	159				
	VTE = no	7009	6784				
	Percent (VTE=yes) / total	3.34%	**2.29%**	14.173 (p<0.01)	0.000 (p<0.01)	0.000 (p<0.01)	1.473 [1.203 & 1.804]
Male	VTE = yes	246	140				
	VTE = no	6971	6678				
	Percent (VTE=yes) / total	3.4%	**2.05%**	24.075 (p<0.01)	0.000 (p<0.01)	0.000 (p<0.01)	1.683 [1.364 & 2.077]

Table 23. LGH Hospital Surgical Calculations – VTE, by Hospital and Sex

Sex	Outcomes and Measures	Control Group	Experi-mental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
Fe-male	VTE = yes	129	25				
	VTE = no	8202	1002				
	Percent (VTE=yes) / total	**1.55%**	2.43%	4.433 (p=0.005)	0.005	0.029	0.630 [0.409 & 0.972]
Male	VTE = yes	133	36				
	VTE = no	6676	931				
	Percent (VTE=yes) / total	**1.99%**	3.72%	12.471 (p<0.01)	0.000 (p<0.01)	0.000 (p<0.01)	0.515 [0.354 & 0.749]

Table 24. LGH Hospital Non-Surgical Calculations – VTE, by Hospital and Sex

Sex	Outcomes and Measures	Control Group	Experi-mental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
Fe-male `	VTE = yes	538	121				
	VTE = no	16173	4381				
	Percent (VTE=yes) / total	3.22%	**2.69%**	3.331 (*p*=0.068)	0.075	0.038	1.204 [0.986 & 1.471]
Male	VTE = yes	429	87				
	VTE = no	12920	3878				
	Percent (VTE=yes) / total	3.21%	**2.19%**	10.989 (*p*=0.001)	0.001	0.001	1.480 [1.172 & 1.869]

VTE Case 2 Findings

This case was set up in the same way as VTE Case 1 but was further categorized by sex of the surgical and non-surgical patients reported for each of the two hospitals. In a few instances, results were not statistically significant, as indicated by Pearson and Fisher's outcomes greater than $p = 0.05$. VTE Case 2 confirmed all of the findings made in VTE Case 1. The conclusion from VTE Case 2 is that sex of the patients does not make a difference in clinical outcomes from utilization of the order sets to prescribe VTE prophylaxis medications. Non-surgical patients benefit from the order sets and surgical patients do not benefit, regardless of sex of the patients.

Case 3: Relationship Between Utilization of VTE Order Sets, Acute VTE, and Charlson Comorbidity Index (Independent vs. Dependent Variables)

The following are categorical comparisons broken down by each of the 0-16 CCI values. Smaller ratios of VTE occurrences relative to the total number of patients in the experimental group represent the benefit of the VTE medication order sets. Smaller ratios in the control group indicate lack of the VTE order set benefit. Tables 25 through 28 are intended as introductory visual data representations, with no firm conclusions. The latter ones will be made in subsequent statistical tests following this introductory data view.

Table 25. Charlson Comorbidy VTE Case Details – IMMC Surgical Patients

CCI	**Control Group**			**Experimental Group**		
	VTE=yes	**VTE=no**	**Ratio**	**VTE=yes**	**VTE=no**	**Ratio**
0	41	4363	0.93%	6	882	0.68%
1	11	1098	0.99%	3	303	0.98%
2	14	1004	1.38%	13	296	4.21%
3	6	558	1.06%	4	244	1.61%
4	1	329	0.30%	3	157	1.88%
5	4	139	2.80%	2	79	2.47%
6	1	108	0.92%		65	
7	1	40	2.44%		45	
8	2	151	1.31%	1	78	1.27%
9	1	50	1.96%		25	
10	2	22	8.33%	1	11	8.33%
11	1	8	11.11%	1	8	11.11%
12		10			4	
13		2		1	1	50.00%
14						
15		2			2	
16						

Table 26. Charlson Comorbidity VTE Case Details – IMMC Non-Surgical Patients

CCI	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
0	152	6770	2.20%	84	5394	1.53%
1	50	1765	2.75%	36	1843	1.92%
2	74	1677	4.23%	48	1849	2.53%
3	61	1307	4.46%	37	1569	2.30%
4	37	937	3.80%	27	1036	2.54%
5	23	494	4.45%	19	595	3.09%
6	19	399	4.55%	9	448	1.97%
7	9	147	5.77%	4	164	2.38%
8	31	276	10.10%	22	308	6.67%
9	6	97	5.83%	2	94	2.08%
10	9	42	17.65%	3	61	4.69%
11	9	36	20.00%	5	54	8.47%
12	4	20	16.67%	2	19	9.52%
13	1	8	11.11%	1	14	6.67%
14	3	3	50.00%		3	
15		1			5	
16		1				

Table 27. Charlson Comorbidity VTE Case Details – LGH Surgical Patients

CCI	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
0	148	8055	1.80%	23	827	2.71%
1	35	1995	1.72%	13	277	4.48%
2	30	2049	1.44%	7	280	2.44%
3	18	1208	1.47%	5	211	2.31%
4	10	443	2.21%	5	96	4.95%
5	4	229	1.72%	2	70	2.78%
6	3	125	2.34%	2	38	5.00%
7		44	0.00%		14	
8	8	513	1.54%	2	75	2.60%
9	5	121	3.97%		22	
10	1	44	2.22%		10	
11		26		1	5	16.67%
12		14			7	
13		7				
14		3				

15		2				
16						

Table 28. Charlson Comorbidity VTE Case Details – LGH Non-Surgical Patients

CCI	**Control Group**			**Experimental Group**		
	VTE=yes	**VTE=no**	**Ratio**	**VTE=yes**	**VTE=no**	**Ratio**
0	439	11870	3.57%	66	2787	2.31%
1	84	3632	2.26%	20	1005	1.95%
2	137	4484	2.96%	41	1438	2.77%
3	96	3441	2.71%	25	1088	2.25%
4	35	1663	2.06%	16	547	2.84%
5	29	1035	2.73%	8	386	2.03%
6	10	600	1.64%	2	216	0.92%
7	9	243	3.57%	3	71	4.05%
8	74	1440	4.89%	11	423	2.53%
9	24	296	7.50%	7	103	6.36%
10	16	158	9.20%	2	74	2.63%
11	8	110	6.78%	4	60	6.25%
12	5	69	6.76%	3	33	8.33%
13	1	34	2.86%		9	
14		10			3	
15		7			3	
16		1			2	

Next, the experimental and control groups were labeled in SPSS for the purpose of examining complex relationships between application of the order sets, occurrence of acute VTE, and CCI. The One-Way ANOVA test with Bonferroni and Tukey post hoc tests selected for this exercise cannot track such complex relationship, because this test is designed to examine the relationship between two variables rather than deal with multiple ones. However, a One-Way ANOVA test can be utilized when each combination of order set utilization is paired with acute VTE outcome and labeled in sequential order, thus integrating two (order set application and occurrence of acute VTE) of three categories

set up for the One-Way ANOVA. Once all combinations of order set utilization and occurrence of acute VTE are paired and labeled, One-Way ANOVA can be applied to examine the relationship between these labeled pairs and CCI. The labels assigned in SPSS were as follows:

Order_Set_Use =1 + Acute_VTE = 1: 1

Order_Set_Use =1 + Acute_VTE = 0: 2

Order_Set_Use =0 + Acute_VTE = 1: 3

Order_Set_Use =0 + Acute_VTE = 0: 4

Therefore, labels 1 and 2 represent the experimental group (order sets used to place medication orders) and labels 3 and 4 represent the control group (sets not used to order medications). Detailed One-Way ANOVA results obtained in SPSS are outlined in Appendix F. In summary, standard means and statistical significance at the 95% confidence level were as follows:

Table 29. One-Way ANOVA Bonferroni/Tukey Results for CCI – VTE Case

Category	**Means**	**Significant at 95% (p =< 0.05)?**
IMMC Surgical	1 : 2 = 0.870	Yes
	3 : 4 = 0.514	No
LGH Surgical	1 : 2 = 0.221	Yes
	3 : 4 = (-) 0.020	No
IMMC Non-Surgical	1 : 2 = 0.861	Yes
	3 : 4 = 1.255	Yes
LGH Non-Surgical	1 : 2 = 0.462	Yes
	3 : 4 = 0.245	Yes

The Dunnett post-hoc One-Way ANOVA *t*-test requires labels but is only capable of comparing one experimental group against one defined control group. Among groups outlined in Table 29 for the One-Way ANOVA test, the following were used for the Dunnett post-hoc exercise. This is a test of CCI in the case of absence of the acute VTE factor.

Order_Set_Use =1 + Acute_VTE = 0: 2 (experimental group)

Order_Set_Use =0 + Acute_VTE = 0: 4 (control group)

Results of the Dunnett *t*-test are summarized in Table 30. Details from SPSS are provided as part of Appendix F.

Table 30. One-Way ANOVA Dunnett Results for CCI – VTE Case

Category	**Means**	**Significant at 95% (p =< 0.05)?**
IMMC Surgical	2 : 4 = 0.796	Yes
LGH Surgical	2 : 4 = 0.308	Yes
IMMC Non-Surgical	2 : 4 = 0.612	Yes
LGH Non-Surgical	2 : 4 = 0.368	Yes

VTE Case 3 Findings

By visually reviewing descriptive CCI statistics and calculated ratios by hospital and patient category, many of the CCI sections appeared to show significant differences between control and experimental groups. However, One-Way ANOVA with three post-hoc tests that followed descriptive statistics shed more light into relationships between groups. The Dunnett *t*-tests confirmed statistical significance between control and experimental groups as related to CCI, leading to the conclusion that VTE medication order sets made a difference in patient outcomes expressed by the CCI complications

index. The more detailed Bonferroni and Tukey (displayed same results using different methods) tests revealed the exact influence of medication order sets on CCI.

There was a significant difference between Charlson Comorbidity Indexes for the IMMC non-surgical groups of patients who received medications via orders sets and CCI for those who received custom orders, $F(3,28271) = 94.297$, $P < 0.05$. Patients in the experimental group had fewer comorbidities compared to those in the control group – indicating benefit of the order sets.

There was a significant difference between Charlson Comorbidity Indexes for the LGH non-surgical groups of patients who received medications via orders sets and CCI for those who received custom orders, $F(3,38813) = 410.373$, $P < 0.05$. Patients in the experimental group had more comorbidities compared to those in the control group, indicating lack of benefit of the order sets. However, more comorbidities may indicate other health concerns were in play, leading to a longer length of hospital stay due to issues unrelated to VTE. More discussion of this topic will be presented in Chapter 5.

There was no significant difference between VTE groups for IMMC and LGH surgical patients, using Charlson Comorbidity Index as a dependent variable. Due to conflicting results among the two hospitals for the non-surgical patients and lack of statistical significance of results among surgical patients, the CCI case results remain inconclusive, leaving discussion of the benefits of medication order sets to reduce complications from acute VTE open for future studies.

Case 4: Relationship Between Utilization of VTE Order Sets, Acute VTE, and Length of Stay (Independent vs. Dependent Variables)

The following are categorical comparisons broken down by groups of patient days. Due to a long list of values, a table broken down by each LOS value would show no statistically significant results and display unrealistically high ratio percentages. Smaller ratios in the experimental group indicate the benefit of the VTE medication order sets. Smaller ratios in the control group indicate lack of the VTE order set benefit. Tables 31 through 34 are intended as introductory visual data representations, with no firm conclusions. The latter ones will be made in subsequent statistical tests under this data view. It would also be difficult to draw conclusions by reviewing the groups of patient days, as smaller or larger numbers on any side of the table leave too many questions open, such as the criteria for explaining fewer days within each group and what other factors could contribute to the length of stay outside of the VTE or prescribing medications to treat one.

Table 31. Length of Stay VTE Case Details – IMMC Surgical Patients

Length	**Control Group**			**Experimental Group**		
	VTE=yes	**VTE=no**	**Ratio**	**VTE=yes**	**VTE=no**	**Ratio**
1 - 5	14	5716	0.24%	3	1180	0.25%
6 - 10	19	1193	1.57%	8	578	1.37%
11 - 15	12	400	2.91%	7	241	2.82%
16 - 20	17	181	8.59%	5	87	5.43%
21 - 25	7	87	7.45%	5	41	10.87%
26 - 30	10	63	13.70%	1	21	4.55%
31 - 35	2	37	5.13%	3	11	21.43%
36 - 40		23		2	4	33.33%
41 - 45		18			6	

Table 32. Length of Stay VTE Case Details – IMMC Non-Surgical Patients

Length	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
1 - 5	265	10960	2.36%	162	10723	1.49%
6 - 10	122	1612	7.04%	58	1580	3.54%
11 - 15	36	365	8.98%	36	372	8.82%
16 - 20	25	152	14.12%	15	115	11.54%
21 - 25	16	59	21.33%	8	29	21.62%
26 - 30	5	29	14.71%	1	26	3.70%
31 - 35		8	0.00%	1	13	7.14%
36 - 40	2	7	22.22%	2	5	28.57%
41 - 45	3	6	33.33%	2	4	33.33%

Table 33. Length of Stay VTE Case Details – LGH Surgical Patients

Length	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
1 - 5	37	10905	0.34%	3	969	0.31%
6 - 10	81	2587	3.04%	11	587	1.84%
11 - 15	48	678	6.61%	14	191	6.83%
16 - 20	27	272	9.03%	5	88	5.38%
21 - 25	14	121	10.37%	9	30	23.08%
26 - 30	13	64	16.88%	5	29	14.71%
31 - 35	9	38	19.15%	5	12	29.41%
36 - 40	10	23	30.30%	4	4	50.00%
41 - 45	14	15	48.28%	1	2	33.33%

Table 34. Length of Stay VTE Case Details – LGH Non-Surgical Patients

Length	Control Group			Experimental Group		
	VTE=yes	VTE=no	Ratio	VTE=yes	VTE=no	Ratio
1 - 5	563	22314	2.46%	74	5833	1.25%
6 - 10	252	4453	5.36%	66	1594	3.98%
11 - 15	75	912	7.60%	27	406	6.24%
16 - 20	27	265	9.25%	15	128	10.49%
21 - 25	12	103	10.43%	7	50	12.28%
26 - 30	11	39	22.00%	7	31	18.42%
31 - 35	7	27	20.59%	5	9	35.71%
36 - 40	3	17	15.00%	1	8	11.11%
41 - 45	2	10	16.67%	1	3	25.00%

Next, experimental and control groups were labeled in SPSS to examine complex relationships between application of the order sets, occurrence of acute VTE, and LOS. The One-Way ANOVA test with Bonferroni and Tukey post hoc tests selected for this analysis cannot track such complex relationship with multiple variables and require examination of one direct relationship between an independent and dependent variable. In order to prepare for such simple relationship setup, control and experimental VTE cases and outcomes were assigned four labels, thus building four cases of the order set application that resulted or did not result in acute VTE. The direct relationship between these cases and LOS will then met the setup requirements for a One-Way ANOVA test. The labels used in SPSS were as follows:

Order_Set_Use =1 + Acute_VTE = 1: 1

Order_Set_Use =1 + Acute_VTE = 0: 2

Order_Set_Use =0 + Acute_VTE = 1: 3

Order_Set_Use =0 + Acute_VTE = 0: 4

Therefore, labels 1 and 2 represented the experimental group and labels 3 and 4 represented the control group. Detailed One-Way ANOVA results obtained in SPSS are outlined in Appendix F. In summary, standard means and statistical significance at the 95% confidence level were as follows:

Table 35. One-Way ANOVA Bonferroni/Tukey Results for LOS – VTE Case

Category	**Means**	**Significant at 95% (p =< 0.05)?**
IMMC Surgical	1 : 2 = 11.370	Yes
	3 : 4 = 11.307	Yes
LGH Surgical	1 : 2 = 12.321	Yes
	3 : 4 = 11.941	Yes
IMMC Non-Surgical	1 : 2 = 3.707	Yes
	3 : 4 = 3.321	Yes
LGH Non-Surgical	1 : 2 = 7.071	Yes
	3 : 4 = 2.488	Yes

The Dunnett post-hoc One-Way ANOVA *t*-test requires labels but compares any one experimental group against a defined control group. Among groups outlined for the One-Way ANOVA test in Table 35, the following were used for the Dunnett post-hoc exercise. This is a test of LOS in the case of absence of acute VTE.

Order_Set_Use =1 + Acute_VTE = 0: 2 (experimental group)

Order_Set_Use =0 + Acute_VTE = 0: 4 (control group)

Results of the Dunnett *t*-test are summarized in Table 36. Details from SPSS are provided as part of Appendix F.

Table 36. One-Way ANOVA Dunnett Results for LOS – VTE Case

Category	**Means**	**Significant at 95% (p =< 0.05)?**
IMMC Surgical	2 : 4 = 2.085	Yes
LGH Surgical	2 : 4 = 0.030	No
IMMC Non-Surgical	2 : 4 = 3.192	Yes
LGH Non-Surgical	2 : 4 = 0.941	Yes

VTE Case 4 Findings

The Dunnett *t*-tests confirmed that VTE medication order sets influenced the length of hospital stay among most patients eligible for this study, except LGH surgical patients, leaving this category without certain results despite availability and statistical significance of the IMMC surgical data. Yet, all of the Bonferroni relationships between groups were statistically significant, leading to the following statements derived from results.

There was a significant difference between Length of Stay for the IMMC non-surgical groups of patients who received medications via orders sets and LOS for those who received custom orders, $F(3,28271) = 172.499$, $P < 0.05$. Patients in the experimental group had slightly longer lengths of stay compared to those in the control group.

There was a significant difference between Length of Stay for the LGH non-surgical groups of patients who received medications via orders sets and LOS for those who received custom orders, $F(3,38813) = 410.373$, $P < 0.05$. Patients in the experimental group had slightly longer lengths of stay compared to those in the control group.

There was a significant difference between Length of Stay for the IMMC surgical groups of patients who received medications via orders sets and LOS for those who

received custom orders, F (3,10237) = 101.509, P < 0.05. Patients in the experimental group had slightly longer lengths of stay compared to those in the control group.

There was a significant difference between Length of Stay for the LGH surgical groups of patients who received medications via orders sets and LOS for those who received custom orders, F (3,17329) = 686.291, P < 0.05. Patients in the experimental group had longer lengths of stay compared to those in the control group.

Despite being statistically significant, the mean length of stay produced for the experimental group patients was higher compared to the control group, indicating a lack of benefit for the order sets relative to LOS. Further discussion of this outcome appears in Chapter 5.

Case 5: Analysis of the Direct Relationship Between Utilization of the Order Sets and Length of Hospital Stay (LOS)

The following are results of the non-parametric independent samples tests suitable for examining relationships between dichotomous and continuous values assigned to utilization of the order sets (categorical) and LOS (continuous) variables. The plots graphically representing these results are available in Appendix F. Mann-Whitney test results are presented in pairs of tables: one containing basic statistics and another displaying the outcomes of frequency distribution and hypothesis testing.

IMMC surgical calculations

Table 37. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Basic Statistics – IMMC Surgical

Mann-Whitney Parameter	Results
Total N	10,259
Mann-Whitney U	11,755,933.500
Wilcoxcon W	14,369,974.500
Test Statistic	11,755,933.500
Standard Error	123,750.007
Standard Test Statistic	21.356
Pearson Chi-Squared Significance	$p < 0.01$

Table 38. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Outcomes – IMMC Surgical

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	7973	4798.53	✓
Experimental	2286	6286.08	

Decision from the test of hypothesis: **Reject null hypothesis**

IMMC non-surgical calculations

Table 39. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Basic Statistics – IMMC Non-Surgical

Mann-Whitney Parameter	Results
Total N	40,950
Mann-Whitney U	189,937,128.500
Wilcoxcon W	297,960,079.500
Test Statistic	189,937,128.500
Standard Error	1,131,645.853
Standard Test Statistic	-2.641
Pearson Chi-Squared Significance	$p < 0.008$

Table 40. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Outcomes – IMMC Non-Surgical

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	26252	20589.35	
Experimental	14698	20272.15	✓

Decision from the test of hypothesis: **Reject null hypothesis**

LGH surgical calculations

Table 41. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Basic Statistics – LGH Surgical

Mann-Whitney Parameter	Results
Total N	17,359
Mann-Whitney U	22,970,959.500
Wilcoxcon W	25,394,260.500
Test Statistic	22,970,959.500
Standard Error	217,959.212
Standard Test Statistic	28.857
Pearson Chi-Squared Significance	$p < 0.01$

Table 42. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Outcomes – LGH Surgical

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	15158	8265.07	✓
Experimental	2201	11537.60	

Decision from the test of hypothesis: **Reject null hypothesis**

LGH non-surgical calculations

Table 43. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Basic Statistics – LGH Non-Surgical

Mann-Whitney Parameter	Results
Total N	56,799
Mann-Whitney U	245,247,010.500
Wilcoxcon W	287,296,045.500
Test Statistic	245,247,010.500
Standard Error	1,421,074.854
Standard Test Statistic	18.907
Pearson Chi-Squared Significance	$p < 0.01$

Table 44. Direct Relationship Between Utilization of VTE Order Sets and LOS, Mann-Whitney Outcomes – LGH Non-Surgical

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	47629	27835.89	✓
Experimental	9170	31329.99	

Decision from the test of hypothesis: **Reject null hypothesis**

VTE Case 5 Findings

The Mann-Whitney tests confirm earlier One-Way ANOVA results, displaying strong statistical significance by rejection of the null hypotheses (indicating no relationship between variables), with a mix mean ranks – leading to inconclusive outcomes relative to the actual benefit of the order sets as represented by the length of stay health outcome.

Case 6: Analysis of Direct Relationship Between Utilization of the Order Sets and Charlson Comorbidity Index (CCI)

The following are results of the non-parametric independent samples tests suitable for examining relationship between dichotomous and continuous values assigned to utilization of the order sets (categorical) and CCI (continuous) variables. The plots graphically representing these results are available in Appendix F.

IMMC surgical calculations

Table 45. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Basic Statistics – IMMC Surgical

Mann-Whitney Parameter	**Results**
Total N	10,241
Mann-Whitney U	10,860,731.500
Wilcoxcon W	13,442,859.500
Test Statistic	10,860,731.500
Standard Error	114,972.223
Standard Test Statistic	15.725
Pearson Chi-Squared Significance	$p < 0.01$

Table 46. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Outcomes – IMMC Surgical

Patient Group	**Total Group Population (N)**	**Mean Group Rank**	**Frequency Distribution Skew (Benefit Indicator)**
Control	7969	4893.13	✓
Experimental	2272	5916.75	

Decision from the test of hypothesis: **Reject null hypothesis**

IMMC non-surgical calculations

Table 47. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Basic Statistics – IMMC Non-Surgical

Mann-Whitney Parameter	**Results**
Total N	28,275
Mann-Whitney U	108,401,386.500
Wilcoxcon W	203,724,914.500
Test Statistic	108,401,386.500
Standard Error	654,218.049
Standard Test Statistic	13.026
Pearson Chi-Squared Significance	$p < 0.01$

Table 48. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Outcomes – IMMC Non-Surgical

Patient Group	**Total Group Population (N)**	**Mean Group Rank**	**Frequency Distribution Skew (Benefit Indicator)**
Control	14468	13549.01	✓
Experimental	13807	14755.19	

Decision from the test of hypothesis: **Reject null hypothesis**

LGH surgical calculations

Table 49. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Basic Statistics – LGH Surgical

Mann-Whitney Parameter	Results
Total N	17,333
Mann-Whitney U	19,295,760.00
Wilcoxcon W	21,701,481
Test Statistic	19,295,760.00
Standard Error	201,827.472
Standard Test Statistic	13.352
Pearson Chi-Squared Significance	$p < 0.01$

Table 50. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Outcomes – LGH Surgical

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	15140	8489.01	✓
Experimental	2193	9895.80	

Decision from the test of hypothesis: **Reject null hypothesis**

LGH non-surgical calculations

Table 51. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Basic Statistics – LGH Non-Surgical

Mann-Whitney Parameter	Results
Total N	38,817
Mann-Whitney U	143,818,946.500
Wilcoxcon W	182,165,849.500
Test Statistic	143,818,946.500
Standard Error	890,680.524
Standard Test Statistic	13.699
Pearson Chi-Squared Significance	$p < 0.01$

Table 52. Direct Relationship Between Utilization of VTE Order Sets and CCI, Mann-Whitney Outcomes – LGH Non-Surgical

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	30060	19003.10	✓
Experimental	8757	20802.31	

Decision from the test of hypothesis: **Reject null hypothesis**

VTE Case 6 Findings

The Mann-Whitney tests confirm earlier One-Way ANOVA results for non-surgical patients, displaying strong statistical significance by rejection of the null hypotheses (indicating strong relationships between variables). The Mann-Whitney test results for surgical patients contradict the One-Way ANOVA test, displaying statistical significance between utilization of the order sets and CCI by rejecting the null hypothesis. However, all mean ranks indicate higher comorbidities for those patients who received VTE

prevention medications via order sets, leading to the conclusion that VTE order sets do not benefit patients in terms of the complications health outcome. In fact, VTE prevention order sets may cause additional complications, although this outcome may depend on other variables that are discussed in Chapter 5. It is also important to note that Mann-Whitney and One-Way ANOVA tests differed in scope, with the former examining a direct relationship between order sets and CCI, and the latter examining the more complex relationship controlled by VTE occurrence. The final outcome remains inconclusive for CCI, due to a mixed bag of outcomes from all tests that either produced contradicting results (for surgical patients) or agreed on outcomes but showed higher rate of complications/comorbidities among experimental group patients.

Case 7: Analysis of Statistical Significance of Several Independent Variables on Occurrence of Acute VTE

This case uses binary logistic regression method to measure and contrast the influence of several independent variables on occurrence of acute VTE, as well as to provide the odds ratios for each scenario.

Table 53. Acute VTE as Affected by Utilization of the Order Sets, Patient Age, Patient Sex, Patient Race, and Surgical/Non-Surgical Status – IMMC and LGH Together

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)	0.000	1.305
Patient Age	0.000	1.007
Patient Sex	0.223	1.052
Patient Race	0.000	0.953
Surgery Status	0.000	1.862
Constant	0.000	0.016

Table 54. Acute VTE as Affected by Utilization of the Order Sets, Patient Age, Patient Sex, Patient Race, and Surgical/Non-Surgical Status – IMMC

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)	0.000	1.534
Patient Age	0.000	1.014
Patient Sex	0.253	1.080
Patient Race	0.000	0.944
Surgery Status	0.000	2.552
Constant	0.000	0.008

Table 55. Acute VTE as Affected by Utilization of the Order Sets, Patient Age, Patient Sex, Patient Race, and Surgical/Non-Surgical Status – LGH

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)	0.060	1.138
Patient Age	0.058	1.003
Patient Sex	0.480	1.038
Patient Race	0.701	0.991
Surgery Status	0.000	1.636
Constant	0.000	0.016

VTE Case 7 Results

For both hospitals as a whole, all variables but patient sex are significant in predicting the value of Acute VTE. However, the odds ratios are highest for surgery status and order set utilization. When considered separately, IMMC had the same outcomes as the two hospitals combined, while LGH had order set utilization and patient age approaching significance, with patient race being insignificant. Therefore, overall age is the strongest influencing factor for acute VTE, followed by surgery status and utilization of the order sets. Among these outcomes, it would be most obvious to clinicians that surgical status

and age have strong influence on VTE. However, clinicians would not expect medication order set utilization to have similar influence on VTE outcomes.

The odds ratios are also high for the order sets, supporting strong case for influence on VTE. High surgery odds ratios are expected due to nature of the problem.

VTE Study Descriptive Statistics

The number of participants broken down by race, sex, and utilization of the order sets appears in Appendix F.

Pneumonia Study Results

Case 1: Relationship Between Utilization of Order Sets and Mortality (Independent vs. Dependent Variables) – Total and Split by Hospital, Hospice Patients Excluded from Study

Table 56. Pneumonia Mortality: Total for GSAM, IMMC, SSUB, TRIN Combined – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	338	11				
Mortality = no	4193	158				
Percent (Mortality=yes) / total	7.5%	**6.5%**	3.736 (*p*=0.053)	0.060	0.029	1.822 [0.983 & 3.380]

Table 57. Pneumonia Mortality: GSAM Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	73	1				
Mortality = no	1756	112				
Percent (Mortality=yes) / total	4%	**0.9%**	2.804 (*p*= 0.094)	0.124	0.062	4.656 [0.641 & 33.809]

Table 58. Pneumonia Mortality: IMMC Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	26	6				
Mortality = no	846	327				
Percent (Mortality=yes) / total	3%	**1.8%**	1.298 (*p*= 0.255)	0.017	0.010	1.675 [0.683 & 4.107]

Table 59. Pneumonia Mortality: SSUB Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	47	1				
Mortality = no	1184	59				
Percent (Mortality=yes) / total	3.8%	**1.7%**	0.740 (*p*= 0.39)	0.723	0.335	2.342 [0.318 & 17.269]

Table 60. Pneumonia Mortality: TRIN Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	12	3				
Mortality = no	407	34				
Percent (Mortality=yes) / total	**2.9%**	8.1%	2.939 (*p*= 0.086)	0.113	0.113	0.334 [0.090 & 1.242]

Pneumonia Case 1 Findings

This first study of the effects of administering pneumonia medication order sets on health outcomes was aimed at calculating basic percentages of patients who died from pneumonia relative to the total population. It might be the best, easiest, and most representative study of the mortality health outcome of order sets utilization, supported by statistical calculations of significance at the 95% confidence interval and binary logistic regression.

Details outlined in Tables 56 through 60 are broken down by hospital, starting with the total of all four facilities participating in the study. Only the latter study produced results that numerically approached significance by Pearson Chi-Squared and 2-sided Fisher's Exact calculations (P approached 0.05). While the odds ratio was calculated for all cases using binary logistic regression, only results for all hospitals, taken as a whole, were valid, based on statistical significance. Both Enter and Backward LR methods of running binary logistic regression equation produced identical results. The reason for lack of statistical significance in each of the individual hospital cases is an insufficient

population sample that gets smaller with each attempt to conduct a more categorized/focused study. The pneumonia study is much smaller compared to VTE by the overall population (total admissions) of pneumonia patients available in EMR history, although this pneumonia data set is much larger than what the majority of the other hospitals with EMR ownership can offer today.

Mortality = yes is represented by the sole discharge disposition code of Expired (=20), while Mortality = no is a combination of many codes that were converted to 0 values for the purposes of this pneumonia study, so Mortality is a calculated field in SPSS. In this case, hospice patients (discharge disposition codes of 50 and 51) were excluded, as this group of patients makes a statistical difference on outcomes due to uncertain survival characteristics, with their outcomes difficult to track at this time (internal and external hospice facilities recording results in their own EMR applications that are not linked). Excluding hospice patients from the study was not a viable option, since these patients were, in fact, treated at the hospitals. So the more valid study was the one that followed it, with all patients accounted for. Yet it was important to show both sets of results, given that hospice patients affect outcome results.

Smaller ratios in the experimental group indicate the benefit of the order sets leading to reduced mortality, while smaller ratios for the control group mean lack of the order set benefit and the possibility of side effects from pneumonia medication order sets. As evidenced from SPSS crosstabs calculations, mortality was 1% lower for patients who received medications and orders via sets – a significant outcome given a total patient population of roughly 5,000. The odds ratio was also high at 1.822 – so the odds of dying from pneumonia while treated with medication order set are much lower compared to

custom physician orders. Patients' health outcomes are more favorable when evidence-based methods are utilized to treat pneumonia.

Case 2: Relationship Between Utilization of Order Sets and Mortality (Independent vs. Dependent Variables) – Total and Split by Hospital, Hospice Patients as Mortality=0 (no)

Table 61. Pneumonia Mortality: Total for GSAM, IMMC, SSUB, TRIN – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	545	11				
Mortality = no	4373	158				
Percent (Mortality=yes) / total	11%	**6.5%**	3.509 (*p*= 0.061	0.060	0.034	1.790 [0.965 and 3.320]

Table 62. Pneumonia Mortality: GSAM Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	119	1				
Mortality = no	1842	73				
Percent (Mortality=yes) / total	6%	**1.4%**	2.859 (*p*= 0.091)	0.126	0.060	4.716 [0.650 and 34.227]

Table 63. Pneumonia Mortality: IMMC Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	333	6				
Mortality = no	885	26				
% (Mortality=yes) / total	27.3%	**23%**	1.164 (*p*= 0.281)	0.321	0.192	1.631 [0.685 and 3.997]

Table 64. Pneumonia Mortality: SSUB Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	59	1				
Mortality = no	1234	47				
Percent (Mortality=yes) / total	4.6%	**2.1%**	0.666 (*p*= 0.415)	0.720	0.336	2.247 [0.305 and 16.569]

Table 65. Pneumonia Mortality: TRIN Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	34	3				
Mortality = no	412	12				
Percent (Mortality=yes) / total	**7.6%**	20%	3.011 (*p*= 0.083)	0.111	0.111	0.33 [0.089 and 1.227]

Pneumonia Case 2 Findings

Case 2 was performed in the same way as Case 1, with the only difference being that hospice patients were included in calculations with the mortality setting of 0 (mortality = no). Statistical significance was slightly smaller at $p = 0.06$ (approached significance), but percentage difference between control and experimental group ratios widened to 4.5%, indicating that "borderline" hospice patients make a significant difference in the results of pneumonia mortality case of the medication order sets. The odds ratio was similar to the one identified in Case 1. As expected, none of the individual hospital cases produced statistically significant results. As evidenced from this case, pneumonia patients who receive medications and physician orders via sets have much higher chances of surviving compared to the experimental group of patients who received orders and medications via custom physician orders.

Case 3: Relationship Between Utilization of Order Sets and Readmission (Independent vs. Dependent Variables) – Total and Split by Hospital

Table 66. Pneumonia Readmissions: Total for GSAM, IMMC, SSUB, TRIN Combined

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Readmission = yes	579	54				
Readmission = no	3952	502				
Percent (Readmission =yes) / total	14.7%	**10.8%**	4.274 (p= 0.039)	0.041	0.020	1.362 [1.015 and 1.827]

Table 67. Pneumonia Readmissions: GSAM Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	237	15			
Readmission = no	1678	105			
Percent (Readmission =yes) / total	**12.4%**	12.5%	0.002 (*p*= 0.968)	1.000	0.528

Table 68. Pneumonia Readmissions: IMMC Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	123	32			
Readmission = no	788	307			
Percent (Readmission =yes) / total	13.5%	**9.4%**	3.753 (*p*= 0.053)	0.054	0.031

Table 69. Pneumonia Readmissions: SSUB Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	167	2			
Readmission = no	1114	58			
Percent (Readmission =yes) / total	13%	**3.3%**	4.9 (*p*= 0.027	0.026	0.013

Table 70. Pneumonia Readmissions: TRIN Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	52	5			
Readmission = no	372	32			
Percent (Readmission =yes) / total	**12.3%**	13.5%	0.049 (*p*= 0.825)	0.795	0.493

Pneumonia Case 3 Findings

The pneumonia case 3 setup in SPSS was similar to both cases 1 and 2, but instead of mortality the dependent variable examined for health outcomes was 30-day readmission passed from EDW as categorical with 0 (no) and 1 (yes) values. As the first case for all hospitals indicates, the difference between readmitted patients for the experimental and control groups was almost 4%, indicating a significantly lower chance of being readmitted after being treated for pneumonia using evidence-based medicine techniques.

Results for this case were statistically significant. The odds ratio was relatively strong at 1.362, indicating a lower chance of readmission after application of the order sets to treat pneumonia. Among individual hospitals in this case, calculations for the SSUB hospital were statistically significant and Pearson Chi-Squared for IMMC approached significance at the 95% confidence level. Binary logistic regression calculations for individual hospitals were omitted due to small experimental group samples that were expected to lead to statistically insignificant results.

It is clear from reading results of this case that patients' chance of being readmitted is lower when order sets are applied to treat pneumonia. Therefore, pneumonia case 3 adds to cases 1 and 2 in statistically proving the point that patients are better off when physicians utilize sets to order treatment and medications for pneumonia, compared to custom orders.

Case 4: Relationship Between Utilization of Order Sets and Length of Stay (Independent vs. Dependent Variables)

This case utilized the Mann-Whitney non-parametric analysis of independent samples to test the null hypothesis for the length of hospital stay for pneumonia patients. It was followed by basic One-Way ANOVA (without post-hoc tests) to compare means between control and experimental groups. Both tests produced means, the former as mean rank and the latter as a mathematical mean. The two tests were set up differently, hence it made sense to apply both for verification purposes. SPSS also provided a nice graphical representation of the null hypothesis test as part of the Mann-Whitney results. The detailed results and figure for Mann-Whitney are available in Appendix G. The overview of Mann-Whitney test results in this chapter are presented in pairs of tables: one

containing basic statistics and another displaying the outcomes of frequency distribution and hypothesis testing.

Total for all hospitals

Table 71. Relationship Between Utilization of Pneumonia Order Sets and LOS, Mann-Whitney Basic Statistics – All Hospitals

Mann-Whitney Parameter	Results
Total N	5087
Mann-Whitney U	1,148,309
Wilcoxcon W	1,303,155
Test Statistic	1,148,309
Standard Error	32,420.610
Pearson Chi-Squared Significance	$p = 0.001$

Table 72. Relationship Between Utilization of Pneumonia Order Sets and LOS, Mann-Whitney Outcomes – All Hospitals

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	4531	2568.57	
Experimental	556	2343.80	✓

Decision from the test of hypothesis: **Reject null hypothesis**

Table 73. One-Way ANOVA for Pneumonia LOS Case – Description View

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	4531	4.84	4.143	.062	4.72	4.96	0	40
1	556	4.43	4.028	.171	4.10	4.77	0	43
Total	5087	4.80	4.132	.058	4.68	4.91	0	43

Table 74. One-Way ANOVA for Pneumonia LOS Case – Basic View

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	81.848	1	81.848	4.798	0.029
Within Groups	86749.531	5085	17.060		
Total	86831.380	5086			

Pneumonia Case 4 Findings

The Mann-Whitney test rejected the null hypothesis for the length of hospital stay, indicating that there is a statistically significant difference between control and experimental groups of pneumonia patients, signaling potential benefit of the order sets in yet another health outcomes category. However, rejection of the null hypothesis does not provide the level of detail necessary to determine whether length of stay was longer or shorter for patients in the experimental groups. Comparison of means within Mann-Whitney test results revealed a higher mean rank for the control group of patients. This indicates that patients who received treatment orders via sets had a shorter hospital stay.

The same results were confirmed by the One-Way ANOVA test that uses mathematical means for each category of patients, with higher mean for the control group. Results of the ANOVA test were as follows: there was significant difference between LOS for pneumonia patients who received medications via order sets and those who had them prescribed via custom orders, $F(1, 5085) = 4.798$, $P < 0.05$; the mean length of stay was lower for patients who received medications via order sets. Case 4 statistically proved the overall benefit of evidence based medicine to treat pneumonia in

terms of the length of hospital stay health outcome. This benefit also indicates lower cost for each case.

Case 5: Relationship Between Utilization of Order Sets and Patient Complications Represented by Charlson Comorbidity Index (Independent vs. Dependent Variables)

This case was set up in the same way as pneumonia case 4 to test the null hypothesis and compare the actual complications indexes between control and experimental groups using mean ranks reported by the Mann-Whitney analysis. Results were subsequently verified using an alternative One-Way ANOVA test of comorbidities. The outcomes from both Mann-Whitney and One-Way ANOVA tests should match to the results.

Total for All Hospitals

Table 75. Relationship Between Utilization of Pneumonia Order Sets and CCI, Mann-Whitney Basic Statistics – All Hospitals

Mann-Whitney Parameter	**Results**
Total N	4983
Mann-Whitney U	1,153,767.500
Wilcoxcon W	1,153,767.500
Test Statistic	1,153,767.500
Standard Error	31,293.357
Pearson Chi-Squared Significance	$p = 0.014$

Table 76. Relationship Between Utilization of Pneumonia Order Sets and CCI, Mann-Whitney Outcomes – All Hospitals

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	4427	2509.38	
Experimental	556	2353.62	✓

Decision from the test of hypothesis: **Reject null hypothesis**

Table 77. One-Way ANOVA for Pneumonia CCI Case – Description View

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	4427	2.40	2.424	.036	2.33	2.47	0	15
1	556	2.13	2.289	.097	1.94	2.33	0	11
Total	4983	2.37	2.410	.034	2.30	2.44	0	15

Table 78. One-Way ANOVA for Pneumonia CCI Case – Basic View

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.551	1	34.551	5.954	0.015
Within Groups	28904.801	4981	5.803		
Total	28939.353	4982			

Pneumonia Case 5 Findings

The Mann-Whitney test of independent samples rejected the null hypothesis and proved that a relationship between utilization of the order sets to treat pneumonia and patient complications exists. The mean rank for the control group of patients was higher

compared to the experimental group, indicating that experimental patients developed fewer complications when order sets were applied to prescribe clinical tests and medications, or these patients had fewer pre-existing conditions that made them appear as less sick for the purposes of the pneumonia order set study. The One-Way ANOVA test confirmed these results using simple mathematical means on a per-patient complications basis. Therefore, patients in the experimental group benefited from application of the order sets and had better health outcomes, in terms of complications. Detailed results and graphs and available in Appendix G. Additional discussion of differences between complications, comorbidities, and length of hospital stay will appear in Chapter 5.

Overall, Case 5 results can be summarized as follows: there was significant difference between CCI for pneumonia patients who received medications via order sets and those who had them prescribed via custom orders, $F(1, 4981) = 5.954$, $P < 0.05$. The mean complications index score was lower for patients who received medications via order sets.

Case 6: Study of Several Independent Variables Affecting Dependent Variables

This case utilized binary logistic regression to examine the influence of several independent variables on the dependent variables of readmissions and mortality. Statistical significance is the primary test in this case, with the odds ratios providing clues into strength of the variable influence.

Table 79. Pneumonia Readmissions as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ration EXP(B)**
Order Set Indicator (categorical – yes/no)	0.079	1.304
Patient Age	0.000	1.006
Patient Sex	0.003	0.778
Patient Race	0.003	0.937
Constant	0.000	0.199

Table 80. Pneumonia Mortality as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ration EXP(B)**
Order Set Indicator (categorical – yes/no)	0.028	1.618
Patient Age	0.000	1.024
Patient Sex	0.460	0.086
Patient Race	0.056	0.053
Constant	0.000	0.005

Pneumonia Case 6 Findings

A patient's age, race, and sex played a greater role in predicting readmission than use of the order set, which in this particular linear regression exercise approached significance. It is important to note that significance numbers are relative within this particular group of independent variables.

Patient age had the most influence on mortality, followed by use of the order set. Patient's race was next and approached significance, while patient sex was statistically insignificant.

Pneumonia Study Descriptive Statistics

The number of participants by race, sex, and utilization of the order sets is available in Appendix G.

CHF Study Results

Case 1: Relationship Between Utilization of Order Sets and Mortality (Independent vs. Dependent variables) – Total and Split by Hospital, Hospice Patients Excluded from Study

Table 81. CHF Mortality: Total for CMC, GSHP, SSUB, IMMC, LGH – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	331	13				
Mortality = no	9505	692				
Percent (Mortality=yes) / total	3.4%	**1.9%**	11.128 (*p*= 0.028)	0.032	0.018	1.854 [1.059 & 3.244]

Table 82. CHF Mortality: CMC Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	130	1				
Mortality = no	4120	68				
Percent (Mortality=yes) / total	3%	**1.4%**	1.255 (*p*= 0.439)	0.724	0.375	2.146 [0.296 & 15.572]

Table 83. CHF Mortality: IMMC Hospital Calculations – Hospice Excluded

Outcomes and Measures	Control Group	Experimental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
Mortality = yes	23	9				
Mortality = no	890	468				
Percent (Mortality=yes) / total	2.5%	**1.9%**	0.616 (*p*= 0.455)	0.573	0.293	1.344 [0.617 & 2.928]

Table 84. CHF Mortality: SSUB Hospital Calculations – Hospice Excluded

Outcomes and Measures	Control Group	Experimental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
Mortality = yes	57	0				
Mortality = no	1811	39				
Percent (Mortality=yes) / total	3%	N/A	2.903 (*p*= 0.268)	0.629	0.303	50845977.60 [0 & N/A]

Table 85. CHF Mortality: GSHP Hospital Calculations – Hospice Excluded

Outcomes and Measures	Control Group	Experimental Group	Pearson Chi-Squared (χ^2)	2-sided Fisher's Exact	1-sided Fisher's Exact	EXP (B) – Binary Logistic Regression
Mortality = yes	48	0				
Mortality = no	1248	18				
Percent (Mortality=yes) / total	3.7%	N/A	4.157 (*p*= 0.406)	1.000	0.510	62133639.57 [0 & N/A]

Table 86. CHF Mortality: LGH Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	73	3				
Mortality = no	1436	99				
Percent (Mortality=yes) / total	4.8%	**2.9%**	3.507 (*p*= 0.382)	0.626	0.277	1.678 [0.519 and 5.418]

CHF Case 1 Findings

Case parameters for pneumonia, CHF, and AMI are similar due to the same health outcomes targets and examination of relationships between one independent and three or four dependent variables. However, population and consequently data sample sizes decline from VTE to pneumonia to CHF to AMI. A greater number of more focused studies categorized by extra variables such as patient sex or treatment facility fails to produce statistically significant results. Only more time and encouragement for physicians to utilize medication order sets would help enrich these studies by increasing population sizes for experimental groups – outside of a controlled experiment where physicians are explicitly asked to prescribe via sets and give up their decision making independence. As a result, for the CHF study, only the total of all participating hospitals will be discussed.

As in the pneumonia study, the lower percentages in the experimental group indicate a benefit of the order set with a lower mortality ratio compared to the total of all cases where order sets were applied. The lower percentage in the control group indicates a lack

of an order set benefit and/or adverse effects. Binary logistic regression was run using Enter and Backward LR specifications in SPSS – both produced identical results. Due to small sample sizes in experimental groups, binary logistic regression results for individual hospital cases were omitted.

As evident from Tables 81 through 86, the mortality rate among experimental group patients was significantly lower than among control group patients, indicating clear benefit of CHF medication order sets in terms of mortality health outcomes. Hospice patients were excluded from Case 1. Including hospice patients would produce a study of greater validity, but due to the differences in outcomes that hospice patients generate, it is important to show both sets of numbers.

Case 2: Relationship Between Utilization of Order Sets and Mortality (Independent vs. Dependent Variables) – Total and Split by Hospital, Hospice Patients as Mortality=0 (no)

Table 87. CHF Mortality: Total for CMC, GSHP, SSUB, IMMC, LGH – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	331	13				
Mortality = no	9888	706				
Percent (Mortality=yes) / total	3.2%	**1.8%**	4.516 (*p*= 0.034)	0.040	0.022	1.818 [1.039 & 3.181]

Table 88. CHF Mortality: CMC Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	130	1			
Mortality = no	4256	69			
Percent (Mortality=yes) / total	3%	**1.4%**	0.569 (*p*= 0.451)	0.724	0.384

Table 89. CHF Mortality: IMMC Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	23	9			
Mortality = no	907	476			
Percent (Mortality=yes) / total	2.5%	**1.9%**	0.550 (*p*= 0.458)	0.573	0.295

Table 90. CHF Mortality: SSUB Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	57	0			
Mortality = no	1889	39			
% (Mortality=yes) / total	2.9%	N/A	1.176 (*p*= 0.278)	0.627	0.317

Table 91. CHF Mortality: GSHP Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	48	0			
Mortality = no	1286	20			
Percent (Mortality=yes) / total	3.6%	N/A	0.746 (*p*= 0.388)	1.000	0.483

Table 92. CHF Mortality: LGH Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	73	3			
Mortality = no	1550	102			
Percent (Mortality=yes) / total	4.5%	**2.9%**	0.631 (*p*= 0.427)	0.622	0.309

CHF Case 2 Findings

The only difference between this case and CHF Case 1 is treatment of the hospice patients by discharge disposition code: Case 1 excluded them and Case 2 included with mortality = no (actual known outcome). Only the case when all hospitals are included was statistically significant and revealed similar results in terms of mortality and benefit for the experimental group patients, thus re-confirming results for mortality.

Case 3: Relationship Between Utilization of Order Sets and Readmission (Independent vs. Dependent variables) – Total and Split by Hospital

Table 93. CHF Readmissions: Total for CMC, IMMC, SSUB, GSHP, LGH Combined

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Readmission = yes	1415	108				
Readmission = no	6168	430				
Percent (Readmission =yes) / total	**19%**	20%	0.659 (*p*= 0.417)	0.424	0.224	0.913 [0.734 & 1.137]

Table 94. CHF Readmissions: CMC Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	555	7			
Readmission = no	2513	34			
Percent (Readmission =yes) / total	18%	**17%**	0.028 (*p*= 0.867)	1.000	0.532

Table 95. CHF Readmissions: IMMC Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	138	74			
Readmission = no	543	270			
Percent (Readmission =yes) / total	20.2%	21.5%	0.217 (*p*= 0.642)	0.683	0.349

Table 96. CHF Readmissions: SSUB Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	239	4			
Readmission = no	1089	26			
Percent (Readmission =yes) / total	18%	**13.3%**	0.434 (*p*= 0.510)	0.635	0.354

Table 97. CHF Readmissions: GSHP Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	193	3			
Readmission = no	768	15			
Percent (Readmission =yes) / total	20%	**16.7%**	0.129 (*p*= 0.720)	1.000	0.499

Table 98. CHF Readmissions: LGH Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	290	20			
Readmission = no	1255	85			
Percent (Readmission =yes) / total	**18.8%**	19%	0.005 (*p*= 0.944)	0.898	0.514

CHF Case 3 Findings

None of the Case 3 results were statistically significant due to insufficient readmissions data and missing fields on the spreadsheet received from EDW. While readmission rates for CHF could potentially be as high as indicated in the results, none of the data in Tables 93 through 98 should be trusted due to missing values in the data history and the small size of the experimental group data sample.

Case 4: Relationship Between Utilization of Order Sets and Length of Stay (Independent vs. Dependent Variables)

The Mann-Whitney test of independent samples was aimed at testing the null hypothesis and comparing the mean ranks to contrast control and experimental groups in order to determine which patients had shorter stays. The Mann-Whitney test was followed by One-Way ANOVA to verify results using mathematical means. While numbers obtained from different comparisons of means methods were not expected to match, end results should. More detailed Mann-Whitney results, including a figure, are available in Appendix H.

Total for All Hospitals

Table 99. Relationship Between Utilization of CHF Order Sets and LOS, Mann-Whitney Basic Statistics – All Hospitals

Mann-Whitney Parameter	Results
Total N	10938
Mann-Whitney U	3,472,652
Wilcoxcon W	3,731,492
Test Statistic	3,472,652
Standard Error	81,223.765
Pearson Chi-Squared Significance	$p = 0.013$

Table 100. Relationship Between Utilization of CHF Order Sets and LOS, Mann-Whitney Outcomes – All Hospitals

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	10219	5489.18	
Experimental	719	5189.84	✓

Decision from the test of hypothesis: **Reject null hypothesis**

Table 101. One-Way ANOVA for CHF LOS Case – Description View

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	10219	5.46	6.473	.064	5.33	5.58	0	149
1	719	4.75	4.827	.180	4.39	5.10	0	86
Total	10938	5.41	6.380	.061	5.29	5.53	0	149

Table 102. One-Way ANOVA for CHF LOS Case – Basic View

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	339.786	1	339.786	8.352	0.004
Within Groups	444894.012	10936	40.682		
Total	445233.798	10937			

CHF Case 4 Findings

The Mann-Whitney and One-Way ANOVA tests both revealed that experimental group patients who received medications via order sets had shorter lengths of stay, with statistically significant results, rejecting the null hypothesis. Therefore, there is a clear benefit to utilization of the order sets to treat CHF, measuring in terms of the length of hospital stay health outcomes. This outcome would, in turn, lead to financial savings from lower expenses. Results from One-Way ANOVA included a significant difference between LOS for CHF patients who received medications via order sets and those who has them prescribed via custom orders, $F(1,10936) = 8.352$, $P < 0.05$; the mean length of stay was lower for patients who received medications via order sets.

Case 5: Relationship Between Utilization of Order Sets and Patient Complications Represented by Charlson Comorbidity Index (Independent vs. Dependent Variables)

This case is similar to Case 4 in terms of statistical methods employed to perform calculations; the only difference was the dependent variable – CCI. More detailed Mann-Whitney results, including a figure, are available in Appendix H.

Total for All Hospitals

Table 103. Relationship Between Utilization of CHF Order Sets and CCI, Mann-Whitney Basic Statistics – All Hospitals

Mann-Whitney Parameter	Results
Total N	7757
Mann-Whitney U	1,840,535.500
Wilcoxcon W	1,978,610.500
Test Statistic	1,840,535.500
Standard Error	48,189.915
Pearson Chi-Squared Significance	$p = 0.23$

Table 104. Relationship Between Utilization of CHF Order Sets and CCI, Mann-Whitney Outcomes – All Hospitals

Patient Group	Total Group Population (N)	Mean Group Rank	Frequency Distribution Skew (Benefit Indicator)
Control	7232	3887	
Experimental	525	3768.78	✓

Decision from the test of hypothesis: **Reject null hypothesis**

Table 105. One-Way ANOVA for CHF CCI Case – Description View

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	7232	3.68	1.795	.021	3.64	3.73	2	15
1	525	3.64	1.885	.082	3.48	3.80	2	16
Total	7757	3.68	1.801	.020	3.64	3.72	2	16

Table 106. One-Way ANOVA for CHF CCI Case – Basic View

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.967	1	0.967	0.298	0.585
Within Groups	25148.893	7755	3.243		
Total	25149.861	7756			

CHF Case 5 Findings

Due to missing values for CCI available in EDW, results are statistically insignificant and the null hypothesis is retained. This does not necessarily mean that CHF patients do not benefit from order sets in terms of complications. Results only indicate insufficient data to complete the study.

Case 6: Study of Several Independent Variables Affecting Dependent Variables.

Table 107. CHF Readmissions as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	Significance, 95% conf level	Odds Ratio EXP(B)
Order Set Indicator (categorical – yes/no)	0.489	0.925
Patient Age	0.560	0.999
Patient Sex	0.125	0.914
Patient Race	0.134	1.023
Constant	0.000	0.215

Table 108. CHF Mortality as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)	0.030	1.866
Patient Age	0.000 ($p < 0.01$)	1.037
Patient Sex	0.410	1.098
Patient Race	0.000 ($p < 0.01$)	1.137
Constant	0.000	0.000

CHF Case 6 Findings

None of the factors – patient age, sex, race, and order set utilization - showed statistical significance in influencing readmissions, as evident from the $P > 0.05$ measurements under all categories in Table 107. This follows lack of statistical significance for all CHF cases involving readmissions.

Patient age and race had the most influence on mortality from CHF, followed by utilization of the order sets. All three factors were statistically significant. Utilization of the order sets had the highest odds ratio among all statistically significant factors, indicating a powerful effect on the outcome. Patient sex had no influence on mortality from CHF.

CHF Study Descriptive Statistics

The number of participants broken down by race, sex, and utilization of the order sets is available in Appendix H.

AMI Study Results

Case 1: Relationship Between Utilization of Order Sets and Mortality (Independent vs. Dependent variables) – Total and Split by Hospital, Hospice Patients Excluded from Study

Table 109. AMI Mortality: Total for TRIN and GSHP – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	53	0				
Mortality = no	1183	32				
Percent (Mortality=yes) / total	4.4%	N/A	1.432 (*p*= 0.231)	0.641	0.251	72375466.14 [0 and N/A]

Table 110. AMI Mortality: TRIN Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	20	0			
Mortality = no	370	13			
Percent (Mortality=yes) / total	5.1%	N/A	0.701 (*p*= 0.402)	1.000	0.511

Table 111. AMI Mortality: GSHP Hospital Calculations – Hospice Excluded

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	33	0			
Mortality = no	813	19			
Percent (Mortality=yes) / total	3.9%	N/A	0.771 (*p*= 0.380)	1.000	0.474

AMI Case 1 Findings

The AMI studies were conducted similarly to the pneumonia and CHF studies, starting with mortality and readmissions examinations, followed by length of stay and complications. Case 1 excluded hospice patients. N/A indicates lack of ratio calculation due to zero cases of mortality within the experimental group of patients.

Even when totals of the two qualified hospitals were utilized, no significant results were obtained due to small population size and, in some cases, lack of expired patients in the experimental group. The experimental group had no expired patients. This could indicate potential benefit of the order sets despite small samples, but because data is not available to produce statistically significant results, this statement cannot be quantitatively supported. Odds ratios are unusually high due to zero expired patients, and these results should be disregarded as invalid calculations. There is no mortality case available for AMI; larger data sets would be necessary to produce statistically significant results.

Case 2: Relationship Between Utilization of Order Sets and Mortality (Independent vs. Dependent Variables) – Total and Split by Hospital, Hospice Patients as Mortality=0 (no)

Table 112. AMI Mortality: Total for TRIN and GSHP – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Mortality = yes	53	0				
Mortality = no	1207	32				
Percent (Mortality=yes) / total	4.2%	N/A	1.404 (*p*= 0.236	0.639	0.257	70936340.51 [0 and N/A]

Table 113. AMI Mortality: TRIN Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	20	0			
Mortality = no	375	13			
Percent (Mortality=yes) / total	5%	N/A	0.692 (*p*= 0.405)	1.000	0.515

Table 114. AMI Mortality: GSHP Hospital Calculations – Hospice Mortality = 0

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Mortality = yes	33	0			
Mortality = no	832	19			
Percent (Mortality=yes) / total	3.8%	N/A	0.753 (*p*= 0.386)	1.000	0.482

AMI Case 2 Findings

The only difference between Studies 1 and 2 is how hospice patients are counted. Case 2 assumed including hospice patients with actual results reported – no expiration. This case still failed to produce statistically significant results, so there is no AMI mortality study that could be used to reach valid conclusions.

Case 3: Relationship Between Utilization of Order Sets and Readmission (Independent vs. Dependent Variables) – Total and Split by Hospital

Table 115. AMI Readmissions: Total for TRIN and GSHP Combined

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**	**EXP (B) – Binary Logistic Regression**
Readmission = yes	132	3				
Readmission = no	893	28				
Percent (Readmission =yes) / total	12.9%	**9.7%**	0.276 (*p*= 0.599)	0.788	0.425	70936340.51 [0 and N/A]

Table 116. AMI Readmissions: TRIN Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	46	1			
Readmission = no	349	12			
Percent (Readmission =yes) / total	11.6%	**7.7%**	0.193 (*p*= 0.660)	1.000	0.546

Table 117. AMI Readmissions: GSHP Hospital Calculations

Outcomes and Measures	**Control Group**	**Experi-mental Group**	**Pearson Chi-Squared (χ^2)**	**2-sided Fisher's Exact**	**1-sided Fisher's Exact**
Readmission = yes	86	2			
Readmission = no	544	16			
Percent (Readmission =yes) / total	**6%**	11.1%	0.096 (*p*= 0.756)	1.000	0.549

AMI Case 3 Findings

While this case of readmissions data looks encouraging in terms of producing favorable results in support of the order sets and evidence based AMI treatment practices, the population size was too small to produce statistically significant results, so there is no study for AMI readmissions. Physicians should be encouraged to apply evidence-based practices to treat AMI patients more frequently, so valid results could be produced for AMI.

Case 4: Relationship Between Utilization of Order Sets and Length of Stay (Independent vs. Dependent Variables)

The Mann-Whitney test of independent samples examined the null hypothesis and produced results in the form of comparison of means, so the length of stay could be compared among control and experimental groups. The Mann-Whitney test was followed by the One-Way ANOVA test to confirm results through comparison of mathematical means among the two groups. Detailed data and a figure are available in Appendix I.

Total for All Hospitals

Table 118. Relationship Between Utilization of AMI Order Sets and LOS, Mann-Whitney Basic Statistics – All Hospitals

Mann-Whitney Parameter	**Results**
Total N	1292
Mann-Whitney U	20,815.500
Wilcoxcon W	21,343.500
Test Statistic	20,815.500
Standard Error	2,061.172
Pearson Chi-Squared Significance	$p = 0.750$

Table 119. Relationship Between Utilization of AMI Order Sets and LOS, Mann-Whitney Outcomes – All Hospitals

Patient Group	**Total Group Population (N)**	**Mean Group Rank**	**Frequency Distribution Skew (Benefit Indicator)**
Control	1260	645.98	✓
Experimental	32	666.98	

Decision from the test of hypothesis: **Reject null hypothesis**

Table 120. One-Way ANOVA for AMI LOS Case – Description View

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	1260	4.73	4.434	.125	4.48	4.97	0	46
1	32	5.16	4.304	.761	3.60	6.71	0	15
Total	1292	4.74	4.429	.123	4.50	4.98	0	46

Table 121. One-Way ANOVA for AMI LOS Case – Basic View

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.751	1	5.751	0.293	0.588
Within Groups	25322.301	1290	19.630		
Total	25328.052	1291			

AMI Case 4 Findings

As with the previous three AMI studies, population sizes were too small to produce statistically significant results – the reason for confirming the null hypothesis. The mean length of stay for AMI patients was also longer when order sets were applied to prescribe medications – not a good sign, but any swings are possible when dealing with small population sizes. Further discussion would only be speculative based on insufficient data. Overall, there was no significant difference between LOS for the AMI patients who received medications via order sets and those who had them prescribed via custom orders in Case 4.

Case 5: Relationship Between Utilization of Order Sets and Patient Complications Represented by Charlson Comorbidity Index (Independent vs. Dependent Variables)

The relationship between utilization of the AMI order sets and patient complications were studied using the Mann-Whitney test of independent samples, followed by One-Way ANOVA to confirm results using mathematical comparison of CCI means. Detailed data and a figure are available in Appendix I.

Total for All Hospitals

Table 122. Relationship Between Utilization of AMI Order Sets and CCI, Mann-Whitney Basic Statistics – All Hospitals

Mann-Whitney Parameter	**Results**
Total N	1256
Mann-Whitney U	17,708.500
Wilcoxcon W	18,236.500
Test Statistic	17,708.500
Standard Error	1,960.795
Pearson Chi-Squared Significance	$p = 0.339$

Table 123. Relationship Between Utilization of AMI Order Sets and CCI, Mann-Whitney Outcomes – All Hospitals

Patient Group	**Total Group Population (N)**	**Mean Group Rank**	**Frequency Distribution Skew (Benefit Indicator)**
Control	1224	630.03	
Experimental	32	569.89	✓

Decision from the test of hypothesis: **Reject null hypothesis**

Table 124. One-Way ANOVA for AMI CCI Case – Description View

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
0	1224	2.78	1.957	.056	2.67	2.89	1	13
1	32	2.34	1.494	.264	1.81	2.88	1	7
Total	1256	2.76	1.947	.055	2.66	2.87	1	13

Table 125. One-Way ANOVA for AMI CCI Case – Basic View

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.808	1	5.808	1.533	0.216
Within Groups	4752.434	1254	3.790		
Total	4758.242	1255			

AMI Case 5 Findings

While comparisons of means showed favorable results for the order sets, indicating fewer complications for the experimental group of patients, results lacked statistical significance due to small populations; hence the null hypothesis is sustained. More data is necessary to continue this investigation of the relationship between utilization of evidence based practices to treat AMI and patient complications. Overall, there was no significant difference between CCI for the AMI patients who received medications via order sets and those who had them prescribed via custom orders.

Case 6: Study of Several Independent Variables Affecting Dependent Variables

Table 126. AMI Readmissions as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf. level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)	0.565	1.428
Patient Age	0.001	1.023
Patient Sex	0.293	0.814
Patient Race	0.134	1.078
Constant	0.000	0.009

Table 127. AMI Mortality as Affected by Order Set Indicator, Patient Age, Patient Sex, and Patient Race

Independent Variable	**Significance, 95% conf level**	**Odds Ratio EXP(B)**
Order Set Indicator (categorical – yes/no)	0.998	62163791.91
Patient Age	0.000 ($p < 0.01$)	1.057
Patient Sex	0.396	1.287
Patient Race	0.795	1.022
Constant	0.997	0.000

AMI Case 6 Findings

Only patient age was statistically significant in predicting mortality and readmissions among AMI patients. However, there is possibility that other variables could have played greater roles if population size was greater. Therefore, results of this case are not statistically significant, just like the rest of AMI studies – due to insufficient population size.

AMI Study Descriptive Statistics

The number of participants broken down by race, sex, and utilization of the order sets is available in Appendix I.

Answers to Research Questions

VTE Order Sets

Question 1: Do VTE/DVT medication order sets help prevent occurrence of acute VTE among adult non-surgical patients?

Answer to Question 1: Yes, evidence based VTE/DVT medication order sets help prevent occurrence of VTE among adult non-surgical patients. Without accounting for patient sex, both study populations of IMMC and LGH teaching hospitals with significant utilization of VTE order sets showed reduced percentage of VTE rates among experimental group patients, with IMMC odds ratio of 1.566 [1.354 and 1.812 at 95% confidence level] and LGH odds ratio of 1.205 [1.043 and 1.393 at 95% confidence level].

Hypothesis 1 (null): VTE/DVT medication order sets do not help prevent occurrence of acute VTE among adult non-surgical patients.

Hypothesis 1 Statement: Hypothesis 1 was rejected by the study.

Question 2: Do VTE/DVT medication order sets help prevent occurrence of acute VTE among adult surgical patients?

Answer to Question 2: No, evidence based VTE/DVT medication order sets did not help prevent occurrence of VTE among adult non-surgical patients. Without accounting for patient sex, both IMMC and LGH teaching hospitals with significant utilization of VTE order sets showed an increased percentage of VTE rates among experimental group patients, with IMMC odds ratio of 0.670 [0.452 and 0.992 at 95% confidence level] and LGH odds ratio of 0.497 [0.383 and 0.645 at 95% confidence level]. The increase in VTE rates could be attributed to (1) factors unrelated to order sets, (2) danger of the VTE order

sets when administered to surgical patients, (3) higher comorbidity rate for these patients, as evidenced from other parts of the VTE/DVT study.

Hypothesis 2 (null): VTE/DVT medication order sets do not help to prevent occurrence of acute VTE among adult surgical patients.

Hypothesis 2 Statement: Hypothesis 2 was not rejected by the study.

Question 3: Does patient sex play a role in this study and alter answers to Questions 1 and 2?

Answer to Question 3: No, patient sex does not introduce any variances to results of the study, with all surgical patients' odds ratios held below 1 and all non-surgical patients' odds ratios held above 1.

Hypothesis 3 (null): Patient sex does not make a difference in the relationship between utilization of the medication order sets to prevent VTE and occurrence of acute VTE.

Hypothesis 3 Statement: Hypothesis 3 was not rejected by the study.

Question 4: What effect does utilization of the VTE medication order sets have on the surgical patient complications index expressed as a calculated Charlson Comorbidity Index?

Answer to Question 4: VTE medication order sets had no significant effect on complications or did not show a strong relationship between ordering via sets and comorbidity. There was no significant difference in CCI between control and experimental surgical patients at both hospitals, as evident from ANOVA tests that took into account the complex relationship between order set utilization, VTE occurrence rate, and CCI. However, a Mann-Whitney evaluation of the direct relationship between order sets and CCI showed significant difference between the groups, with sicker patients in the

experimental group. The latter could explain longer lengths of stay for these patients. Due to these differences in results among various methods of research and outcomes, the best conclusion in this case is that ordering VTE medications via sets has no significant influence on CCI.

Hypothesis 4 (null): VTE medication order sets have no effect on surgical patient complications as expressed by the Charlson Comorbidity Index.

Hypothesis 4 Statement: Hypothesis 4 was not rejected by the ANOVA methods and rejected by the Mann-Whitney method. The former method took into account the more complex relationship between order sets, VTE occurrence rate, and CCI. Therefore, the conclusion is made based on the ANOVA outcomes.

Question 5: What effect does utilization of the VTE medication order sets have on non-surgical patient complications index expressed as a calculated Charlson Comorbidity Index?

Answer to Question 5: VTE medication order sets had no significant effect on complications or did not show a strong relationship between ordering via sets and comorbidity, according to the ANOVA tests that took into account the complex relationship between order sets, CCI, and VTE occurrence rates. There were significant differences in CCI for the IMMC and LGH non-surgical patients in the control and experimental groups ($F(3,28271) = 94.297$, $P < 0.05$ and $F(3,38813) = 410.373$, $P < 0.05$ respectively for the two hospitals), but IMMC patients had fewer comorbidities, while LGH patients had greater comorbidities. Mixed ANOVA results failed to produce a clear outcome. The Mann-Whitney tests of the direct relationship between CCI and order sets, without control for the VTE occurrence rate, produced clear outcomes of higher

comorbidity among experimental group patients at both hospitals (mean rank of 14755 for experimental group vs. mean rank of 13549 for the control group at IMMC and mean rank of 20802 for experimental group vs. a mean rank of 19003 for control group at LGH). Despite these clear Mann-Whitney results, there was a mix of outcomes between the two methods, so there was no significant effect of the VTE order sets on CCI overall among non-surgical patients. However, lower or higher comorbidity could serve as a side effect on length of stay and VTE occurrence, as sicker patients may have a tendency to remain in the hospital longer and acquire VTE at higher rates due to reasons unrelated to ordering medications via sets or in a custom way.

Hypothesis 5 (null): VTE medication order sets had no effect on non-surgical patient complications as expressed by the Charlson Comorbidity Index.

Hypothesis 5 Statement: Hypothesis 5 was not rejected by the ANOVA studies of the complex relationship between order sets, VTE rates, and CCI. Hypothesis 5 was rejected by the Mann-Whitney test of the direct relationship between VTE order sets and CCI. Since the ANOVA test was more comprehensive, the null hypothesis for CCI among non-surgical patients is not rejected.

Question 6: What effect does utilization of the VTE medication order sets have on the length of surgical patients' hospital stays?

Answer to Question 6: There was a strong relationship between the medication ordering method and length of stay for surgical patients, but the length of stay was higher among experimental group patients, with $P < 0.01$. The outcome could be explained by (1) outside factors beyond the scope of this research, (2) higher comorbidity among

surgical patients, and (3) danger of applying order sets to administer VTE medications to surgical patients.

Hypothesis 6 (null): Utilization of the VTE medication order sets has no effect on the length of surgical patients' hospital stays.

Hypothesis 6 Statement: Hypothesis 6 was rejected, but the mean length of stay was higher among experimental surgical patients (Mann-Whitney mean rank of 11537 for experimental group vs. 8265 for control group at LGH and mean rank of 6286 for experimental group vs. 4798 for control group at IMMC).

Question 7: What effect does utilization of the VTE medication order sets have on the length of non-surgical patients' hospital stays?

Answer to Question 7: There was a strong relationship between the medication ordering method and length of stay for non-surgical patients, but results were mixed at $P < 0.01$. On average IMMC patients stayed longer, while LGH patients had shorter stays.

Hypothesis 7 (null): Utilization of the VTE medication order sets has no effect on the length of non-surgical patients' hospital stays.

Hypothesis 7 Statement: Hypothesis 7 was rejected, but the mean length of stay was higher for experimental group non-surgical patients at LGH (Mann-Whitney mean rank of 31329 for experimental group vs. 27836 for control group) and lower for experimental group non-surgical patients at IMMC (mean rank of 20272 for experimental group vs. 20589 for control group). Mixed results indicate failure to draw clear conclusions regarding benefits or disadvantages of ordering VTE medications via sets for non-surgical patients, as evident by the length of stay health outcome.

Question 8: Which among independent variables of order set utilization, patient age, patient sex, patient race, and surgery status has most influence on the independent variable of acute VTE?

Answer to Question 8: The variables of utilization of order sets, patient age, patient race, and surgery status had strong influence on the variable of acute VTE. The variable of patient sex had no significant effect on acute VTE.

Hypothesis 8 (null): None of the independent variables of order set utilization, patient age, patient sex, patient race, and surgery status has any effect on acute VTE, or all of these variables have equal influence on acute VTE.

Hypothesis 8 Statement: Hypothesis 8 was rejected by the study.

Pneumonia Order Sets

Question 1: Do pneumonia medication order sets help decrease mortality among pneumonia patients?

Answer to Question 1: Yes, utilization of the order sets for pneumonia medications produced lower mortality rates in both studies that excluded and included hospice patients, with the odds ratios of 1.79 [0.965 and 3.320 at 95% confidence level] in the latter study and 1.822 [0.983 and 3.380 at the 95% confidence level] in the former study.

Hypothesis 1 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and in-hospital mortality among pneumonia patients.

Hypothesis 1 Statement: Hypothesis 1 was rejected by the study.

Question 2: Is there a difference in the relationship between utilization of the pneumonia medication order sets and in-hospital mortality when patients with a hospice discharge code are excluded from the study?

Answer to Question 2: No, there is no difference in the overall outcome. However, there are differences in mortality rates and odds ratios, which indicate that hospice patients have a tendency to influence results of the health outcomes.

Hypothesis 2 (null): There is no statistical difference in mortality health outcomes relative to utilization of the pneumonia medication order sets when hospice patients are excluded from the study.

Hypothesis 2 Statement: Hypothesis 2 was not rejected by the study.

Question 3: Do pneumonia medication order sets help prevent and/or decrease 30-day readmission rate among pneumonia patients?

Answer to Question 3: Yes, readmission rates among pneumonia patients in the experimental group were much lower, with the odds ratio of 1.362 [1.015 and 1.827at 95% confidence level].

Hypothesis 3 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and 30-day readmission rates among pneumonia patients.

Hypothesis 3 Statement: Hypothesis 3 was rejected by the study.

Question 4: Is there a statistical relationship between utilization of the pneumonia medication order sets and in-hospital length of stay?

Answer to Question 4: Yes, there is a statistical relationship between utilization of pneumonia order sets and length of stay, with the Mann-Whitney mean rank lower for

experimental group patients (2343 for experimental group vs. 2568 for control group), indicating the benefit of pneumonia order sets in reducing the length of hospital stay.

Hypothesis 4 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and length of stay among pneumonia patients.

Hypothesis 4 Statement: Hypothesis 4 was rejected by the study.

Question 5: Is there a statistical relationship between utilization of the pneumonia medication order sets and patient complications represented by the Charlson Comorbidity Index?

Answer to Question 5: Yes, there is a statistical relationship between utilization of pneumonia medication order sets and the rate of complications/comorbidity. The Mann-Whitney rank for experimental group was lower (2353 vs. 2509), indicating potential benefit of the order sets as evident by the CCI health outcome. However, lower CCI could also mean that experimental group patients were not as sick as control group patients, leading to shorter hospital stays among the latter group.

Hypothesis 5 (null): There is no statistically significant relationship between utilization of pneumonia medication order sets and patient complications.

Hypothesis 5 Statement: Hypothesis 5 was rejected by the study.

Question 6: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of 30-day hospital readmission among pneumonia patients?

Answer to Question 6: Patient age, sex, and race were more significant in predicting readmission rate among pneumonia patients than utilization of the order sets.

Hypothesis 6 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict 30-day hospital readmission among pneumonia patients.

Hypothesis 6 Statement: Hypothesis 6 was rejected by the study.

Question 7: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of in-hospital mortality among pneumonia patients?

Answer to Question 7: Utilization of the order sets, patient age, and patient race were significant in predicting mortality among pneumonia patients. Patient sex was not significant.

Hypothesis 7 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict in-hospital mortality among pneumonia patients.

Hypothesis 7 Statement: Hypothesis 7 was rejected by the study.

CHF Order Sets

Question 1: Do CHF medication order sets help decrease mortality among CHF patients?

Answer to Question 1: Yes, utilization of the order sets for CHF medications produced lower mortality rates in both studies that excluded and included hospice patients, with the odds ratios of 1.854 [1.059 and 3.244 at 95% confidence level] in the latter study and 1.822 [0.983 and 3.380 at the 95% confidence level] in the former study.

Hypothesis 1 (null): There is no statistically significant relationship between utilization of CHF medication order sets and in-hospital mortality among CHF patients.

Hypothesis 1 Statement: Hypothesis 1 was rejected by the study.

Question 2: Is there a difference in the relationship between utilization of the CHF medication order sets and in-hospital mortality when patients with a hospice discharge code are excluded from the study?

Answer to Question 2: No, the differences between mortality cases where hospice patients were included and excluded were subtle.

Hypothesis 2 (null): There is no statistical difference in mortality health outcomes relative to utilization of the CHF medication order sets when hospice patients are excluded from the study.

Hypothesis 2 Statement: Hypothesis 2 was not rejected by the study.

Question 3: Do CHF medication order sets help prevent and/or decrease 30-day readmission rate among CHF patients?

Answer to Question 3: There is insufficient data to answer this question ($p = 0.417$) for the total of all hospitals participating in the study. An increase in CHF order sets utilization is necessary in order to conduct this study.

Hypothesis 3 (null): There is no statistically significant relationship between utilization of CHF medication order sets and 30-day readmission rates among CHF patients.

Hypothesis 3 Statement: Hypothesis 3 was not rejected by the study.

Question 4: Is there a statistical relationship between utilization of the CHF medication order sets and in-hospital length of stay?

Answer to Question 4: Yes, there is a statistical relationship between application of the order sets to administer medications to CHF patients and hospital length of stay. The

Mann-Whitney mean rank for the experimental group is lower than the mean rank for the control group (5189 vs. 5489), indicating that patients who received CHF medications via sets had shorter hospital stays. This fact could be attributed to both application of the sets and lower comorbidity among experimental group patients, in terms of comorbidity serving as the rate of pre-existing health conditions.

Hypothesis 4 (null): There is no statistically significant relationship between utilization of CHF medication order sets and length of stay among CHF patients.

Hypothesis 4 Statement: Hypothesis 4 was rejected by the study.

Question 5: Is there a statistical relationship between utilization of the CHF medication order sets and complications quantified via Charlson Comorbidity Index?

Answer to Question 5: There is insufficient data to answer this question ($p = 0.23$). However, comorbidity was lower for the experimental group (3768 Mann-Whitney mean rank) compared to the control group (mean rank 3887). This outcome could partially explain shorter hospital stays by experimental group patients, if CCI is assumed to serve as the rate of pre-existing health conditions.

Hypothesis 5 (null): There is no statistically significant relationship between utilization of CHF medication order sets and complications among CHF patients.

Hypothesis 5 Statement: Hypothesis 5 was not rejected by the study.

Question 6: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of 30-day hospital readmission among CHF patients?

Answer to Question 6: There was insufficient data to answer this question.

Hypothesis 6 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict 30-day hospital readmission among CHF patients.

Hypothesis 6 Statement: Hypothesis 6 was not rejected by the study.

Question 7: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of in-hospital mortality among CHF patients?

Answer to Question 7: Order set utilization, patient age, and patient race had strong influence on mortality – with patient age and race being the strongest factors among the three. Patient sex made no difference on mortality.

Hypothesis 7 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict in-hospital mortality among CHF patients.

Hypothesis 7 Statement: Hypothesis 7 was rejected by the study.

AMI Order Sets

Question 1: Do AMI medication order sets help decrease mortality among AMI patients?

Answer to Question 1: There was insufficient data to answer this question. Significant increase in AMI order set utilization is necessary in order to validate answers raised in the study.

Hypothesis 1 (null): There is no statistically significant relationship between utilization of AMI medication order sets and in-hospital mortality among AMI patients.

Hypothesis 1 Statement: Hypothesis 1 was not rejected by the study.

Question 2: Is there a difference in the relationship between utilization of the AMI medication order sets and in-hospital mortality when patients with hospice discharge code are excluded from the study?

Answer to Question 2: There was insufficient data to answer this question.

Hypothesis 2 (null): There is no statistical difference in mortality health outcomes relative to utilization of the AMI medication order sets when hospice patients are excluded from the study.

Hypothesis 2 Statement: Hypothesis 2 was not rejected by the study.

Question 3: Do AMI medication order sets help prevent and/or decrease 30-day readmission rate among AMI patients?

Answer to Question 3: There was insufficient data to answer this question.

Hypothesis 3 (null): There is no statistically significant relationship between utilization of AMI medication order sets and 30-day readmission rates among AMI patients.

Hypothesis 3 Statement: Hypothesis 3 was not rejected by the study.

Question 4: Is there a statistical relationship between utilization of the AMI medication order sets and in-hospital length of stay?

Answer to Question 4: There was insufficient data to answer this question.

Hypothesis 4 (null): There is no statistically significant relationship between utilization of AMI medication order sets and length of stay among AMI patients.

Hypothesis 4 Statement: Hypothesis 4 was not rejected by the study.

Question 5: Is there a statistical relationship between utilization of the AMI medication order sets and complications quantified via Charlson Comorbidity Index?

Answer to Question 5: There was insufficient data to answer this question.

Hypothesis 5 (null): There is no statistically significant relationship between utilization of AMI medication order sets and complications among AMI patients.

Hypothesis 5 Statement: Hypothesis 5 was not rejected by the study.

Question 6: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of 30-day hospital readmission among AMI patients?

Answer to Question 6: There was insufficient data to answer this question.

Hypothesis 6 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict 30-day hospital readmission among AMI patients.

Hypothesis 6 Statement: Hypothesis 6 was not rejected by the study.

Question 7: Among independent variables of the order set utilization, patient age, patient sex, and patient race – which have the most influence on the dependent variable of in-hospital mortality among AMI patients?

Answer to Question 7: There was insufficient data to answer this question.

Hypothesis 7 (null): None of the independent variables of order set utilization, patient age, patient sex, and patient race can predict in-hospital mortality among AMI patients.

Hypothesis 7 Statement: Hypothesis 7 was not rejected by the study.

Summary

All studies for the VTE, pneumonia, CHF, and AMI suffered from low utilization of order sets and subsequently low data samples within experimental groups. Among the four patient conditions, VTE case offered the best opportunity to conduct focused

categorized studies by hospital and patient sex. The latter studies revealed no significant differences, although a follow-up study of the male patients receiving treatment via VTE order sets was recommended. Lack of significant differences from the more focused studies benefitting from greater granularity of data points to the overall validity of results in all cases where statistical significance was achieved without categorization of data by patient sex, hospital procedure type, and treatment facility.

Among the four patient conditions, only three – VTE, pneumonia, and CHF – produced statistically significant results. Within VTE study, there was a clear benefit of the order sets in prevention of occurrence of acute VTE, while the length of hospital stay and readmissions cases were either inconclusive or pointed to potential negative effect(s) of using order sets to prescribe VTE medications. The latter effects could have multiple explanations, require narrower follow-up studies, and are further explained in Chapter 5. Pneumonia study was the most successful of all four, showing benefits of the order sets as measured by all four health outcomes: mortality, readmissions, complications, and length of stay. While CHF study failed to deliver conclusive results in the complications and readmissions categories, its positive mortality outcome alone has the potential of saving many lives. Discussion of the health outcomes continues in Chapter 5.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

Conclusions

Introduction

Despite numerous barriers and limitations to conducting this order set study, a number of positive outcomes not only provides clear conclusions leading to calls for increased utilization of the order sets in clinical settings but also builds foundational ground for follow-up investigations supported by physicians. The latter support could come from quantitative evidence behind conclusions made in this study. Such support could lead to more focused experimental clinical trials with higher percentages of order set utilization and subsequently larger data samples within experimental groups of patients. Therefore, results of this study are foundational in nature and expected to play a motivational role in encouraging follow-ups.

All studies employed complex and varied statistical methods to explore quantitatively benefits of the order sets as expressed by patient health outcomes. This complexity and barriers outlined in the Research Proposal led to a smaller than expected set of clear results indicating the benefit, or the lack of benefit, for order sets. One of the barriers was the small percentage of orders placed via pre-defined CPOE medication sets, leading to small data samples in the experimental patient groups and consequently to statistically

insignificant or somewhat inconclusive results. Another barrier was lack of the healthcare industry standard for measuring patient complications as outcome, as opposed to experimental study pre-qualification (pre-existing condition). This barrier led to selection of a controversial method of utilizing Charlson Comorbidity Index that can be interpreted in conflicting ways: as explanation of pre-existing health conditions of the patient prior to hospital admission or as a health outcome indicating complication as a result of current hospital stay. The ambiguity is due to comorbidity being measured and recorded once as a patient discharge task. Thus, no statistical method can derive the actual relationship between comorbidity recorded in CPOE and the actual studied patient condition. Therefore, conclusions of this study should account for the dual explanations of the results, taking on both possible outcomes from CCI measurements and calculations.

Another barrier was a lack of granularity of the data contained in CPOE, leading to an inability to explain cause and effect relationships for each patient condition, i.e. since chronic VTE patients were excluded from the study, none of the subjects was admitted with VTE condition, so procedures and medications unrelated to VTE were administered to the patient between the times of admission and discharge, hindering direct cause-effect relationship between application of the VTE medication order set and acute VTE. This information on events altering the relationship, while generally available in CPOE, cannot in any reliable way be correctly linked to the study. The reason is that CPOE application is programmed with the record-keeping and sharing purposes in mind, rather than to help researchers examine sequences of events and causal relationships between them. While it is possible to extract data on patients and their clinical treatments, it is difficult to track clinical progress and numerous variables that contribute to outcomes.

The audience for this research must make certain assumptions or follow up with a narrow, focused study to explore other dependencies. The latter would be performed in a manual way through detailed investigation of each patient case, since CPOE has no ability to link results when information is pulled from the database via scripts.

Overall, there is a mix of clear conclusions constrained by the possible existence of health factors not included in this study and speculative conclusions that warrant follow-up studies, especially in the areas where order sets show promise of improved quality of care. Opportunities for follow-up studies are discussed in detail in the Recommendations section of this chapter.

VTE Study Conclusions

There are two clear conclusions resulting from the VTE study. First, order sets lead to decreased rates of acute VTE among non-surgical patients, with possible lower rates of improvement for the male patients, although sex differences did not prove to be significant among any groups of patients considered for the study. Second, among independent variables of race, sex, order set utilization, and surgical status – only sex was an insignificant factor in determining the odds of a non-surgical patient acquiring acute VTE condition. While some of these independent variables were previously known to influence acute VTE rates, combining order set application with them in a single group to determine their statistical significance in preventing VTE was first attempted as part of this study. The promise of decreasing VTE rates among eligible non-surgical patients is alone a huge argument for further exploration of the role of standardized care and prescriptions in hospitals. Moreover, the differences in the rate of acute VTE were hovering around 1% of the total patient population that included thousands of patients.

This means that order sets have the potential of hundreds of patients avoiding VTE through application of standardized care methods. Such gain would be invaluable in the process of quality improvement and would also lead to financial savings. However, the financial and health benefits are problematic because VTE is a by-product of a procedure or another condition that served as a chief complaint for admission to the hospital. So implications of acquiring a VTE may or may not have direct impact on patient outcomes, although no one wants to have a VTE regardless of the explanation of the overall health and financial outcomes. This is the area where the study lacks confidence and data to explore exactly how patients and hospitals may benefit from the health and financial perspectives, other than not acquiring harmful VTE condition.

Despite success in achieving lower acute VTE rates among non-surgical patients, the study failed to reveal conclusive results in reducing the length of hospital stay among eligible VTE patients. Moreover, in some cases VTE stay was longer. Why did patients who avoided VTE due to application of standardized treatment sets stay longer? One explanation is another factor unaccounted for in the VTE study that led to longer stay, most likely factors related to the patient's chief complaint on admission to the hospital, or a side condition, such as infection or complication that happened during his/her stay at the hospital. Only detailed manual review of the health record could help explain the exact factors, which were outside of the scope of this order set study. However, Charlson Comorbidity Index, another inconclusive outcome of the study, could help explain longer or shorter stays in some instances. For example, non-surgical patients who received medications via VTE order sets at LGH had both higher CCI and longer hospital stays, despite lower VTE rates. This is where CCI could be treated as a pre-existing condition

index rather than health outcomes and explain that experimental group patients at LGH were sicker prior to admission, so despite avoiding VTE during their LGH hospital stay, they ended up with other problems as results of their pre-existing conditions and needed to remain in the hospital longer.

Results above are also inconclusive, because IMMC patients had longer stays despite lower CCI and avoiding VTE, indicating that CCI cannot always be put forth as an explanatory factor, or other issues not part of the study are still in play. If CCI is treated as a complications health outcome, its results in relation to the VTE study are inconclusive, with variances among hospitals for every group of patients. It is also important to highlight that surgical patients did not only fail to benefit from VTE order sets, but their outcomes were worse when sets were utilized. This means that clinicians must avoid order sets applied to surgical patients' CPOE orders, or other stronger factors are in play that overshadow any VTE results. Either way, what is clear is that surgical patients do not benefit from VTE order sets. As far as financial benefits go, while not included in the scope of this study, with complications and hospital stay outcomes showing inconclusive results, it would be difficult to use the VTE order set study to argue for cost of care savings.

Pneumonia Study Conclusions

Unlike outcomes of the VTE study, the vast majority of the pneumonia cases showed clear results that encourage utilization of the order sets to treat pneumonia patients. First, application of the order sets led to lower mortality from pneumonia. Exactly how much mortality was lowered depended on the inclusion or exclusion of the patients discharged to hospice care. While outside of the scope of this study, factors about hospice patients in

relation to the pneumonia study affect results, although not to the degree of changing the overall mortality outcome. Pneumonia outcomes from utilizing order sets remain positive and indicative of the order sets benefit regardless of the inclusion of the hospice patients and resulting changes in numbers. With hospice patients excluded from the study, the difference in mortality between experimental and control groups was within the 1% to 5% range. With hospice patients included as 0 mortality (since it was not known for how long these patients survived once they were transferred to hospice care, only that they were alive at the time of discharge), the mortality difference between control and experimental groups increased significantly for some hospitals, up to 12%. But, even if it were assumed in the 1% to 5% range, there was a survival benefit for dozens of patients across the system annually. If order sets were applied industry-wide, this evidence-based clinical innovation could result in thousands of saved lives.

The length of stay for experimental pneumonia patients was shorter, with a mean rank of roughly 0.5 days difference. This difference could lead to lower cost of care. However, the conclusive result for lower CCI among experimental patients could somewhat diminish results of the length of stay study, or support it depending on the exact interpretation of CCI. One interpretation states that pneumonia patients in the experimental group had a lower rate of pre-existing conditions, i.e. experimental group contained healthier patients, thus arguing that shorter length of stay resulted from fewer pre-existing health conditions and not application of pneumonia order sets. However, if CCI is treated as a complications index at the time of discharge, the argument changes to the dual benefit of pneumonia order sets expressed by both length of stay and complications outcomes. Reality is likely somewhere in between. This was not a

controlled study with assigned categories of patients by their pre-existing conditions, so the argument for selection of the healthier patients to join experimental group would be invalid. The groups contained a mix of patients with varied pre-existing conditions.

Results of the 30-day readmission quality study indicated a much lower rate of readmissions among experimental patients. The difference approached 30% (14.7% for the control group versus 10.8% for the experimental group). This could lead to dozens of patients across the system not having to go through another hospital experience, in addition to obvious financial savings for hospitals (readmissions with the same conditions within 30-day period are often not reimbursed by insurance companies).

Not having an answer to the CCI categorization question, conclusions must be drawn based on available statistics, as follows: application of pneumonia order sets to treat eligible patients leads to lower mortality, shorter length of stay, lower rate of complications, and fewer readmissions. The only problem with the data sample used for the study was its small size, which led to an inability to further categorize patients by sex, treatment facility, and pneumonia type (community acquired versus nosocomial) - due to risk of obtaining statistically insignificant results.

Comparison tests among independent variables influencing readmissions showed greatest significance by age, sex, and race and lower significance of the order sets when compared to the former three factors. However, order sets, age, and, to a lesser degree, approaching significance, race showed strong influence on mortality from pneumonia. In this case, sex showed no role, while the order set indicator was significant. The importance of this comparison study was that order sets were not part of any past study of the factors influencing mortality and readmissions among pneumonia patients.

CHF Study Conclusions

As with the pneumonia study, small data samples resulting from low utilization of the order sets at Advocate's hospitals affected outcomes, including an inability to categorize patients by cause of CHF, sex, and treatment facility. In the CHF case, data samples were even smaller compared to pneumonia, and this small size disqualified readmissions, which resulted in a Pearson Chi-Squared over 0.05. For the remaining studies, mortality among experimental patients was roughly half compared to the control group, with no significant differences accounted for the discharge reason factor. Accounting for small data samples, the difference translates to about a dozen saved lives for the five-year span system-wide – a small difference that could gain momentum if achieved across all hospitals nationwide. Even with such small actual gains, healthcare's aim is to save lives one life at a time, so mortality outcomes indicates a strong non-tangible influence on patients' and their families' lives.

The length of stay was shorter for experimental group and CCI was lower – both positive outcomes with dual interpretation. If treated as a pre-existing condition index, lower CCI could indicate that shorter length of stay among experimental patients was due to an overall healthier patient population. Yet, it would be difficult to make this argument given that the study did not incorporate control for a pre-existing conditions component. If treated as a health outcome, lower CCI means fewer complications and shorter hospital stay for patients who were prescribed medications via CPOE order sets. The mean difference in LOS approached 1 day, leading to a promise of lower cost of care for CHF patients.

Comparison of influence on mortality among several independent variables led to disqualification of sex - with race, age, and order set utilization exhibiting strong influence. As with other studies performed as part of this research, this is the first time when order set utilization was tested against mortality in a group of other factors that have been explored in the past.

AMI Study Conclusions

AMI order set utilization across Advocate was too low to produce statistically significant results, invalidating outcomes of all of the AMI cases performed as part of this study. Therefore, while statistical analysis for AMI was reported as part of Chapter 4, there is no basis for drawing conclusions in this chapter.

Implications

There are several important implications from this study that suggest effectiveness of evidence based medicine and introduction of new treatment standardization techniques to regular hospital procedure and medication ordering routines. Despite relatively small data samples in nearly all experimental groups for the four patient conditions studied as part of this order set research, there is sufficient evidence that application of the order sets could lead to better health outcomes, with encouragement for further collaboration between clinicians and researchers to increase utilization of the order sets and subsequently to increase experimental group data sample sizes to produce stronger evidence of patient outcomes. The VTE study suggests that numerous patients could escape the fate of being treated for VTE following non-surgical procedures in hospitals, although their length of stay is unlikely to shorten. Yet even the same length of stay without one serious VTE complication would improve quality of care, patient satisfaction, and potentially lower

cost of care outside of the length of stay cost category (i.e. materials, procedures, personnel, medications, equipment, etc.). Thus application of the VTE order sets potentially leads to tangible and non-tangible benefits for hospitals, patients, and insurers, as well as increase core measures compliance.

The pneumonia study produced highly favorable results, indicating potential for lower mortality, shorter stay, decreased chance of readmission, and fewer complications. The latter category is less well-defined, as it could indicate lower rate and/or significance of pre-existing health conditions prior to hospital admission, partially explaining shorter hospital stay. Yet, even a remote chance that some of the patients had shorter stays and fewer complications as a result of standardized treatment practices has significance for everyone involved in the process of caring for patients and paying the bills for care. At the very least, the possibility of these two factors being the direct result of application of the order sets warrants further studies in the order set and evidence based practices domains. Lower mortality from pneumonia alone represents a strong outcome of the study and introduction of evidence based techniques to treat typical cases of community acquired pneumonia.

Even though the combination of lower comorbidity and shorter hospital stay for CHF patients casts doubt on outcomes of the CHF study (healthier patients could have shorter CHF stay), lower mortality represents a sound outcome in favor of the order set utilization to treat typical CHF cases. Overall, while all of the categories studied produced no or negative results, there is strong evidence in a number of categories under VTE, pneumonia, and CHF conditions to (1) suggest further studies outlined in the Recommendations section, (2) encourage higher utilization of the order sets in hospitals

in order to provide more sufficient data to support further evidence based clinical practices research, and (3) make direct connection between application of the order sets in CPOE and patient outcomes to suggest increased utilization and/or introduction of evidence based practices to treat well-defined patient conditions as a quality improvement mechanism with benefits to patients, care givers, and insurers. Table 128 summarizes specific outcomes of the study as they apply to the four conditions covered in the order set research.

Table 128. Cumulative Patient Benefit Summary by Patient Conditions

Condition	**Mortality**	**Readmission**	**Length of Stay**	**Complications**	**Acute VTE**
VTE	N/A	N/A	No	No	Yes – non-surgical No – surgical
Pneumonia	Yes	Yes	Yes	Yes	N/A
CHF	Yes	No Data	Yes	No data	N/A
AMI	No data	No Data	No data	No data	N/A

Recommendations

A number of recommendations arise from results and observations recorded as part of the research on effectiveness of the order sets to improve patient health outcomes. The most obvious recommendation seen through analysis of the data and summary of the research implications is the need to partner with physicians to increase the number of CPOE orders placed via sets. More orders for experimental groups would produce higher

data samples, increase statistical significance of the results or turn some currently insignificant categories into significant ones, and make an AMI study more viable. It would also make other order studies involving more order sets a reality – those studies that have not been selected for the purposes of this study due to smaller patient population sizes and lower CPOE set utilization. Some of the encouraging results from this research should be sufficient to convince physicians to support further data collection through their ordering actions.

A longer-term outcome would be to design CPOE applications in a manner that enables more detailed research into causal relationships between different fields, so researchers could draw parallels between patient case details, outcomes, discharges, and other records on a case-by-case basis. Today, CPOE applications offer strong logging and documentation capabilities, but have little in the way of making sense of the data for research purposes. These applications have simply been designed with operations and basic reporting functions in mind, not research. The alternative is a growing clinical decision making domain of healthcare information technology, where applications are specifically designed to support physicians based on existing knowledge structurally available in computer databases. Yet, these applications must also be designed with powerful data retrieval and analysis functions in mind, not mere search capabilities.

A few smaller and more focused studies would be helpful as follow-ups to this research, which utilized massive amounts of data to reach significance in statistical analysis over an extended period of time. First, each individual patient case or a small set of representative cases could be analyzed to determine pre-existing health conditions, relationships between these conditions and outcomes, other factors and/or complications

that influenced outcomes and discharge description, and other case specifics. Such research could help shed more light into the exact status of Charlson Comorbidity Index as an either pre-existing or complications barometer in the study, as well as determine how this research could be altered to include more mediating variables to increase accuracy of reporting (assuming that corresponding data is available in the EMR). Second, a researcher might be interested in pulling groups of records from both experimental and control groups by physician to analyze ordering patterns associated with each physician, and then further analyzing physician factors such as age, experience, and professional style to determine success patterns in patient care as those relate to ordering medications and patient outcomes. Third, it would be interesting to study physician demographics in terms of tendency to choose order sets and evidence based treatment methods as opposed to custom ordering. Ballard, Ogola, Fleming, Stauffer, Leonard, Khetan, and Yancy (2010) have already attempted such basic research as part of their CHF order set effectiveness study at Baylor Health. Expanding such research to larger data sets, other clinical settings, and other patient conditions could further extend accuracy and outreach of such study with the goal of properly targeting individual groups of physicians when working with them to increase buy-in and/or compliance.

Other examples of diversifying the study of order sets into smaller focused chunks could include categorizing patients by treatment facilities, sex, and specific types of illnesses. For example, teaching and community hospitals could be studied separately to determine whether residents make a difference when it comes to medication orders and outcomes. Other than VTE, validation of results by sex was impossible due to small experimental group data samples. Introducing this constraint to the study could be

valuable. Furthermore, illnesses covered in this study have various types, i.e. pneumonia could be categorized as either community acquired (majority of the patients) or nosocomial (hospital acquired). All of these examples require larger data samples that would be impossible to produce without collaboration with physicians to increase order set utilization in CPOE.

This study of order sets has only brushed upon relationships between independent variables such as set utilization, sex, age, and race. Larger data sets could afford greater flexibility to afford exploration of various age categories that might have differing characteristics in responding to order placed via sets. An example of a contributing factor related to age difference would be the risk level of applying bundled orders, as it applies to certain age ranges. Race as a general factor is only a starting point in initiating a specific study into each race, as differences in response rates to order sets could be significant among various races listed in the tables appended to this study. A study focused on application of different sets by race has the potential of benefitting patients with more precise treatment options designed for them based on their existing body of knowledge.

Healthcare industry research analysts are already working to develop new methods of measuring complications and introducing more effective methods compared to comorbidity index that leaves results open to interpretation. Development of such methods could lead to greater accuracy of the research outcomes for the variables of length of stay and complications – both are parts of the core compliance and key result measurements for the majority of the US hospitals.

A study of delineation between treatment and prophylaxis classifications for VTE would be helpful in the process of documenting a clinical basis for parameter selection in this order set study. The 48-hours from the time of admission to VTE order delineation was chosen based on interviews with physicians rather than published research – the issue outlined in the Research Proposal. Quantitative study on VTE prophylaxis versus treatment could change results of this order set study based on adjustment in the in-scope data criteria.

Completion and general availability of the proposed research above could lead to redesign of this study to achieve greater accuracy with a fewer number of issues and limitations compared to the ones outlined in this study. Consequently, a more accurate study will lead to convincing outcomes prompting hospitals to mandate standardization of ordering practices for certain patient conditions in an effort to increase core measures and quality compliance. Moreover, quality and compliance principles could change based on the industry shift to greater treatment standardization and new levels of expectations of the patient care outcomes. Such a shift in standards is likely to be publicized at the level of consumer comprehension and further drive competition among healthcare organizations to achieve better outcomes at a lower cost. The market shift of this magnitude is in line with national efforts to improve quality of care, lower cost, and increase affordability and access to care.

Publication of research based on the knowledge offered by EMR/CPOE systems could prompt IT healthcare vendors to invest into expansion of software functionality to support data analysis efforts in addition to offering documentation and record sharing capability. Entering the clinical research arena at a new level would essentially drive

profits by offering hospitals more reasons to invest into software upgrades and new applications. Current versions of EMR and CPOE applications are not designed with clinical research in mind, and hospital IT departments do not configure these systems for research even if such capabilities could be explored at a custom level. It takes significant research to show promise and return on such investments, and results positively affecting health outcomes are good reasons to justify a new wave in healthcare technology investment.

Summary

Efforts to employ evidence based medicine to treat well-researched patient conditions, improve core clinical measures compliance, and increase quality through process standardization have been ongoing for the past three decades. A majority of the studies culminated in breakthrough publications on reductions in the rate of adverse drug effects (ADE) through application of quality and process standardization routines, further advanced by healthcare information technologies such as automated VTE alerts developed at Brigham Women's Hospital in Boston and documented by Kucher, Koo, Quiroz, Cooper, Paterno, Soukonnikov, and Goldhaber (2005). But no other technology breakthroughs advanced effectiveness of the evidence based medicine as much as medication order sets available to physicians via Computerized Physician Order Entry (CPOE) applications. These sets enable treatment process standardization for certain patient conditions via pre-defined order sets approved by multi-disciplinary professional committees typically consisting of physicians, nurses, and pharmacists. A number of organizations with fully implemented EMR and CPOE computer applications rolled out hundreds of order sets that are widely utilized by physicians. However, few clinical

studies have been completed that empirically explore and justify utilization of the order sets to treat eligible patients. This study is aimed at closing this research gap and quantitatively exploring effectiveness of the order sets to improve health outcomes.

The methodology applied to conduct the study was based on empirical analysis of over four years of patient data between 2007 and 2012, with the goal of determining effectiveness of the order sets applied to experimental groups of patients based on the health outcomes of mortality, readmissions, length of stay, and complications/comorbidity. Patient conditions of venous thromboembolism (VTE), pneumonia, congestive heart failure (CHF), and acute myocardial infarction (AMI) were selected based on large patient volumes and inclusion in the set of current key results areas of focus for the research site, Oak Brook, Illinois based integrated healthcare delivery network – Advocate Health Care.

Zafar and Dixon (2009) defined the theoretical foundation of order sets and their potential effectiveness to standardize treatment in a study sponsored by the US Department of Health and Human Services. Since publication of their study, Ballard, Ogola, Fleming, Stauffer, Leonard, Khetan, and Yancy (2010) published results of their Congestive Heart Failure (CHF) order set study conducted at Baylor Health and concluded that evidence based prescription methods decrease mortality, hospital stay, and rate of readmissions. Best, Frith, Anderson, Rapp, Rioux, and Ciccarello (2011) found reduced interval rates in initiation of antibiotic therapy from the time of diagnosis in the process of treating febrile neutropenia, with potential for greater success in treating this condition as a result of swifter clinical response. Wright, Sitting, Carpenter, Krall, Pang, and Middleton (2010) analyzed patterns in the order set utilization among several leading

healthcare facilities in the Northeastern part of the United States. Khanna, Vittinghoff, Maselli, and Auerbach (2011) at University of California, San Francisco quantitatively proved that the application of VTE order sets to treat certain groups of patients can be dangerous, arguing that more detailed studies of order sets are necessary to determine their effectiveness, benefits, and risks of side effects from standardization. No broader studies analyzing the overall effectiveness of the order sets based on patient history have been published to date.

For VTE, the independent variables were utilization of the order sets and occurrence of acute VTE – with prophylaxis focus of the study delineated by exclusion of any VTE orders placed after 48 hours of admission and exclusion of chronic VTE patients with chief complaint of VTE. For all other conditions, the independent variable was utilization of the order sets. The list of dependent variables included four major health outcomes: mortality, 30-day readmissions, length of stay, and complications. Additionally, the study analyzed the influence of several other variables such as age, race, and sex, in conjunction with order set utilization, on health outcomes. Mortality was derived from analysis of the discharge codes, and complications were identified by employing Charlson Comorbidity Index (CCI) due to lack of the more effective methods to quantify complications. The latter led to dual meaning of the CCI that could identify post-treatment complications rate or indicate severity of pre-existing health conditions prior to hospital admission. Other barriers included lack of information on other factors influencing health outcomes beyond those included in the study and the small size of experimental groups in the CHF, AMI, and pneumonia studies, leading to either

statistically insignificant results in some categories or an inability to categorize patients into more diverse groups by type of condition, sex, race, and other factors.

In the VTE category, results found lower acute VTE rates among non-surgical patients in the experimental group but higher length of stay and comorbidity. The latter two could be interdependent if higher comorbidity represented sicker patients with pre-existing health conditions prior to admission, ultimately leading to longer length of stay for these patients, caused by health factors independent from the VTE condition. Mortality and readmission were not important as VTE health outcomes and excluded from the study. The reason for exclusion of these factors is lack of clinical evidence that patients may die or return to a hospital within 30-days due to symptoms associated specifically with VTE. Such patients are likely to experience other issues causing death or readmission. Sex differences were insignificant, with a slightly lower benefit from order sets among male non-surgical patients. Surgical patients did not benefit from medication ordering via CPOE sets.

In the pneumonia category, patients in the experimental group had lower mortality, lower readmission rate, lower complications rate, and had shorter hospital stays – all benefits at least in part attributable to utilization of the order sets. These outcomes hold true even if some of the patients benefitted from smaller pre-existing condition rates if CCI is interpreted as comorbidity rate prior to admission. In the CHF category, experimental group patients had lower mortality, shorter hospital stays, and smaller CCI. Even with potential conflict among the latter two outcomes, mortality benefit was significant. In the AMI category, the experimental group was too small relative to the control group to produce statistically significant results. Among several independent

variables influencing various health outcomes, utilization of order sets resulted in significant outcomes or outcomes approaching significance in most categories, indicating significance of order sets as factors leading up to adjustment in health outcomes. This study of health outcomes influence was the first of its kind to include order sets among basic human factors of race, sex, and age.

Overall, the study was significant in the following ways. First, it quantified the benefit of order sets to treat three patient conditions and supplied data behind hospitals' assumptions that ongoing utilization of CPOE medication sets was/is justified. Second, it proved the effectiveness of order sets to treat three of the four patient conditions studied, based on some of the attempted health outcomes. Third, it provided significant backing to the claim of effectiveness of evidence based medicine in improving quality and health outcomes, through quantitative support for one of the core elements of the method – medication order set. Fourth, despite identified barriers and limitations, the study serves to encourage further collaboration between researchers and physicians to increase utilization of the order sets necessary to produce larger experimental group data sets and consequently more convincing results of empirical order set effectiveness analysis. Fifth, it opened up new areas of future research, including (1) more detailed studies of each patient condition and ways to improve health outcomes based on more targeted utilization of order sets, (2) factors influencing physicians' willingness to employ order sets in the treatment and ordering processes, (3) investigation of order set effectiveness as it applies to patients in various race, sex, and age categories in order to avoid unintended consequences, (4) data-driven encouragement for healthcare facilities to invest into healthcare information technology as a way to improve quality and drive down cost of

care, and (5) the potential to spur activity among healthcare software vendors to develop new generations of code that are more research-friendly and enable investigation of the relationships between many variables involved in the treatment process.

Appendix A

Medication Order Set Listing

Table 129. Medication Order Sets

Category	Hospital Code	Order Set Title	Catalog ID	Year Available	Monthly Utilization Average (Aug 2010)
Acute MI	GSHP	Acute Coronary Syndrome Order Set GSH	49493862	2005	4
	SSUB	Low Risk Chest Pain Evaluation Program Order Set SSH	178578195	2007	4
	TRIN	Chest Pain Orders Order Set TRI	483944189	2009	36
CHF	CMC	CHF Unit Admission Order Set CMC	13026418	2004	3
	GSHP	Congestive Heart Failure Admission Order Set GSH	49502942	2005	2
	IMMC	Congestive Heart Failure Admission Order Set IMC	24458894	2005	26
	LGH	Heart Failure Management Order Set LGH	369504735	2008	6
	SSUB	Heart Failure Order Set SSH	173004691	2007	4

Category	Hospital Code	Order Set Title	Catalog ID	Year Available	Monthly Utilization Average (Aug 2010)
Pneumonia	CMC	Community Acquired Pneumonia Adult Order Set CMC	33166393	2005	2
	GSAM	Pneumonia Adult Order Set GSA	48577863	2005	7
	GSHP	Pneumonia Order Set GSH	49610362	2005	2
	IMMC	Community Acquired Pneumonia (CAP) Order Set IMC	32342226	2005	20
	SSUB	Pneumonia Inpatient Adult Order Set SSH	139008712	2006	4
	TRIN	Community Acquired Pneumonia Order Set TRI	483701535	2007	6
VTE	CMC	Venous Thromboembolism Prophylaxis Order Set CMC	209906896	2007	11
	GSHP	Deep Vein Thrombosis Prophylaxis Order Set GSH	49503537	2005	2
	IMMC	DVT Prophylaxis Order Set IMC	13040866	2004	624
	LGH	VTE Prophylaxis Order Set LGH	254585783	2008	458

Category	Hospital Code	Order Set Title	Catalog ID	Year Available	Monthly Utilization Average (Aug 2010)
	SSUB	DVT Prophylaxis Order Set SSH	142677644	2006	2
	SSUB	DVT Prophylaxis Order Set TRI	483221836	2009	5

Appendix B

Supplemental VTE Methodology Tables

Table 130**.** Monthly Utilization of the VTE Order Sets

Category	Hospital Code	Order Set Title	Catalog ID	Year Available	Monthly Utilization Average (Aug 2010)
VTE	CMC	Venous Thromboembolis Prophylaxis Order Set CMC	209906896	2007	11
	GSHP	Deep Vein Thrombosis Prophylaxis Order Set GSH	49503537	2005	2
	IMMC	DVT Prophylaxis Order Set IMC	13040866	2004	624
	LGH	VTE Prophylaxis Order Set LGH	254585783	2008	458
	SSUB	DVT Prophylaxis Order Set SSH	142677644	2006	2
	SSUB	DVT Prophylaxis Order Set TRI	483221836	2009	5

Table 131. Variables Used in the VTE Study

Variable	Source	Type	Definition	Notes
Encounter Number	EDW	Identifying/Continuous	Numeric	
Patient Key	EDW	Identifying/Continuous	Numeric	
Order Set Title	EDW	Identifying/Continuous	Text	DVT Prophylaxis Order Set IMC, VTE Prophylaxis Order Set LGH
Order Set Catalog Number	EDW	Identifying/Continuous	Numeric	13040866 (IMMC), 254585783 (LGH)
Discharge Date	EDW	Identifying/Continuous	Date	
Patient Sex	EDW	Identifying/Categorical	1=female 0=male	
Discharge Disposition Code	EDW	Identifying/Continuous	Text	
Race_Caucasian	EDW	Identifying/Categorical	1=yes 0=no	
Race_Africal_American	EDW	Identifying/Categorical	1=yes 0=no	
Race_Hispanic	EDW	Identifying/Categorical	1=yes 0=no	
Attending Physician Name	EDW	Identifying/Continuous	Text	Future study
VTE (yes or no)	EDW	Independent/Categorical	1=present 0=not present	ICD-9-CM codes: 451.11, 451.19, 451.2, 451.81, 451.9, 453.40, 453.41, 453.42,

Variable	Source	Type	Definition	Notes
				453.8, 453.9, 415.1, 415.11, 415.19
Order Set (yes or no)	EDW	Independent/Categorical	1=present 0=not present	
Facility Key	EDW	Intervening/Categorical	Text	
Surgery (yes or no)	EDW	Intervening/Categorical	1=present 0=not present	See Table 135
Patient Age	EDW	Intervening/Continuous	Numeric	
Length of Stay	EDW	Dependent/Continuous	Numeric	
Charlson Comorbidity Index	EDW	Dependent/Continuous	Numeric	See Table 132

Table 132. Charlson Comorbidity Index of Patient Complications

Illness	**Point Count**
Myocardial infarction	1
Peripheral vascular disease	1
CVA	1
Diabetes without complications	1
Congestive heart failure	2
COPD	2
Mild liver disease	2
Malignancy	2
Dementia	3
Connective tissue disease	3
HIV	4
Moderate to severe liver disease	4
Metastatic cancer	6

Table 133. Listing of Race Codes Utilized in the VTE Study

Race	**Randomly Assigned Code**
African American / Black	10
American Indian / Alaska Native	11
Asian/Filipino	12
Caucasian/White	13
Declined	14
Eastern Indian	15
Hispanic	16
Middle East	17
Other	18
Pacific Islander / Hawaiian	19
Unknown	20

Table 134. VTE Medication Order Sets Content, by Hospital

Hospital	Order Set Title (from EMR)	Order Set Content
IMMC	DVT Prophylaxis Order Set IMC	Activity Patient Coumadin Heparin INR/PT Lovenox Nursing Communication Order Platelet Count Blood (PLT) Pulsation Boot Sequential Compression Device
LGH	VTE Prophylaxis Order Set LGH	Antiembolytic Hose CPD SCD Machine/Sleeve Enoxaparin Heparin Nursing Communication Order

Table 135. AHRQ PSI-12 Appendix A: Operating Room Procedure Codes

Code	Description
50	IMPL CRT PACEMAKER SYS
51	IMPL CRT DEFIBRILLAT SYS
52	IMP/REP LEAD LF VEN SYS
53	IMP/REP CRT PACEMAKR GEN
54	IMP/REP CRT DEFIB GENAT
56	INS/REP IMPL SENSOR LEAD OCT06-
57	IMP/REP SUBCUE CARD DEV OCT06-
61	PERC ANGIO PRECEREB VES (OCT 04)
62	PERC ANGIO INTRACRAN VES (OCT 04)
66	PTCA OR CORONARY ATHER OCT05-
70	REV HIP REPL-ACETAB/FEM OCT05-
71	REV HIP REPL-ACETAB COMP OCT05-
72	REV HIP REPL-FEM COMP OCT05-
73	REV HIP REPL-LINER/HEAD OCT05-
80	REV KNEE REPLACEMT-TOTAL OCT05-
81	REV KNEE REPL-TIBIA COMP OCT05-
82	REV KNEE REPL-FEMUR COMP OCT05-
83	REV KNEE REPLACE-PATELLA OCT05-

Code	Description
84	REV KNEE REPL-TIBIA LIN OCT05-
85	RESRF HIPTOTAL-ACET/FEM OCT06-
86	RESRF HIPPART-FEM HEAD OCT06-
87	RESRF HIPPART-ACETABLUM OCT06-
94	INTRA-OP NEURO PHYS MONTR OCT08-
110	INTRACRAN PRESSURE MONTR OCT08-
112	OPEN CEREB MENINGES BX
114	OPEN BRAIN BIOPSY
115	SKULL BIOPSY
116	INTRACRANIAL 2 MONITOR OCT08-
117	BRAIN TEMP MONITORING OCT08-
118	OTHER BRAIN DX PROCEDURE
119	OTHER SKULL DX PROCEDURE
121	CRANIAL SINUS I & D
122	REMOV INTRACRAN STIMULAT
123	REOPEN CRANIOTOMY SITE
124	OTHER CRANIOTOMY
125	OTHER CRANIECTOMY
128	INTRACEREB CTH-BURR HOLE OCT06-
131	INCISE CEREBRAL MENINGES
132	LOBOTOMY & TRACTOTOMY
139	OTHER BRAIN INCISION
141	THALAMUS OPERATIONS
142	GLOBUS PALLIDUS OPS
151	EX CEREB MENINGEAL LES
152	HEMISPHERECTOMY
153	BRAIN LOBECTOMY
159	OTHER BRAIN EXCISION
16	EXCISE SKULL LESION
201	LINEAR CRANIECTOMY
202	ELEVATE SKULL FX FRAGMNT
203	SKULL FLAP FORMATION
204	BONE GRAFT TO SKULL
205	SKULL PLATE INSERTION
206	CRANIAL OSTEOPLASTY NEC
207	SKULL PLATE REMOVAL
211	SIMPLE SUTURE OF DURA
212	BRAIN MENINGE REPAIR NEC
213	MENINGE VESSEL LIGATION
214	CHOROID PLEXECTOMY
22	VENTRICULOSTOMY
231	VENTRICL SHUNT-HEAD/NECK
232	VENTRI SHUNT-CIRCULA SYS

Code	Description
233	VENTRICL SHUNT-THORAX
234	VENTRICL SHUNT-ABDOMEN
235	VENTRI SHUNT-UNINARY SYS
239	OTHER VENTRICULAR SHUNT
242	REPLACE VENTRICLE SHUNT
243	REMOVE VENTRICLE SHUNT
291	LYSIS CORTICAL ADHESION
292	BRAIN REPAIR
293	IMPLANT BRAIN STIMULATOR
294	INSERT/REPLAC SKULL TONG
299	SKULL & BRAIN OP NEC
301	REMOVAL FB SPINAL CANAL
302	REOPEN LAMINECTOMY SITE
309	SPINAL CANAL EXPLOR NEC
31	INTRASPIN NERVE ROOT DIV
321	PERCUTANEOUS CHORDOTOMY
329	OTHER CHORDOTOMY
332	SPINAL CORD/MENINGES BX
339	OTHER SPINAL DX PROC
34	EXCIS SPINAL CORD LESION
351	SPINE MENINGOCELE REPAIR
352	MYELOMENINGOCEL REPAIR
353	VERTEBRAL FX REPAIR
359	SPINAL STRUCT REPAIR NEC
36	SPINAL CORD ADHESIOLYSIS
371	SUBARACH-PERITON SHUNT
372	SUBARACH-URETERAL SHUNT
379	OTH SPINAL THECAL SHUNT
393	INSERT SPINAL STIMULATOR
394	REMOVE SPINAL STIMULATOR
397	REVISE SPINE THECA SHUNT
398	REMOVE SPINE THECA SHUNT
399	SPINE CANAL STRUC OP NEC
401	EXCISION ACOUSTC NEUROMA
402	TRIGEMINAL NERV DIVISION
403	PERIPH NERVE DIV NEC
404	PERIPH NERVE INCIS NEC
405	GASSERIAN GANGLIONECTOMY
406	PERIPH GANGLIONECT NEC
407	PERIPH NERV EXCISION NEC
412	OPEN PERIPH NERVE BIOPSY
419	PERIPH NERVE DX PROC NEC
43	PERIPHERAL NERVE SUTURE

Code	Description
441	DECOMPRESS TRIGEM ROOT
442	CRAN NERV ROOT DECOM NEC
443	CARPAL TUNNEL RELEASE
444	TARSAL TUNNEL RELEASE
449	PER NERVE ADHESIOLYS NEC
45	PERIPHERAL NERVE GRAFT
46	PERIPH NERVE TRANSPOSIT
471	HYPOGLOSS-FACIAL ANASTOM
472	ACCESSORY-FACIAL ANASTOM
473	ACCESS-HYPOGLOSS ANASTOM
474	PERIPH NERV ANASTOM NEC
475	POSTOP REVIS PER NERV OP
476	LATE REPAIR PER NERV INJ
479	OTHER NEUROPLASTY
491	NEURECTASIS
492	IMPLANT PERIPH STIMULAT
493	REMOVE PERIPH STIMULATOR
499	PERIPHERAL NERVE OPS NEC
50	SYMPATH NERVE DIVISION
511	SYMPATHETIC NERVE BIOPSY
519	SYMPATH NRV DX PROC NEC
521	SPHENOPALATIN GANGLIONEC
522	CERVICAL SYMPATHECTOMY
523	LUMBAR SYMPATHECTOMY
524	PRESACRAL SYMPATHECTOMY
525	PERIART SYMPATHECTOMY
529	OTHER SYMPATHECTOMY
581	SYMPATHETIC NERVE REPAIR
589	SYMPATHETIC NERVE OP NEC
59	OTHER NERVOUS SYSTEM OPS
602	REOPEN THYROID FIELD WND
609	INCIS THYROID FIELD NEC
612	OPEN THYROID GLAND BX
613	PARATHYROID BIOPSY
619	THYR/PARATHY DX PROC NEC
62	UNILAT THYROID LOBECTOMY
631	EXCISION THYROID LESION
639	PART THYROIDECTOMY NEC
64	COMPLETE THYROIDECTOMY
650	SUBSTERN THYROIDECT NOS
651	PART SUBSTERN THYROIDECT
652	TOT SUBSTERN THYROIDECT
66	LINGUAL THYROID EXCISION

Code	Description
67	THYROGLOSS DUCT EXCISION
681	TOTAL PARATHYROIDECTOMY
689	OTHER PARATHYROIDECTOMY
691	THYROID ISTHMUS DIVISION
692	THYROID VESSEL LIGATION
693	THYROID SUTURE
694	THYROID REIMPLANTATION
695	PARATHYROID REIMPLANT
698	OTHER THYROID OPERATIONS
699	OTHER PARATHYROID OPS
700	ADRENAL EXPLORATION NOS
701	UNILAT ADRENAL EXPLORAT
702	BILAT ADRENAL EXPLORAT
712	OPEN ADRENAL GLAND BX
713	TRANSFRONT PITUITARY BX
714	TRANSPHEN PITUITARY BX
715	PITUITARY BIOPSY NOS
716	THYMUS BIOPSY
717	PINEAL BIOPSY
719	ENDOCRINE DX PROC NEC
721	ADRENAL LESION EXCISION
722	UNILATERAL ADRENALECTOMY
729	PART ADRENALECTOMY NEC
73	BILATERAL ADRENALECTOMY
741	ADRENAL INCISION
742	ADRENAL NERVE DIVISION
743	ADRENAL VESSEL LIGATION
744	ADRENAL REPAIR
745	ADRENAL REIMPLANTATION
749	ADRENAL OPERATION NEC
751	PINEAL FIELD EXPLORATION
752	PINEAL GLAND INCISION
753	PARTIAL PINEALECTOMY
754	TOTAL PINEALECTOMY
759	PINEAL OPERATION NEC
761	EXC PITUIT LES-TRANSFRON
762	EXC PITUIT LES-TRANSPHEN
763	PART EXCIS PITUITARY NOS
764	TOT EXC PITUIT-TRANSFRON
765	TOT EXC PITUIT-TRANSPHEN
768	TOTAL EXC PITUITARY NEC
769	TOTAL EXC PITUITARY NOS
771	PITUITARY FOSSA EXPLORAT

Code	Description
772	PITUITARY GLAND INCISION
779	PITUITARY OPERATION NEC
780	THYMECTOMY NOS
781	PART EXCISION OF THYMUS
782	TOTAL EXCISION OF THYMUS
783	THORAC PART EXISN THYMUS OCT08-
784	THORAC TOTAL EXC THYMUS OCT08-
791	THYMUS FIELD EXPLORATION
792	INCISION OF THYMUS
793	REPAIR OF THYMUS
794	THYMUS TRANSPLANTATION
795	THORAC INCISION THYMUS OCT08-
798	OTH THORAC OP THYMUS NOS OCT08-
799	THYMUS OPERATION NEC
811	EYELID BIOPSY
820	REMOVE EYELID LESION NOS
821	CHALAZION EXCISION
822	EXCISE MINOR LES LID NEC
823	EXC MAJ LES LID PRT-THIC
824	EXC MAJ LES LID FUL-THIC
825	DESTRUCTION LID LESION
831	PTOSIS REP-FRONT MUS SUT
832	PTOSIS REP-FRON MUS SLNG
833	PTOSIS REP-LEVAT MUS ADV
834	PTOSIS REP-LEVAT MUS NEC
835	PTOS REP-TARSAL TECHNIQ
836	BLEPHAROPTOS REPAIR NEC
837	REDUC OVERCORRECT PTOSIS
838	CORRECT LID RETRACTION
841	THERMOCAUT/ENTROPION REP
842	SUTURE ENTROPION REPAIR
843	WEDG RESEC ENTROPION REP
844	LID RECONS ENTROPION REP
849	ENTROPION/ECTROP REP NEC
851	CANTHOTOMY
852	BLEPHARORRHAPHY
859	ADJUST LID POSITION NEC
861	LID RECONST W SKIN GRAFT
862	LID RECONST W MUC GRAFT
863	LID RECONST W HAIR GRAFT
864	LID RECON-TARSOCONJ FLAP
869	LID RECONSTR W GRAFT NEC
870	LID RECONSTRUCTION NOS

Code	Description
871	LID MARG RECON-PART THIC
872	LID RECONS-PART THIC NEC
873	LID MARG RECONS FUL THIC
874	LID RECONST-FUL THIC NEC
891	ELECTROSURG LID EPILAT
892	CRYOSURG LID EPILATION
893	EYELID EPILATION NEC
899	EYELID OPERATION NEC
90	LACRIMAL GLAND INCISION
911	LACRIMAL GLAND BIOPSY
912	LACRIMAL SAC BIOPSY
919	LACRIMAL SYS DX PROC NEC
920	EXC LACRIMAL GLAND NOS
921	EXCIS LES LACRIMAL GLAND
922	PART DACRYOADENECT NEC
923	TOTAL DACRYOADENECTOMY
93	OTHER LACRIMAL GLAND OPS
941	LACRIMAL PUNCTUM PROBE
942	LAC CANALICULI PROBE
943	NASOLACRIMAL DUCT PROBE
944	NASOLAC DUCT INTUBAT
949	LAC PASSAGE MANIP NEC
951	LAC PUNCTUM INCISION
952	LAC CANALICULI INCISION
953	LACRIMAL SAC INCISION
959	LACRIM PASSAGE INCIS NEC
96	LACRIM SAC/PASSAGE EXCIS
971	CORRECT EVERTED PUNCTUM
972	PUNCTUM REPAIR NEC
973	CANALICULUS REPAIR
981	DACRYOCYSTORHINOSTOMY
982	CONJUNCTIVOCYSTORHINOST
983	CONJUNCTIVORHINOS W TUBE
991	LAC PUNCTUM OBLITERATION
999	LACRIMAL SYSTEM OP NEC
100	INCISE/REMOV CONJUNCT FB
101	CONJUNCTIVA INCISION NEC
1021	CONJUNCTIVAL BIOPSY
1029	CONJUNCTIVA DX PROC NEC
1031	EXCISE CONJUNCTIV LESION
1032	DESTRUCT CONJUNC LES NEC
1033	OTH CONJUNC DESTRUC PROC
1041	SYMBLEPH REP W FREE GRFT

Code	Description
1042	GRAFT CONJUNC CUL-DE-SAC
1043	CONJUN CUL-DE-SAC RX NEC
1044	CONJUNC FREE GRAFT NEC
1049	CONJUNCTIVOPLASTY NEC
105	CONJUNC/LID ADHESIOLYSIS
106	REPAIR CONJUNCT LACERAT
1091	SUBCONJUNCTIVAL INJECT
1099	CONJUNCTIVAL OP NEC
110	MAGNET REMOVAL CORNEA FB
111	CORNEAL INCISION
1121	CORNEAL SCRAPE FOR SMEAR
1122	CORNEAL BIOPSY
1129	CORNEAL DX PROC NEC
1131	PTERYGIUM TRANSPOSITION
1132	PTERYG EXC W CORNEA GRFT
1139	PTERYGIUM EXCISION NEC
1141	MECH REMOV CORNEA EPITH
1142	THERMOCAUT CORNEA LESION
1143	CRYOTHERAP CORNEA LESION
1149	DESTRUCT CORNEA LES NEC
1151	SUTURE CORNEA LACERATION
1152	REP CORNEA POSTOP DEHISC
1153	RX CORNEA LAC W CONJ FLP
1159	CORNEAL REPAIR NEC
1160	CORNEAL TRANSPLANT NOS
1161	LAM KERATPLAST W AUTGRFT
1162	LAMELLAR KERATOPLAST NEC
1163	PERF KERATOPL W AUTOGRFT
1164	PERFORAT KERATOPLAST NEC
1169	CORNEAL TRANSPLANT NEC
1171	KERATOMILEUSIS
1172	KERATOPHAKIA
1173	KERATOPROSTHESIS
1174	THERMOKERATOPLASTY
1175	RADIAL KERATOTOMY
1176	EPIKERATOPHAKIA
1179	CORNEA RECONSTRUCT NEC
1191	CORNEAL TATTOOING
1192	REMOVE CORNEAL IMPLANT
1199	CORNEAL OPERATION NEC
1200	REMOV ANT SEGMNT FB NOS
1201	MAGNET REMOV ANT SEG FB
1202	NONMAG REMOV ANT SEG FB

Code	Description
1211	IRIDOTOMY W TRANSFIXION
1212	IRIDOTOMY NEC
1213	PROLAPSED IRIS EXCISION
1214	IRIDECTOMY NEC
1221	DX ASPIRAT-ANT CHAMBER
1222	IRIS BIOPSY
1229	ANT SEGMENT DX PROC NEC
1231	GONIOSYNECHIAE LYSIS
1232	ANT SYNECHIA LYSIS NEC
1233	POST SYNECHIAE LYSIS
1234	CORNEOVITREAL ADHESIOLYS
1235	COREOPLASTY
1239	IRIDOPLASTY NEC
1240	REMOV ANT SEGMNT LES NOS
1241	NONEXC DESTRUC IRIS LES
1242	EXCISION OF IRIS LESION
1243	NONEXC DESTR CIL BOD LES
1244	EXCISE CILIARY BODY LES
1251	GONIOPUNCTURE
1252	GONIOTOMY
1253	GONIOTOMY W GONIOPUNCTUR
1254	TRABECULOTOMY AB EXTERNO
1255	CYCLODIALYSIS
1259	FACILIT INTRAOC CIRC NEC
1261	TREPHIN SCLERA W IRIDECT
1262	THERMCAUT SCLER W IRIDEC
1263	IRIDENCLEISIS/IRIDOTASIS
1264	TRABECULECTOM AB EXTERNO
1265	SCLER FISTULIZ W IRIDECT
1266	POSTOP REVIS SCL FISTUL
1269	SCLER FISTULIZING OP NEC
1271	CYCLODIATHERMY
1272	CYCLOCRYOTHERAPY
1273	CYCLOPHOTOCOAGULATION
1274	CIL BODY DIMINUTION NOS
1279	GLAUCOMA PROCEDURE NEC
1281	SUTURE SCLERAL LACER
1282	SCLERAL FISTULA REPAIR
1283	REVIS ANT SEG OP WND NEC
1284	DESTRUCT SCLERAL LESION
1285	REPAIR STAPHYLOM W GRAFT
1286	REP SCLER STAPHYLOMA NEC
1287	GRAFT REINFORCE SCLERA

Code	Description
1288	SCLERA REINFORCEMENT NEC
1289	SCLERAL OPERATION NEC
1291	THERAPEUT EVAC ANT CHAMB
1292	ANTERIOR CHAMBER INJECT
1293	REMOV EPITHEL DOWNGROWTH
1297	IRIS OPERATION NEC
1298	CILIARY BODY OP NEC
1299	ANTERIOR CHAMBER OP NEC
1300	REMOVE FB LENS NOS
1301	MAGNET REMOVE FB LENS
1302	NONMAGNET REMOVE FB LENS
1311	TEMP-INF INTRCAP LENS EX
1319	INTRACAPSUL LENS EXT NEC
132	LINEAR EXTRACAP LENS EXT
133	SIMPL ASPIR LENS EXTRACT
1341	CATARAC PHACOEMULS/ASPIR
1342	POST CATARAC FRAG/ASPIR
1343	CATARACT FRAG/ASPIR NEC
1351	TEMP-INF XTRACAP LENS EX
1359	EXTRACAP LENS EXTRAC NEC
1361	EXTRACAP LENS EXTRAC NEC
1362	EXTRACAP LENS EXTRAC NEC
1363	EXTRACAP LENS EXTRAC NEC
1364	AFTER-CATAR DISCISSION
1365	AFTER-CATARACT EXCISION
1366	AFTER CATAR FRAGMNTATION
1369	CATARACT EXTRACTION NEC
1370	INSERT PSEUDOPHAKOS NOS
1371	INSERT LENS AT CATAR EXT
1372	SECONDARY INSERT LENS
138	IMPLANTED LENS REMOVAL
139	OTHER OPERATIONS ON LENS
1390	OPERATION ON LENS NEC OCT06-
1391	IMPL INTRAOC TELESC PROS OCT06-
1400	REMOV POST SEGMNT FB NOS
1401	MAGNET REMOV POST SEG FB
1402	NONMAG REMOV POST SEG FB
1411	DIAGNOST VITREOUS ASPIR
1419	DX PROC POST SEG NEC
1421	CHORIORET LES DIATHERMY
1422	CHORIORETIN LES CRYOTHER
1426	CHORIORET LES RADIOTHER
1427	CHORIORET LES RAD IMPLAN

Code	Description
1429	CHORIORET LES DESTR NEC
1431	RETINAL TEAR DIATHERMY
1432	RETINAL TEAR CRYOTHERAPY
1439	RETINAL TEAR REPAIR NEC
1441	SCLERAL BUCKLE W IMPLANT
1449	SCLERAL BUCKLING NEC
1451	DETACH RETINA-DIATHERMY
1452	DETACH RETINA-CRYOTHERAP
1453	DETACH RETINA XENON COAG
1454	DETACH RETINA LASER COAG
1455	DETACH RET PHOTOCOAG NOS
1459	REPAIR RETINA DETACH NEC
146	REMOV PROS MAT POST SEG
1471	ANTERIOR REMOV VITREOUS
1472	VITREOUS REMOVAL NEC
1473	ANTERIOR MECHAN VITRECT
1474	MECH VITRECTOMY NEC
1475	VITREOUS SUBSTITUT INJEC
1479	VITREOUS OPERATION NEC
149	OTHER POST SEGMENT OPS
1501	EXTRAOC MUSC-TEND BIOPSY
1509	EXTRAOC MUSC DX PROC NEC
1511	ONE EXTRAOC MUS RECESS
1512	1 EXTRAOC MUSCL ADVANCE
1513	1 EXTRAOC MUSCL RESECT
1519	XTRAOC MUS OP/DETACH NEC
1521	LENGTHEN 1 EXTRAOC MUSC
1522	SHORTEN 1 EXTRAOC MUSC
1529	OP ON 1 EXTRAOC MUSC NEC
153	TEMP DETACH >1 XTROC MUS
154	OTH OP ON >L EXTRAOC MUS
155	EXTRAOCUL MUS TRANSPOSIT
156	REVIS EXTRAOC MUSC SURG
157	EXTRAOC MUSC INJ REPAIR
159	OTH EXTRAOC MUS-TEND OP
1601	ORBITOTOMY W BONE FLAP
1602	ORBITOTOMY W IMPLANT
1609	ORBITOTOMY NEC
161	REMOVE PENETRAT FB EYE
1622	DIAGNOSTIC ASP OF ORBIT
1623	EYEBALL & ORBIT BIOPSY
1629	EYEBAL/ORBIT DX PROC NEC
1631	EYE EVISC W SYNCH IMPLAN

Code	Description
1639	EYEBALL EVISCERATION NEC
1641	EYE ENUC/IMPLAN/MUSC ATT
1642	EYE ENUC W IMPLANT NEC
1649	EYEBALL ENUCLEATION NEC
1651	RADICAL ORBITOMAXILLECT
1652	ORBIT EXENT W BONE REMOV
1659	ORBITAL EXENTERATION NEC
1661	2NDRY OCULAR IMP INSERT
1662	REVIS/REINSERT OCUL IMP
1663	REVIS ENUC SOCKET W GRFT
1664	ENUC SOCKET REVIS NEC
1665	2NDRY EXENT CAVITY GRAFT
1666	REVIS EXENTER CAVITY NEC
1669	2ND OP POST EYE REM NEC
1671	REMOVE OCULAR IMPLANT
1672	REMOVE ORBITAL IMPLANT
1681	REPAIR OF ORBITAL WOUND
1682	REPAIR EYEBALL RUPTURE
1689	EYE/ORBIT INJ REPAIR NEC
1692	EXCISION ORBITAL LESION
1693	EXCISION EYE LESION NOS
1698	OPERATION ON ORBIT NEC
1699	OPERATION ON EYEBALL NEC
1711	LAP DIR ING HERN-GRAFT OCT08-
1712	LAP INDIR ING HERN-GRAFT OCT08-
1713	LAP ING HERN-GRAFT NOS OCT08-
1721	LAP BIL DIR ING HRN-GRFT OCT08-
1722	LAP BI INDIR ING HRN-GRF OCT08-
1723	LAP BI DR/IND ING HRN-GR OCT08-
1724	LAP BIL ING HERN-GRF NOS OCT08-
1731	LAP MUL SEG RES LG INTES OCT08-
1732	LAPAROSCOPIC CECECTOMY OCT08-
1733	LAP RIGHT HEMICOLECTOMY OCT08-
1734	LAP RES TRANSVERSE COLON OCT08-
1735	LAP LEFT HEMICOLECTOMY OCT08-
1736	LAP SIGMOIDECTOMY OCT08-
1739	LAP PT EX LRG INTEST NEC OCT08-
1751	IMPLANT CCM, TOTAL SYSTEM OCT09-
1752	IMPLANT CCM PULSE GENRTR OCT09-
1761	LITT LESN BRAIN, GUIDANCE OCT09-
1762	LITT LESN HD/NCK GUIDANCE OCT09-
1763	LITT LESN LIVER, GUIDEANCE OCT09-
1769	LITT LESN GUIDE OTH/NOS OCT09-

Code	Description
1821	PREAURICULAR SINUS EXCIS
1831	RAD EXCIS EXT EAR LES
1839	EXCIS EXTERNAL EAR NEC
185	CORRECTION PROMINENT EAR
186	EXT AUDIT CANAL RECONSTR
1871	CONSTRUCTION EAR AURICLE
1872	REATTACH AMPUTATED EAR
1879	PLASTIC REP EXT EAR NEC
189	OTHER EXT EAR OPERATIONS
190	STAPES MOBILIZATION
1911	STAPEDECT W REPLAC INCUS
1919	STAPEDECTOMY NEC
1921	REV STAPDEC W INCUS REPL
1929	STAPEDECTOMY REVIS NEC
193	OSSICULAR CHAIN OP NEC
194	MYRINGOPLASTY
1952	TYPE 2 TYMPANOPLASTY
1953	TYPE 3 TYMPANOPLASTY
1954	TYPE 4 TYMPANOPLASTY
1955	TYPE 5 TYMPANOPLASTY
196	TYMPANOPLASTY REVISION
199	MIDDLE EAR REPAIR NEC
2001	MYRINGOTOMY W INTUBATION
2021	MASTOID INCISION
2022	PETRUS PYRAM AIR CEL INC
2023	MIDDLE EAR INCISION
2032	MID & INNER EAR BIOPSY
2039	MID/IN EAR DX PROC NEC
2041	SIMPLE MASTOIDECTOMY
2042	RADICAL MASTOIDECTOMY
2049	MASTOIDECTOMY NEC
2051	EXCISE MIDDLE EAR LESION
2059	MIDDLE EAR EXCISION NEC
2061	INNER EAR FENESTRATION
2062	REVIS INNER EAR FENESTRA
2071	ENDOLYMPHATIC SHUNT
2072	INNER EAR INJECTION
2079	INC/EXC/DESTR IN EAR NEC
2091	TYMPANOSYMPATHECTOMY
2092	MASTOIDECTOMY REVISION
2093	REPAIR OVAL/ROUND WINDOW
2095	ELECMAG HEAR DEV IMPLANT
2096	IMPLT COCHLEAR PROST NOS

Code	Description
2097	IMP/REP SCHAN COCH PROS
2098	IMP/REP MCHAN COCHL PROS
2099	MID-INNER EAR OPS NEC
2104	ETHMOID ART LIGAT-EPIST
2105	MAX ART LIG FOR EPISTAX
2106	EXT CAROT ART LIG-EPIST
2107	NASAL SEPT GRFT-EPISTAX
2109	EPISTAXIS CONTROL NEC
214	RESECTION OF NOSE
215	SUBMUC NASAL SEPT RESECT
2161	DIATHER/CRYO TURBINECTOM
2162	TURBINATE FRACTURE
2169	TURBINECTOMY NEC
2172	OPEN REDUCTION NASAL FX
2182	NASAL FISTULA CLOSURE
2183	TOT NASAL RECONSTRUCTION
2184	REVISION RHINOPLASTY
2185	AUGMENTATION RHINOPLASTY
2186	LIMITED RHINOPLASTY
2187	RHINOPLASTY NEC
2188	SEPTOPLASTY NEC
2189	NASAL REPAIR NEC
2199	NASAL OPERATION NEC
2212	OPEN BIOPSY NASAL SINUS
2231	RADICAL MAXILLARY ANTROT
2239	EXT MAXILLARY ANTROT NEC
2241	FRONTAL SINUSOTOMY
2242	FRONTAL SINUSECTOMY
2250	SINUSOTOMY NOS
2251	ETHMOIDOTOMY
2252	SPHENOIDOTOMY
2253	MULTIPLE SINUS INCISION
2260	SINUSECTOMY NOS
2261	C-LUC EXC MAX SINUS LES
2262	EXC MAX SINUS LESION NEC
2263	ETHMOIDECTOMY
2264	SPHENOIDECTOMY
2271	NASAL SINUS FISTULA CLOS
2279	NASAL SINUS REPAIR NEC
229	OTHER NASAL SINUS OPS
242	GINGIVOPLASTY
244	EXC OF DENTAL LES OF JAW
245	ALVEOLOPLASTY

Code	Description
2502	OPEN BIOPSY OF TONGUE
251	DESTRUCTION TONGUE LES
252	PARTIAL GLOSSECTOMY
253	COMPLETE GLOSSECTOMY
254	RADICAL GLOSSECTOMY
2559	REPAIR OF TONGUE NEC
2594	OTHER GLOSSOTOMY
2599	TONGUE OPERATION NEC
2612	OPEN BX SALIV GLAND/DUCT
2621	SALIVARY CYST MARSUPIAL
2629	SALIV LESION EXCIS NEC
2630	SIALOADENECTOMY NOS
2631	PARTIAL SIALOADENECTOMY
2632	COMPLETE SIALOADENECTOMY
2641	SUTURE OF SALIV GLND LAC
2642	SALIVARY FISTULA CLOSURE
2649	SALIVARY REPAIR NEC
2699	SALIVARY OPERATION NEC
270	DRAIN FACE & MOUTH FLOOR
271	INCISION OF PALATE
2721	BONY PALATE BIOPSY
2722	UVULA AND SOFT PALATE BX
2731	LOC EXC BONY PALATE LES
2732	WIDE EXC BONY PALATE LES
2742	WIDE EXCISION OF LIP LES
2743	EXCISION OF LIP LES NEC
2749	EXCISION OF MOUTH NEC
2753	CLOSURE OF MOUTH FISTULA
2754	REPAIR OF CLEFT LIP
2755	FULL-THICK GRFT TO MOUTH
2756	SKIN GRAFT TO MOUTH NEC
2757	PEDICLE ATTACH TO MOUTH
2759	MOUTH REPAIR NEC
2761	SUTURE OF PALATE LACERAT
2762	CLEFT PALATE CORRECTION
2763	REVIS CLEFT PALAT REPAIR
2769	OTH PLASTIC REPAIR PALAT
2771	INCISION OF UVULA
2772	EXCISION OF UVULA
2773	REPAIR OF UVULA
2779	OTHER UVULA OPERATIONS
2792	MOUTH INCISION NOS
2799	ORAL CAVITY OPS NEC

Code	Description
280	PERITONSILLAR I & D
2811	TONSIL&ADENOID BIOPSY
2819	TONSIL&ADENOID DX OP NEC
282	TONSILLECTOMY
283	TONSILLECTOMY/ADENOIDEC
284	EXCISION OF TONSIL TAG
285	EXCISION LINGUAL TONSIL
286	ADENOIDECTOMY
287	HEMORR CONTRL POST T & A
2891	INCIS TO REMOV TONSIL FB
2892	EXCIS TONSIL/ADENOID LES
2899	TONSIL/ADENOID OPS NEC
290	PHARYNGOTOMY
292	EXC BRANCHIAL CLEFT CYST
293	EXC BRANCHIAL CLEFT CYST
2931	CRICOPHARYNGEAL MYOTOMY
2932	PHARYNGEAL DIVERTICULEC
2933	PHARYNGECTOMY
2939	EXCIS/DESTR LES PHAR NEC
294	PLASTIC OP ON PHARYNX
2951	SUTURE OF PHARYNGEAL LAC
2952	CLOS BRANCH CLEFT FISTUL
2953	CLOS PHARYNX FISTULA NEC
2954	LYSIS PHARYNGEAL ADHES
2959	PHARYNGEAL REPAIR NEC
2992	DIVIS GLOSSOPHARYNG NERV
2999	PHARYNGEAL OPERATION NEC
3001	LARYNX CYST MARSUPIALIZ
3009	DESTRUCT LARYNX LES NEC
301	HEMILARYNGECTOMY
3021	EPIGLOTTIDECTOMY
3022	VOCAL CORDECTOMY
3029	OTHER PART LARYNGECTOMY
303	COMPLETE LARYNGECTOMY
304	RADICAL LARYNGECTOMY
3121	MEDIASTINAL TRACHEOSTOMY
3129	OTHER PERM TRACHEOSTOMY
313	INCIS LARYNX TRACHEA NEC
3145	OPN BX LARYNX OR TRACHEA
315	LOCAL DESTRUC TRACH LES
3161	SUTURE OF LARYNGEAL LAC
3162	LARYNGEAL FISTULA CLOS
3163	LARYNGOSTOMY REVISION

Code	Description
3164	LARYNGEAL FX REPAIR
3169	OTHER LARYNGEAL REPAIR
3171	SUTURE OF TRACHEAL LACER
3172	CLOSURE OF TRACHEOSTOMY
3173	TRACHEA FISTULA CLOS NEC
3174	REVISION OF TRACHEOSTOMY
3175	TRACHEAL RECONSTRUCTION
3179	OTHER TRACHEAL REPAIR
3191	LARYNGEAL NERV DIVISION
3192	LYSIS TRACH/LARYNX ADHES
3198	OTH LARYNGEAL OPERATION
3199	OTHER TRACHEAL OPERATION
320	OTHER TRACHEAL OPERATION
3209	OTHER DESTRUC BRONC LES
321	OTHER BRONCHIAL EXCISION
3220	THORAC EXC LUNG LESION OCT08-
3221	EMPHYSEMA BLEB PLICATION
3222	LUNG VOL REDUCTION SURG
3223	OPEN ABLTN LUNG LES/TISS OCT06-
3224	PERC ABLTN LUNG LES/TISS OCT06-
3225	THOR ABLTN LUNG LES/TISS OCT06-
3226	ABLTN LUNG TISS NEC/NOS OCT06-
3229	DESTROY LOC LUNG LES NEC
323	SEGMENTAL LUNG RESECTION
3230	THORAC SEG LUNG RESECT OCT08-
3239	OTH SEG LUNG RESECT NOS OCT08-
324	LOBECTOMY OF LUNG
3241	THORAC LOBECTOMY LUNG OCT08-
3249	LOBECTOMY OF LUNG NEC OCT08-
325	COMPLETE PNEUMONECTOMY
3250	THORACOSPC PNEUMONECTOMY OCT08-
3259	OTHER PNEUMONECTOMY NOS OCT08-
326	RAD DISSEC THORAC STRUCT
329	OTHER EXCISION OF LUNG
330	INCISION OF BRONCHUS
331	INCISION OF LUNG
3320	THORACOSCOPC LUNG BIOPSY OCT08-
3325	OPEN BRONCHIAL BIOPSY
3327	CLOS ENDOSCOPIC LUNG BX
3328	OPEN LUNG BIOPSY
3329	BRONCH/LUNG DX PROC NEC
3334	THORACOPLASTY
3339	SURG COLLAPS OF LUNG NEC

Code	Description
3341	BRONCHIAL LACERAT SUTURE
3342	BRONCHIAL FISTULA CLOS
3343	LUNG LACERATION CLOSURE
3348	BRONCHIAL REPAIR NEC
3349	LUNG REPAIR NEC
335	LUNG REPAIR NEC
3350	LUNG TRANSPLANT NOS
3351	UNILAT LUNG TRANSPLANT
3352	BILAT LUNG TRANSPLANT
336	COMB HEART/LUNG TRANSPLA
3392	BRONCHIAL LIGATION
3393	PUNCTURE OF LUNG
3398	BRONCHIAL OPERATION NEC
3399	LUNG OPERATION NEC
3402	EXPLORATORY THORACOTOMY
3403	REOPEN THORACOTOMY SITE
3406	THORAC DRAIN PLEURL CAV OCT08-
341	INCISION OF MEDIASTINUM
3420	THORACOSCOPIC PLEURAL BX OCT08-
3421	TRANSPLEURA THORACOSCOPY
3422	MEDIASTINOSCOPY
3426	OPEN MEDIASTINAL BIOPSY
3427	BIOPSY OF DIAPHRAGM
3428	DX PROCEDURE THORAX NEC
3429	DX PROC MEDIASTINUM NEC
343	DESTRUCT MEDIASTIN LES
344	DESTRUCT CHEST WALL LES
3451	DECORTICATION OF LUNG
3452	THORACOSCOPC DECORT LUNG OCT08-
3459	OTHER PLEURAL EXCISION
346	SCARIFICATION OF PLEURA
3473	CLOS THORACIC FISTUL NEC
3474	PECTUS DEFORMITY REPAIR
3479	OTHER CHEST WALL REPAIR
3481	EXCISE DIAPHRAGM LESION
3482	SUTURE DIAPHRAGM LACERAT
3483	CLOSE DIAPHRAGM FISTULA
3484	OTHER DIAPHRAGM REPAIR
3485	IMPLANT DIAPHRA PACEMAKE
3489	DIAPHRAGM OPERATION NEC
3493	REPAIR OF PLEURA
3499	THORACIC OPERATION NEC
3500	CLOSED VALVOTOMY NOS

Code	Description
3501	CLOSED AORTIC VALVOTOMY
3502	CLOSED MITRAL VALVOTOMY
3503	CLOSED PULMON VALVOTOMY
3504	CLOSED TRICUSP VALVOTOMY
3510	OPEN VALVULOPLASTY NOS
3511	OPN AORTIC VALVULOPLASTY
3512	OPN MITRAL VALVULOPLASTY
3513	OPN PULMON VALVULOPLASTY
3514	OPN TRICUS VALVULOPLASTY
3520	REPLACE HEART VALVE NOS
3521	REPLACE AORT VALV-TISSUE
3522	REPLACE AORTIC VALVE NEC
3523	REPLACE MITR VALV-TISSUE
3524	REPLACE MITRAL VALVE NEC
3525	REPLACE PULM VALV-TISSUE
3526	REPLACE PULMON VALVE NEC
3527	REPLACE TRIC VALV-TISSUE
3528	REPLACE TRICUSP VALV NEC
3531	PAPILLARY MUSCLE OPS
3532	CHORDAE TENDINEAE OPS
3533	ANNULOPLASTY
3534	INFUNDIBULECTOMY
3535	TRABECUL CARNEAE CORD OP
3539	TISS ADJ TO VALV OPS NEC
3542	CREATE SEPTAL DEFECT
3550	PROSTH REP HRT SEPTA NOS
3551	PROS REP ATRIAL DEF-OPN
3552	PROS REPAIR ATRIA DEF-CL
3553	PROST REPAIR VENTRIC DEF
3554	PROS REP ENDOCAR CUSHION
3555	PROS REP VENTRC DEF-CLOS OCT06-
3560	GRFT REPAIR HRT SEPT NOS
3561	GRAFT REPAIR ATRIAL DEF
3562	GRAFT REPAIR VENTRIC DEF
3563	GRFT REP ENDOCAR CUSHION
3570	HEART SEPTA REPAIR NOS
3571	ATRIA SEPTA DEF REP NEC
3572	VENTR SEPTA DEF REP NEC
3573	ENDOCAR CUSHION REP NEC
3581	TOT REPAIR TETRAL FALLOT
3582	TOTAL REPAIR OF TAPVC
3583	TOT REP TRUNCUS ARTERIOS
3584	TOT COR TRANSPOS GRT VES

Code	Description
3591	INTERAT VEN RETRN TRANSP
3592	CONDUIT RT VENT-PUL ART
3593	CONDUIT LEFT VENTR-AORTA
3594	CONDUIT ARTIUM-PULM ART
3595	HEART REPAIR REVISION
3596	PERC HEART VALVULOPLASTY
3598	OTHER HEART SEPTA OPS
3599	OTHER HEART VALVE OPS
3600	OTHER HEART VALVE OPS
3601	PTCA-1 VES/ATH W/O AGENT
3602	PTCA-1 VES/ATH W AGENT
3603	OPEN CORONRY ANGIOPLASTY
3605	PTCA-MULTIPLE VESSEL/ATH
3609	REM OF COR ART OBSTR NEC
3610	AORTOCORONARY BYPASS NOS
3611	AORTOCOR BYPAS-1 COR ART
3612	AORTOCOR BYPAS-2 COR ART
3613	AORTOCOR BYPAS-3 COR ART
3614	AORTCOR BYPAS-4+ COR ART
3615	1 INT MAM-COR ART BYPASS
3616	2 INT MAM-COR ART BYPASS
3617	ABD-CORON ARTERY BYPASS
3619	HRT REVAS BYPS ANAS NEC
362	ARTERIAL IMPLANT REVASC
363	ARTERIAL IMPLANT REVASC
3631	OPEN CHEST TRANS REVASC
3632	OTH TRANSMYO REVASCULAR
3633	ENDO TRANSMYO REVASCULAR OCT06-
3634	PERC TRANSMYO REVASCULAR OCT06-
3639	OTH HEART REVASCULAR
3691	CORON VESS ANEURYSM REP
3699	HEART VESSEL OP NEC
3710	INCISION OF HEART NOS
3711	CARDIOTOMY
3712	PERICARDIOTOMY
3724	PERICARDIAL BIOPSY
3731	PERICARDIECTOMY
3732	HEART ANEURYSM EXCISION
3733	EXC/DEST HRT LESION OPEN
3734	EXC/DEST HRT LES OTHER
3735	PARTIAL VENTRICULECTOMY
374	HEART & PERICARD REPAIR
3741	IMPL CARDIAC SUPPORT DEV OCT05-

Code	Description
3749	HEART/PERICARD REPR NEC OCT05-
375	HEART & PERICARD REPAIR
3751	HEART TRANSPLANTATION OCT03-
3752	IMPLANT TOT REP HRT SYS
3753	REPL/REP THORAC UNIT HRT
3754	REPL/REP OTH TOT HRT SYS
3755	REM INT BIVENT HRT SYS OCT08-
3760	IMP BIVN EXT HRT AST SYS OCT08-
3761	PULSATION BALLOON IMPLAN
3762	IMPLANT HRT ASST SYS NEC
3763	REPLACE HRT ASSIST SYST
3764	REMOVE HEART ASSIST SYS
3765	IMP EXT PUL HRT ASST SYS
3766	IMP IMP PUL HRT ASST SYS
3767	IMP CARDIOMYOSTIMUL SYS
3768	PERCUTAN HRT ASSIST SYST
3774	INT OR REPL LEAD EPICAR
3775	REVISION OF LEAD
3776	REPL TV ATRI-VENT LEAD
3777	REMOVAL OF LEAD W/O REPL
3779	REVIS OR RELOCATE POCKET
3780	INT OR REPL PERM PACEMKR
3785	REPL PACEM W 1-CHAM, NON
3786	REPL PACEM 1-CHAM, RATE
3787	REPL PACEM W DUAL-CHAM
3789	REVISE OR REMOVE PACEMAK
3791	OPN CHEST CARDIAC MASSAG
3794	IMPLT/REPL CARDDEFIB TOT
3795	IMPLT CARDIODEFIB LEADS
3796	IMPLT CARDIODEFIB GENATR
3797	REPL CARDIODEFIB LEADS
3798	REPL CARDIODEFIB GENRATR
3799	OTHER HEART/PERICARD OPS
3800	INCISION OF VESSEL NOS
3801	INTRACRAN VESSEL INCIS
3802	HEAD/NECK VES INCIS NEC
3803	UPPER LIMB VESSEL INCIS
3804	INCISION OF AORTA
3805	THORACIC VESSEL INC NEC
3806	ABDOMEN ARTERY INCISION
3807	ABDOMINAL VEIN INCISION
3808	LOWER LIMB ARTERY INCIS
3809	LOWER LIMB VEIN INCISION

Code	Description
3810	ENDARTERECTOMY NOS
3811	INTRACRAN ENDARTERECTOMY
3812	HEAD & NECK ENDARTER NEC
3813	UPPER LIMB ENDARTERECTOM
3814	ENDARTERECTOMY OF AORTA
3815	THORACIC ENDARTERECTOMY
3816	ABDOMINAL ENDARTERECTOMY
3818	LOWER LIMB ENDARTERECT
3821	BLOOD VESSEL BIOPSY
3829	BLOOD VESSEL DX PROC NEC
3830	VESSEL RESECT/ANAST NOS
3831	INTRACRAN VES RESEC-ANAS
3832	HEAD/NECK VES RESEC-ANAS
3833	ARM VESSEL RESECT/ANAST
3834	AORTA RESECTION & ANAST
3835	THOR VESSEL RESECT/ANAST
3836	ABD VESSEL RESECT/ANAST
3837	ABD VEIN RESECT & ANAST
3838	LEG ARTERY RESECT/ANAST
3839	LEG VEIN RESECT/ANASTOM
3840	VESSEL RESECT/REPLAC NOS
3841	INTRACRAN VES RESEC-REPL
3842	HEAD/NECK VES RESEC-REPL
3843	ARM VES RESECT W REPLACE
3844	RESECT ABDM AORTA W REPL
3845	RESECT THORAC VES W REPL
3846	ABD ARTERY RESEC W REPLA
3847	ABD VEIN RESECT W REPLAC
3848	LEG ARTERY RESEC W REPLA
3849	LEG VEIN RESECT W REPLAC
3850	VARICOSE V LIG-STRIP NOS
3851	INTCRAN VAR V LIG-STRIP
3852	HEAD/NECK VAR V LIG-STR
3853	ARM VARICOSE V LIG-STRIP
3855	THORAC VAR V LIG-STRIP
3857	ABD VARICOS V LIGA-STRIP
3859	LEG VARICOS V LIGA-STRIP
3860	EXCISION OF VESSEL NOS
3861	INTRACRAN VESSEL EXCIS
3862	HEAD/NECK VESSEL EXCIS
3863	ARM VESSEL EXCISION
3864	EXCISION OF AORTA
3865	THORACIC VESSEL EXCISION

Code	Description
3866	ABDOMINAL ARTERY EXCIS
3867	ABDOMINAL VEIN EXCISION
3868	LEG ARTERY EXCISION
3869	LEG VEIN EXCISION
3880	SURG VESSEL OCCLUS NEC
3881	OCCLUS INTRACRAN VES NEC
3882	OCCLUS HEAD/NECK VES NEC
3883	OCCLUDE ARM VESSEL NEC
3884	OCCLUDE AORTA NEC
3885	OCCLUDE THORACIC VES NEC
3886	OCCLUDE ABD ARTERY NEC
3887	OCCLUDE ABD VEIN NEC
3888	OCCLUDE LEG ARTERY NEC
3889	OCCLUDE LEG VEIN NEC
390	SYSTEMIC-PULM ART SHUNT
391	INTRA-ABD VENOUS SHUNT
398	CARTD BODY/SINUS/VASC OP OCT08-
3921	CAVAL-PULMON ART ANASTOM
3922	AORTA-SUBCLV-CAROT BYPAS
3923	INTRATHORACIC SHUNT NEC
3924	AORTA-RENAL BYPASS
3925	AORTA-ILIAC-FEMOR BYPASS
3926	INTRA-ABDOMIN SHUNT NEC
3927	DIALYSIS ARTERIOVENOSTOM
3928	EXTRACRAN-INTRACR BYPASS
3929	VASC SHUNT & BYPASS NEC
3930	SUTURE OF VESSEL NOS
3931	SUTURE OF ARTERY
3932	SUTURE OF VEIN
3941	POSTOP VASC OP HEM CONTR
3942	REVIS REN DIALYSIS SHUNT
3943	REMOV REN DIALYSIS SHUNT
3949	VASC PROC REVISION NEC
3950	ANGIO/ATH NON-CORO VES
3951	CLIPPING OF ANEURYSM
3952	ANEURYSM REPAIR NEC
3953	ARTERIOVEN FISTULA REP
3954	RE-ENTRY OPERATION
3955	REIMPLAN ABERR RENAL VES
3956	REPAIR VESS W TIS PATCH
3957	REP VESS W SYNTH PATCH
3958	REPAIR VESS W PATCH NOS
3959	REPAIR OF VESSEL NEC

Code	Description
397	PER CARDIOPULMON BYPASS
3971	ENDO IMPL GRFT ABD AORTA
3972	ENDOVASC REPAIR HEAD VES
3973	ENDO IMP GRFT THOR AORTA OCT05-
3974	ENDO REM OBS HD/NECK VES OCT06-
3975	ENDO EM HD/NK, BARE COILD OCT09-
3976	ENDO EM HD/NK, BIOAC COIL OCT09-
3979	ENDO REPAIR OTHER VESSEL
398	VASCULAR BODY OPERATIONS
3991	FREEING OF VESSEL
3992	VEIN INJECT-SCLEROS AGNT
3993	INSERT VES-TO-VES CANNUL
3994	REPLAC VES-TO-VES CANNUL
3998	HEMORRHAGE CONTROL NOS
3999	VESSEL OPERATION NEC
400	INCIS LYMPHATIC STRUCTUR
4011	LYMPHATIC STRUCT BIOPSY
4019	LYMPHATIC DIAG PROC NEC
4021	EXCIS DEEP CERVICAL NODE
4022	EXCISE INT MAMMARY NODE
4023	EXCISE AXILLARY NODE
4024	EXCISE INGUINAL NODE
4029	SIMP EXC LYMPH STRUC NEC
403	REGIONAL LYMPH NODE EXC
4040	RAD NECK DISSECTION NOS
4041	UNILAT RAD NECK DISSECT
4042	BILAT RAD NECK DISSECT
4050	RAD NODE DISSECTION NOS
4051	RAD DISSEC AXILLARY NODE
4052	RAD DISSEC PERIAORT NODE
4053	RAD DISSECT ILIAC NODES
4054	RADICAL GROIN DISSECTION
4059	RAD NODE DISSECTION NEC
4061	THORAC DUCT CANNULATION
4062	THORACIC DUCT FISTULIZAT
4063	CLOSE THORACIC DUCT FIST
4064	LIGATE THORACIC DUCT
4069	THORACIC DUCT OP NEC
409	LYMPH STRUCTURE OP NEC
412	SPLENOTOMY
4133	OPEN SPLEEN BIOPSY
4141	SPLENIC CYST MARSUPIAL
4142	EXC SPLENIC LESION/TISS

Code	Description
4143	PARTIAL SPLENECTOMY
415	TOTAL SPLENECTOMY
4193	EXC OF ACCESSORY SPLEEN
4194	SPLEEN TRANSPLANTATION
4195	REPAIR OF SPLEEN
4199	SPLEEN OPERATION NEC
4201	ESOPHAGEAL WEB INCISION
4209	ESOPHAGEAL INCISION NEC
4210	ESOPHAGOSTOMY NOS
4211	CERVICAL ESOPHAGOSTOMY
4212	ESOPH POUCH EXTERIORIZAT
4219	EXT FISTULIZAT ESOPH NEC
4221	ESOPHAGOSCOPY BY INCIS
4225	OPEN BIOPSY OF ESOPHAGUS
4231	LOC EXCIS ESOPH DIVERTIC
4232	LOCAL EXCIS ESOPHAG NEC
4239	DESTRUCT ESOPHAG LES NEC
4240	ESOPHAGECTOMY NOS
4241	PARTIAL ESOPHAGECTOMY
4242	TOTAL ESOPHAGECTOMY
4251	THORAC ESOPHAGOESOPHAGOS
4252	THORAC ESOPHAGOGASTROST
4253	THORAC SM BOWEL INTERPOS
4254	THORAC ESOPHAGOENTER NEC
4255	THORAC LG BOWEL INTERPOS
4256	THORAC ESOPHAGOCOLOS NEC
4258	THORAC INTERPOSITION NEC
4259	THORAC ESOPHAG ANAST NEC
4261	STERN ESOPHAGOESOPHAGOST
4262	STERN ESOPHAGOGASTROSTOM
4263	STERN SM BOWEL INTERPOS
4264	STERN ESOPHAGOENTER NEC
4265	STERN LG BOWEL INTERPOS
4266	STERN ESOPHAGOCOLOS NEC
4268	STERN INTERPOSITION NEC
4269	STERN ESOPHAG ANAST NEC
427	ESOPHAGOMYOTOMY
4282	SUTURE ESOPHAGEAL LACER
4283	ESOPHAGOSTOMY CLOSURE
4284	ESOPH FISTULA REPAIR NEC
4285	ESOPHAG STRICTURE REPAIR
4286	PROD SUBQ TUNNEL NO ANAS
4287	ESOPHAGEAL GRAFT NEC

Code	Description
4289	ESOPHAGEAL REPAIR NEC
4291	LIGATION ESOPH VARIX
430	GASTROTOMY
431	GASTROTOMY
432	OTHER GASTROSTOMY
433	PYLOROMYOTOMY
4342	LOCAL GASTR EXCISION NEC
4349	LOCAL GASTR DESTRUCT NEC
435	PROXIMAL GASTRECTOMY
436	DISTAL GASTRECTOMY
437	PART GASTREC W JEJ ANAST
4381	PART GAST W JEJ TRANSPOS
4389	PARTIAL GASTRECTOMY NEC
4391	TOT GAST W INTES INTERPO
4399	TOTAL GASTRECTOMY NEC
4400	VAGOTOMY NOS
4401	TRUNCAL VAGOTOMY
4402	HIGHLY SELECT VAGOTOMY
4403	SELECTIVE VAGOTOMY NEC
4411	TRANSABDOMIN GASTROSCOPY
4415	OPEN GASTRIC BIOPSY
442	GASTRIC DIAGNOS PROC NEC
4421	DILATE PYLORUS, INCISION
4429	OTHER PYLOROPLASTY
4431	HIGH GASTRIC BYPASS
4432	PERCU GASTROJEJUNOSTOMY
4438	LAP GASTROENTEROSTOMY (OCT 04)
4439	GASTROENTEROSTOMY NEC
4440	SUTURE PEPTIC ULCER NOS
4441	SUT GASTRIC ULCER SITE
4442	SUTURE DUODEN ULCER SITE
445	REVISION GASTRIC ANASTOM
4461	SUTURE GASTRIC LACERAT
4463	CLOSE GASTRIC FISTUL NEC
4464	GASTROPEXY
4465	ESOPHAGOGASTROPLASTY
4466	CREAT ESOPHAGASTR SPHINC
4467	LAP CREAT ESOPH SPHINCT (OCT 04)
4468	LAPAROSCOP GASTROPLSTY (OCT 04)
4469	GASTRIC REPAIR NEC
4491	LIGATE GASTRIC VARICES
4492	INTRAOP GASTRIC MANIPUL
4495	LAP GASTRIC RESTRIC PROC (OCT 04)

Code	Description
4496	LAP REV GAST RESTRI PROC (OCT 04)
4497	LAP REM GAST RESTRIC DEV (OCT 04)
4498	ADJUST GAST RESTRICT DEV (OCT 04)
4499	GASTRIC OPERATION NEC
4500	INTESTINAL INCISION NOS
4501	DUODENAL INCISION
4502	SMALL BOWEL INCISION NEC
4503	LARGE BOWEL INCISION
4511	TRANSAB SM BOWEL ENDOSC
4515	OPEN SMALL BOWEL BIOPSY
4521	TRANSAB LG BOWEL ENDOSC
4526	OPEN LARGE BOWEL BIOPSY
4531	OTH EXCISE DUODENUM LES
4532	DESTRUCT DUODEN LES NEC
4533	LOCAL EXCIS SM BOWEL NEC
4534	DESTR SM BOWEL LES NEC
4541	EXCISE LG INTESTINE LES
4549	DESTRUC LG BOWEL LES NEC
4550	INTEST SEG ISOLAT NOS
4551	SM BOWEL SEGMENT ISOLAT
4552	LG BOWEL SEGMENT ISOLAT
4561	MULT SEG SM BOWEL EXCIS
4562	PART SM BOWEL RESECT NEC
4563	TOTAL REMOVAL SM BOWEL
4571	MULT SEG LG BOWEL EXCIS
4572	CECECTOMY
4573	RIGHT HEMICOLECTOMY
4574	TRANSVERSE COLON RESECT
4575	LEFT HEMICOLECTOMY
4576	SIGMOIDECTOMY
4579	PART LG BOWEL EXCIS NEC
458	TOT INTRA-ABD COLECTOMY
4581	LAP TOT INTR-AB COLECTMY OCT08-
4582	OP TOT INTR-ABD COLECTMY OCT08-
4583	TOT ABD COLECTMY NEC/NOS OCT08-
4590	INTESTINAL ANASTOM NOS
4591	SM-TO-SM BOWEL ANASTOM
4592	SM BOWEL-RECT STUMP ANAS
4593	SMALL-TO-LARGE BOWEL NEC
4594	LG-TO-LG BOWEL ANASTOM
4595	ANAL ANASTOMOSIS
4601	SM BOWEL EXTERIORIZATION
4602	RESECT EXT SEG SM BOWEL

Code	Description
4603	LG BOWEL EXTERIORIZATION
4604	RESECT EXT SEG LG BOWEL
4610	COLOSTOMY NOS
4611	TEMPORARY COLOSTOMY
4612	TEMPORARY COLOSTOMY
4613	PERMANENT COLOSTOMY
4620	ILEOSTOMY NOS
4621	TEMPORARY ILEOSTOMY
4622	CONTINENT ILEOSTOMY
4623	PERMANENT ILEOSTOMY NEC
4640	INTEST STOMA REVIS NOS
4641	SM BOWEL STOMA REVISION
4642	PERICOLOST HERNIA REPAIR
4643	LG BOWEL STOMA REVIS NEC
4650	INTEST STOMA CLOSURE NOS
4651	SM BOWEL STOMA CLOSURE
4652	LG BOWEL STOMA CLOSURE
4660	INTESTINAL FIXATION NOS
4661	SM BOWEL-ABD WALL FIXAT
4662	SMALL BOWEL FIXATION NEC
4663	LG BOWEL-ABD WALL FIXAT
4664	LARGE BOWEL FIXATION NEC
4671	DUODENAL LACERAT SUTURE
4672	DUODENAL FISTULA CLOSURE
4673	SMALL BOWEL SUTURE NEC
4674	CLOSE SM BOWEL FIST NEC
4675	SUTURE LG BOWEL LACERAT
4676	CLOSE LG BOWEL FISTULA
4679	REPAIR OF INTESTINE NEC
4680	INTRA-AB BOWEL MANIP NOS
4681	INTRA-ABD SM BOWEL MANIP
4682	INTRA-ABD LG BOWEL MANIP
4691	MYOTOMY OF SIGMOID COLON
4692	MYOTOMY OF COLON NEC
4693	REVISE SM BOWEL ANASTOM
4694	REVISE LG BOWEL ANASTOM
4697	TRANSPLANT OF INTESTINE
4699	INTESTINAL OP NEC
470	INTESTINAL OP NEC
4701	LAP APPENDECTOMY
4709	OTHER APPENDECTOMY
471	OTHER APPENDECTOMY
4711	LAP INCID APPENDECTOMY

Code	Description
4719	OTHER INCID APPENDECTOMY
472	DRAIN APPENDICEAL ABSC
4791	APPENDICOSTOMY
4792	CLOSE APPENDICEAL FISTUL
4799	APPENDICEAL OPS NEC
480	PROCTOTOMY
481	PROCTOSTOMY
4821	TRANSAB PROCTOSIGMOIDOSC
4825	OPEN RECTAL BIOPSY
4835	LOCAL EXCIS RECTAL LES
4840	PULL-THRU RES RECTUM NOS OCT08-
4841	SOAVE SUBMUC RECT RESECT
4842	LAP PULL-THRU RES RECTUM OCT08-
4843	OPN PULL-THRU RES RECTUM OCT08-
4849	PULL-THRU RECT RESEC NEC
485	ABD-PERINEAL RECT RESECT
4850	ABDPERNEAL RES RECTM NOS 0CT09-
4851	LAP ABDPERNEAL RESC REC OCT08-
4852	OPN ABDPERNEAL RESC REC OCT08-
4859	ABDPERNEAL RESC RECT NEC OCT08-
4861	TRANSSAC RECTOSIGMOIDECT
4862	ANT RECT RESECT W COLOST
4863	ANTERIOR RECT RESECT NEC
4864	POSTERIOR RECT RESECTION
4865	DUHAMEL RECTAL RESECTION
4866	DUHAMEL RECTAL RESECTION
4869	RECTAL RESECTION NEC
4871	SUTURE OF RECTAL LACER
4872	CLOSURE OF PROCTOSTOMY
4873	CLOSE RECTAL FIST NEC
4874	RECTORECTOSTOMY
4875	ABDOMINAL PROCTOPEXY
4876	PROCTOPEXY NEC
4879	REPAIR OF RECTUM NEC
4881	PERIRECTAL INCISION
4882	PERIRECTAL EXCISION
4891	INCIS RECTAL STRICTURE
4892	ANORECTAL MYOMECTOMY
4893	REPAIR PERIRECT FISTULA
4899	RECTAL PERIRECT OP NEC
4901	INCIS PERIANAL ABSCESS
4902	PERIANAL INCISION NEC
4904	PERIANAL EXCISION NEC

Code	Description
4911	ANAL FISTULOTOMY
4912	ANAL FISTULECTOMY
493	ANAL/PERIAN DX PROC NEC
4939	OTHER DESTRUC ANUS LES
4944	HEMORRHOID CRYOTHERAPY
4945	HEMORRHOID LIGATION
4946	HEMORRHOIDECTOMY
4949	HEMORRHOID PROCEDURE NEC
4951	LEFT LAT SPHINCTEROTOMY
4952	POST SPHINCTEROTOMY
4959	ANAL SPHINCTEROTOMY NEC
496	EXCISION OF ANUS
4971	SUTURE ANAL LACERATION
4972	ANAL CERCLAGE
4973	CLOSURE OF ANAL FISTULA
4974	GRACILIS MUSC TRANSPLAN
4975	IMPL OR REV ART ANAL SPH
4976	REMOV ART ANAL SPHINCTER
4979	ANAL SPHINCT REPAIR NEC
4991	INCISION OF ANAL SEPTUM
4992	INSERT SUBQ ANAL STIMUL
4993	ANAL INCISION NEC
4994	REDUCTION ANAL PROLAPSE
4995	CONTROL ANAL HEMORRHAGE
4999	ANAL OPERATION NEC
500	HEPATOTOMY
5012	OPEN LIVER BIOPSY
5013	TRANSJUGULAR LIVER BX OCT08-
5014	LAPAROSCOPIC LIVER BX OCT08-
5019	HEPATIC DX PROC NEC
5021	MARSUPIALIZAT LIVER LES
5022	PARTIAL HEPATECTOMY
5023	OPN ABLTN LIVER LES/TISS OCT06-
5024	PERC ABLTN LIVER LES/TIS OCT06-
5025	LAP ABLTN LIVER LES/TISS OCT06-
5026	ABLTN LIVER LES/TISS NEC OCT06-
5029	DESTRUC HEPATIC LES NEC
503	HEPATIC LOBECTOMY
504	TOTAL HEPATECTOMY
5013	TRANSJUGULAR LIVER BX OCT08-
5014	LAPAROSCOPIC LIVER BX OCT08-
5051	AUXILIARY LIVER TRANSPL
5059	LIVER TRANSPLANT NEC

Code	Description
5061	CLOSURE LIVER LACERAT
5069	LIVER REPAIR NEC
5102	TROCAR CHOLECYSTOSTOMY
5103	CHOLECYSTOSTOMY NEC
5104	CHOLECYSTOTOMY NEC
5113	OPEN BILIARY TRACT BX
5119	BILIARY TR DX PROC NEC
5121	OTH PART CHOLECYSTECTOMY
5122	CHOLECYSTECTOMY
5123	LAPAROSCOPIC CHOLECYSTEC
5124	LAP PART CHOLECYSTECTOMY
5131	GB-TO-HEPAT DUCT ANAST
5132	GB-TO-INTESTINE ANASTOM
5133	GB-TO-PANCREAS ANASTOM
5134	GB-TO-STOMACH ANASTOMOS
5135	GALLBLADDER ANASTOM NEC
5136	CHOLEDOCHOENTEROSTOMY
5137	HEPATIC DUCT-GI ANASTOM
5139	BILE DUCT ANASTOMOS NEC
5141	CDE FOR CALCULUS REMOV
5142	CDE FOR OBSTRUCTION NEC
5143	CHOLEDOCHOHEPAT INTUBAT
5149	INCIS OBSTR BILE DUC NEC
5151	COMMON DUCT EXPLORATION
5159	BILE DUCT INCISION NEC
5161	EXCIS CYST DUCT REMNANT
5162	EXCIS AMPULLA OF VATER
5163	COMMON DUCT EXCIS NEC
5169	BILE DUCT EXCISION NEC
5171	SIMPLE SUT-COMMON DUCT
5172	CHOLEDOCHOPLASTY
5179	BILE DUCT REPAIR NEC
5181	SPHINCTER OF ODDI DILAT
5182	PANCREAT SPHINCTEROTOM
5183	PANCREAT SPHINCTEROPLAS
5189	SPHINCT OF ODDI OP NEC
5191	REPAIR GB LACERATION
5192	CLOSURE CHOLECYSTOSTOMY
5193	CLOS BILIARY FISTUL NEC
5194	REVIS BILE TRACT ANASTOM
5195	REMOVE BILE DUCT PROSTH
5199	BILIARY TRACT OP NEC
5201	CATH DRAIN-PANCREAT CYST

Code	Description
5209	PANCREATOTOMY NEC
5212	OPEN PANCREATIC BIOPSY
5219	PANCREATIC DX PROC NEC
522	PANCREATIC DX PROC NEC
5222	OTHER DESTRU PANCREA LES
523	PANCREAT CYST MARSUPIALI
524	INT DRAIN PANCREAT CYST
5251	PROXIMAL PANCREATECTOMY
5252	DISTAL PANCREATECTOMY
5253	RAD SUBTOT PANCREATECTOM
5259	PARTIAL PANCREATECT NEC
526	TOTAL PANCREATECTOMY
527	RAD PANCREATICODUODENECT
5280	PANCREAT TRANSPLANT NOS
5281	REIMPLANT PANCREATIC TIS
5282	PANCREATIC HOMOTRANSPLAN
5283	PANCREATIC HETEROTRANSPL
5291	TRNSPLNT ISLETS LANG NOS
5292	CANNULATION PANCREA DUC
5295	PANCREATIC REPAIR NEC
5296	PANCREATIC ANASTOMOSIS
5299	PANCREATIC OPERATION NEC
5300	UNILAT ING HERN REP NOS
5301	REPAIR DIRECT ING HERNIA
5302	REPAIR INDIR ING HERNIA
5303	DIR ING HERNIA REP-GRAFT
5304	IND ING HERNIA REP-GRAFT
5305	ING HERNIA REP-GRAFT NOS
5310	BILAT ING HERNIA REP NOS
5311	BILAT DIR ING HERN REP
5312	BILAT IND ING HERN REP
5313	BIL DIR/IND ING HRN REP
5314	BIL DIR ING HRN REP-GRFT
5315	BIL IND ING HRN REP-GRFT
5316	BIL DIR/IND ING HERN-PRO
5317	BIL ING HRN REP-GRFT NOS
5321	UNIL FEMOR HRN REP-GRFT
5329	UNIL FEMOR HERN REP NEC
5331	BIL FEM HERN REPAIR-GRFT
5339	BIL FEM HERN REPAIR NEC
5341	UMBIL HERNIA REPAIR-GRFT
5342	LAP UMBIL HERNIA-GRAFT OCT08-
5343	LAP UMBILICAL HERNIA NEC OCT08-

Code	Description
5349	UMBIL HERNIA REPAIR NEC
5351	INCISIONAL HERNIA REPAIR
5359	ABD WALL HERN REPAIR NEC
5361	INCIS HERNIA REPAIR-GRFT
5362	LAP INCIS HERN REPR-GRFT OCT08-
5363	LAP HERN ANT ABD-GFT NEC OCT08-
5369	ABD HERN REPAIR-GRFT NEC
537	ABD REPAIR-DIAPHR HERNIA
5371	LAP ABD REP-DIAPHR HERN OCT08-
5372	OPN ABD DIAPHRM HERN NEC OCT08-
5375	ABD REP-DIAPHR HERN NOS OCT08-
5380	THOR REP-DIAPH HERN NOS
5381	DIAPHRAGMATIC PLICATION
5382	PARASTERN HERNIA REPAIR
5383	LAP THORC APP-DIAPH HERN OCT08-
5384	OPN THORC DIAPH HERN NEC OCT08-
539	OTHER HERNIA REPAIR
540	ABDOMINAL WALL INCISION
5411	EXPLORATORY LAPAROTOMY
5412	REOPEN RECENT LAP SITE
5419	LAPAROTOMY NEC
5421	LAPAROSCOPY
5422	ABDOMINAL WALL BIOPSY
5423	PERITONEAL BIOPSY
5429	ABD REGION DX PROC NEC
543	DESTRUCT ABD WALL LESION
544	DESTRUCT PERITONEAL TISS
545	DESTRUCT PERITONEAL TISS
5451	LAP PERITON ADHESIOLYSIS
5459	OTH PERITON ADHESIOLYSIS
5461	RECLOSE POST OP DISRUPT
5462	DELAYED CLOS ABD WOUND
5463	ABD WALL SUTURE NEC
5464	PERITONEAL SUTURE
5471	REPAIR OF GASTROSCHISIS
5472	ABDOMEN WALL REPAIR NEC
5473	PERITONEAL REPAIR NEC
5474	OMENTAL REPAIR NEC
5475	MESENTERIC REPAIR NEC
5492	REMOVE FB FROM PERITON
5493	CREATE CUTANPERITON FIST
5494	CREAT PERITONEOVAS SHUNT
5495	PERITONEAL INCISION

Code	Description
5501	NEPHROTOMY
5502	NEPHROSTOMY
5503	PERCU NEPHROSTM W/O FRAG
5504	PERCU NEPHROSTMY W FRAG
5511	PYELOTOMY
5512	PYELOSTOMY
5524	OPEN RENAL BIOPSY
5529	RENAL DIAGNOST PROC NEC
5531	RENAL LES MARSUPIALIZAT
5532	OPN ABLTN RENAL LES/TISS OCT06-
5533	PERC ABLTN RENL LES/TISS OCT06-
5534	LAP ABLTN RENAL LES/TISS OCT06-
5535	ABLTN RENAL LES/TISS NEC OCT06-
5539	LOC DESTR RENAL LES NEC
554	PARTIAL NEPHRECTOMY
5551	NEPHROURETERECTOMY
5552	SOLITARY KIDNEY NEPHRECT
5553	REJECTED KIDNEY NEPHRECT
5554	BILATERAL NEPHRECTOMY
5561	RENAL AUTOTRANSPLANT
5569	KIDNEY TRANSPLANT NEC
557	NEPHROPEXY
5581	SUTURE KIDNEY LACERATION
5582	CLOSE NEPHROST & PYELOST
5583	CLOSE RENAL FISTULA NEC
5584	REDUCE RENAL PEDICL TORS
5585	SYMPHYSIOTOMY
5586	RENAL ANASTOMOSIS
5587	CORRECT URETEROPELV JUNC
5589	RENAL REPAIR NEC
5591	RENAL DECAPSULATION
5597	IMPLANT MECHANIC KIDNEY
5598	REMOV MECHANICAL KIDNEY
5599	RENAL OPERATION NEC
560	TU REMOV URETER OBSTRUCT
561	URETERAL MEATOTOMY
562	URETEROTOMY
5634	OPEN URETERAL BIOPSY
5639	URETERAL DX PROCEDUR NEC
5640	URETERECTOMY NOS
5641	PARTIAL URETERECTOMY
5642	TOTAL URETERECTOMY
5651	FORM CUTAN ILEOURETEROST

Code	Description
5652	REVIS CUTAN ILEOURETEROS
5661	FORM CUTAN URETEROSTOMY
5662	REVIS CUTAN URETEROS NEC
5671	URIN DIVERSION TO BOWEL
5672	REVIS URETEROENTEROSTOMY
5673	NEPHROCYSTANASTOMOSI NOS
5674	URETERONEOCYSTOSTOMY
5675	TRANSURETEROURETEROSTOMY
5679	URETERAL ANASTOMOSIS NEC
5681	INTRALUM URETE ADHESIOLY
5682	SUTURE URETERAL LACERAT
5683	URETEROSTOMY CLOSURE
5684	CLOSE URETER FISTULA NEC
5685	URETEROPEXY
5686	REMOVE URETERAL LIGATURE
5689	REPAIR OF URETER NEC
5692	IMPLANT URETERAL STIMUL
5693	REPLACE URETERAL STIMUL
5694	REMOVE URETERAL STIMULAT
5695	LIGATION OF URETER
5699	URETERAL OPERATION NEC
5712	CYSTOTOMY & ADHESIOLYSIS
5718	OTHER SUPRAPU CYSTOSTOMY
5719	CYSTOTOMY NEC
5721	VESICOSTOMY
5722	REVISE CLO VESICOSTOMY
5733	CLOS TRANSURETH BLADD BX
5734	OPEN BLADDER BIOPSY
5739	BLADDER DIAGNOS PROC NEC
5741	TU ADHESIOLYSIS BLADDER
5749	TU DESTRUC BLADD LES NEC
5751	EXCISION OF URACHUS
5759	BLADDER LES DESTRUCT NEC
576	PARTIAL CYSTECTOMY
5771	RADICAL CYSTECTOMY
5779	TOTAL CYSTECTOMY NEC
5781	SUTURE BLADDER LACERAT
5782	CYSTOSTOMY CLOSURE
5783	ENTEROVESICO FIST REPAIR
5784	VESIC FISTULA REPAIR NEC
5785	CYSTOURETHROPLASTY
5786	BLADDER EXSTROPHY REPAIR
5787	BLADDER RECONSTRUCTION

Code	Description
5788	BLADDER ANASTOMOSIS NEC
5789	BLADDER REPAIR NEC
5791	BLADDER SPHINCTEROTOMY
5793	CONTROL BLADD HEMORRHAGE
5796	IMPLANT BLADDER STIMULAT
5797	REPLACE BLADDER STIMULAT
5798	REMOVE BLADDER STIMULAT
5799	BLADDER OPERATION NEC
580	URETHROTOMY
581	URETHRAL MEATOTOMY
5841	SUTURE URETHRAL LACERAT
5842	URETHROSTOMY CLOSURE
5843	CLOSE URETH FISTULA NEC
5844	URETHRAL REANASTOMOSIS
5845	HYPO-EPISPADIUS REPAIR
5846	URETH RECONSTRUCTION NEC
5847	URETHRAL MEATOPLASTY
5849	URETHRAL REPAIR NEC
585	URETH STRICTURE RELEASE
5891	PERIURETHRAL INCISION
5892	PERIURETHRAL EXCISION
5893	IMPLT ARTF URIN SPHINCT
5899	URETH/PERIURETH OP NEC
5900	RETROPERIT DISSECT NOS
5901	RETROPERIT DISSECT NOS
5902	PERIREN ADHESIOLYS NEC
5903	LAP LYS PERIREN/URET ADH
5909	PERIREN/URETER INCIS NEC
5911	OTH LYS PERIVES ADHESIO
5912	LAP LYS PERIVESURETH ADH
5919	PERIVESICAL INCISION NEC
5921	PERIREN/URETERAL BIOPSY
5929	PERIREN/URET DX PROC NEC
593	URETHROVES JUNCT PLICAT
594	SUPRAPUBIC SLING OP
595	RETROPUBIC URETH SUSPENS
596	PARAURETHRAL SUSPENSION
5971	LEVATOR MUSC SUSPENSION
5979	URIN INCONTIN REPAIR NEC
5991	PERIREN/VESICLE EXCISION
5992	PERIREN/VESICLE OP NEC
600	INCISION OF PROSTATE
6012	OPEN PROSTATIC BIOPSY

Code	Description
6014	OPEN SEMINAL VESICLES BX
6015	PERIPROSTATIC BIOPSY
6018	PROSTATIC DX PROCED NEC
6019	SEMIN VES DX PROCED NEC
602	SEMIN VES DX PROCED NEC
6021	TRANSURETH PROSTATECTOMY
6029	OTH TRANSURETH PROSTATEC
603	SUPRAPUBIC PROSTATECTOMY
604	RETROPUBIC PROSTATECTOMY
605	RADICAL PROSTATECTOMY
6061	LOS EXCIS PROSTATIC LES
6062	PERINEAL PROSTATECTOMY
6069	PROSTATECTOMY NEC
6072	SEMINAL VESICLE INCISION
6073	SEMINAL VESICLE EXCISION
6079	SEMINAL VESICLE OP NEC
6081	PERIPROSTATIC INCISION
6082	PERIPROSTATIC EXCISION
6093	REPAIR OF PROSTATE
6094	CONTROL PROSTATE HEMORR
6095	TRANS BAL DIL PROS URETH
6096	TU DESTR PROSTATE BY MT
6097	OTH TU DESTR PROS - RT
6099	PROSTATIC OPERATION NEC
612	EXCISION OF HYDROCELE
6142	SCROTAL FISTULA REPAIR
6149	SCROTUM/TUNIC REPAIR NEC
6192	EXCISION TUNICA LES NEC
6199	SCROTUM & TUNICA OP NEC
620	INCISION OF TESTES
6212	OPEN TESTICULAR BIOPSY
6219	TESTES DX PROCEDURE NEC
622	TESTICULAR LES DESTRUCT
623	UNILATERAL ORCHIECTOMY
6241	REMOVE BOTH TESTES
6242	REMOVE SOLITARY TESTIS
625	ORCHIOPEXY
6261	SUTURE TESTICULAR LACER
6269	TESTICULAR REPAIR NEC
627	INSERT TESTICULAR PROSTH
6299	TESTICULAR OPERATION NEC
6309	SPERMAT CORD/VAS DX NEC
631	EXC SPERMATIC VARICOCELE

Code	Description
632	EXCISE EPIDIDYMIS CYST
633	EXCISE CORD/EPID LES NEC
634	EPIDIDYMECTOMY
6351	SUTURE CORD & EPID LACER
6353	TRANSPLANT SPERMAT CORD
6359	CORD & EPIDID REPAIR NEC
6381	SUTURE VAS & EPIDID LAC
6382	POSTOP VAS RECONSTRUCT
6383	EPIDIDYMOVASOSTOMY
6385	REMOV VAS DEFERENS VALVE
6389	VAS & EPIDIDY REPAIR NEC
6392	EPIDIDYMOTOMY
6393	SPERMATIC CORD INCISION
6394	SPERM CORD ADHESIOLYSIS
6395	INSERT VALVE IN VAS DEF
6399	CORD/EPID/VAS OPS NEC
640	CIRCUMCISION
6411	PENILE BIOPSY
642	LOCAL EXCIS PENILE LES
643	AMPUTATION OF PENIS
6441	SUTURE PENILE LACERATION
6442	RELEASE OF CHORDEE
6443	CONSTRUCTION OF PENIS
6444	RECONSTRUCTION OF PENIS
6445	REPLANTATION OF PENIS
6449	PENILE REPAIR NEC
645	SEX TRANSFORMAT OP NEC
6492	INCISION OF PENIS
6493	DIVISION OF PENILE ADHES
6495	INS NONINFL PENIS PROSTH
6496	REMOVE INT PENILE PROSTH
6497	INS INFLATE PENIS PROSTH
6498	PENILE OPERATION NEC
6499	MALE GENITAL OP NEC
650	MALE GENITAL OP NEC
6501	LAPAROSCOPIC OOPHOROTOMY
6509	OTHER OOPHOROTOMY
6511	OVARIAN ASPIRAT BIOPSY
6512	OVARIAN BIOPSY NEC
6513	LAP BIOPSY OF OVARY
6514	OTH LAP DX PROC OVARIES
6519	OVARIAN DX PROCEDURE NEC
6521	OVARIAN CYST MARSUPIALIZ

Code	Description
6522	OVARIAN WEDGE RESECTION
6523	LAP MARSUP OVARIAN CYST
6524	LAP WEDGE RESECT OVARY
6525	OTH LAP LOC EXC DEST OVA
6529	LOCAL DESTR OVA LES NEC
653	LOCAL DESTR OVA LES NEC
6531	LAP UNILAT OOPHORECTOMY
6539	OTH UNILAT OOPHORECTOMY
654	OTH UNILAT OOPHORECTOMY
6541	LAP UNI SALPINGO-OOPHOR
6549	OTH UNI SALPINGO-OOPHOR
6551	OTH REMOVE BOTH OVARIES
6552	OTH REMOVE REMAIN OVARY
6553	LAP REMOVE BOTH OVARIES
6554	LAP REMOVE REMAIN OVARY
6561	OTH REMOVE OVARIES/TUBES
6562	OTH REMOVE REM OVA/TUBE
6563	LAP REMOVE OVARIES/TUBES
6564	LAP REMOVE REM OVA/TUBE
6571	OTH SIMPLE SUTURE OVARY
6572	OTH REIMPLANT OF OVARY
6573	OTH SALPINGO-OOPHOROPLAS
6574	LAP SIMPLE SUTURE OVARY
6575	LAP REIMPLANT OF OVARY
6576	LAP SALPINGO-OOPHOROPLAS
6579	REPAIR OF OVARY NEC
658	REPAIR OF OVARY NEC
6581	LAP ADHESIOLYS OVA/TUBE
6589	ADHESIOLYSIS OVARY/TUBE
6591	ASPIRATION OF OVARY
6592	TRANSPLANTATION OF OVARY
6593	MANUAL RUPT OVARIAN CYST
6594	OVARIAN DENERVATION
6595	OVARIAN TORSION RELEASE
6599	OVARIAN OPERATION NEC
660	OVARIAN OPERATION NEC
6601	SALPINGOTOMY
6602	SALPINGOSTOMY
6611	FALLOPIAN TUBE BIOPSY
6619	FALLOP TUBE DX PROC NEC
6621	BILAT ENDOSC CRUSH TUBE
6622	BILAT ENDOSC DIVIS TUBE
6629	BILAT ENDOS OCC TUBE NEC

Code	Description
6631	BILAT TUBAL CRUSHING NEC
6632	BILAT TUBAL DIVISION NEC
6639	BILAT TUBAL DESTRUCT NEC
664	TOTAL UNILAT SALPINGECT
6651	REMOVE BOTH FALLOP TUBES
6652	REMOVE SOLITARY FAL TUBE
6661	DESTROY FALLOP TUBE LES
6662	REMOV TUBE & ECTOP PREG
6663	BILAT PART SALPINGEC NOS
6669	PARTIAL SALPINGECTOM NEC
6671	SIMPL SUTURE FALLOP TUBE
6672	SALPINGO-OOPHOROSTOMY
6673	SALPINGO-SALPINGOSTOMY
6674	SALPINGO-UTEROSTOMY
6679	FALLOP TUBE REPAIR NEC
6692	UNILAT FALLOP TUBE DESTR
6693	IMPL FALLOP TUBE PROSTH
6694	REMOV FALLOP TUBE PROSTH
6695	BLOW THERAPEUT INTO TUBE
6696	FALLOPIAN TUBE DILATION
6697	BURY FIMBRIAE IN UTERUS
6699	FALLOPIAN TUBE OP NEC
6711	ENDOCERVICAL BIOPSY
6712	CERVICAL BIOPSY NEC
6719	CERVICAL DX PROCEDUR NEC
672	CONIZATION OF CERVIX
6731	CERVICAL CYST MARSUPIAL
6732	CERVICAL LES CAUTERIZAT
6733	CERVICAL LES CRYOTHERAPY
6739	CERVICAL LES DESTRUC NEC
674	AMPUTATION OF CERVIX
675	AMPUTATION OF CERVIX
6751	TRANSAB CERCLAGE CERVIX
6759	OTH REP INT CERVICAL OS
6761	SUTURE CERVICAL LACERAT
6762	CERVICAL FISTULA REPAIR
6769	CERVICAL REPAIR NEC
680	HYSTEROTOMY
6813	OPEN UTERINE BIOPSY
6814	OPEN UTERINE LIGAMENT BX
6815	CLOS UTERINE LIGAMENT BX
6816	CLOSED UTERINE BIOPSY
6819	UTERUS/ADNEX DX PROC NEC

Code	Description
6821	ENDOMET SYNECHIAE DIVIS
6822	INCISION UTERINE SEPTUM
6823	ENDOMETRIAL ABLATION
6829	UTERINE LES DESTRUCT NEC
683	UTERINE LES DESTRUCT NEC
6831	LAP SCERVIC HYSTERECTOMY
6839	OTH SUBTOT ABD HYSTERECT OCT03-
684	TOTAL ABD HYSTERECTOMY
6841	LAP TOTAL ABDOMINAL HYST OCT06-
6849	TOTAL ABD HYST NEC/NOS OCT06-
685	VAGINAL HYSTERECTOMY
6851	LAP AST VAG HYSTERECTOMY
6859	VAG HYSTERECTOMY NEC/NOS
686	RADICAL ABD HYSTERECTOMY
6861	LAP RADICAL ABDOMNL HYST OCT06-
6869	RADICAL ABD HYST NEC/NOS OCT06-
687	RADICAL VAG HYSTERECTOMY
6871	LAP RADICAL VAGINAL HYST OCT06-
6879	RADICAL VAG HYST NEC/NOS OCT06-
688	PELVIC EVISCERATION
689	HYSTERECTOMY NEC/NOS
6901	D & C FOR PREG TERMINAT
6902	D & C POST DELIVERY
6909	D & C NEC
6911	D & C NEC
6919	DESTRUC UTER SUPPORT NEC
6921	INTERPOSIT OP UTERIN LIG
6922	UTERINE SUSPENSION NEC
6923	VAG REPAIR INVERS UTERUS
6929	UTERUS/ADNEXA REPAIR NEC
693	PARACERV UTERINE DENERV
6941	SUTURE UTERINE LACERAT
6942	CLOSURE UTERINE FISTULA
6949	UTERINE REPAIR NEC
6951	ASPIRAT CURET-PREG TERMI
6952	ASPIRAT CURET-POST DELIV
6995	INCISION OF CERVIX
6997	REMOVE PENETRAT CERV FB
6998	UTERINE SUPPORT OP NEC
6999	UTERINE OPERATION NEC
7012	CULDOTOMY
7013	INTRALUM VAG ADHESIOLYS
7014	VAGINOTOMY NEC

Code	Description
7023	CUL-DE-SAC BIOPSY
7024	VAGINAL BIOPSY
7029	VAGIN/CUL-DE-SAC DX NEC
7031	HYMENECTOMY
7032	EXCIS CUL-DE-SAC LESION
7033	EXCISION VAGINAL LESION
704	VAGINAL OBLITERATION
7050	CYSTOCEL/RECTOCEL REPAIR
7051	CYSTOCELE REPAIR
7052	RECTOCELE REPAIR
7053	CYSTO & RECTO W GRF/PROS OCT08-
7054	REP CYSTOCEL W GRFT/PROS OCT08-
7055	REP RECTOCELE W GRF/PROS
7061	VAGINAL CONSTRUCTION
7062	VAGINAL RECONSTRUCTION
7063	VAGINAL CONST W GRF/PROS OCT08-
7064	VAG RECONST W GRFT/PROS OCT08-
7071	SUTURE VAGINA LACERATION
7072	REPAIR COLOVAGIN FISTULA
7073	REPAIR RECTOVAG FISTULA
7074	REP VAGINOENT FISTUL NEC
7075	REPAIR VAG FISTULA NEC
7076	HYMENORRHAPHY
7077	VAGINAL SUSPENS & FIXAT
7078	VAG SUSP/FIX W GRFT/PROS OCT08-
7079	VAGINAL REPAIR NEC
708	VAGINAL VAULT OBLITERAT
7091	VAGINAL OPERATION NEC
7092	CUL-DE-SAC OPERATION NEC
7093	CUL-DE-SAC GRF/PROS NEC OCT08-
7101	VULVAR ADHESIOLYSIS
7109	INCIS VULVA/PERINEUM NEC
7111	VULVAR BIOPSY
7119	VULVAR DIAGNOS PROC NEC
7122	INCISE BARTHOLIN"S GLAND
7123	BARTHOLIN GLAND MARSUP
7124	DESTRUC BARTHOLIN GLAND
7129	BARTHOLIN"S GLAND OP NEC
713	LOCAL VULVAR EXCIS NEC
714	OPERATIONS ON CLITORIS
715	RADICAL VULVECTOMY
7161	UNILATERAL VULVECTOMY
7162	BILATERAL VULVECTOMY

Code	Description
7171	SUTURE VULVAR LACERATION
7172	REPAIR VULVAR FISTULA
7179	VULVAR/PERIN REPAIR NEC
718	OTHER VULVAR OPERATIONS
719	OTHER FEMALE GENITAL OPS
7394	PUBIOTOMY TO ASSIST DEL
7399	OPS ASSISTING DELIV NEC
740	CLASSICAL C-SECTION
741	LOW CERVICAL C-SECTION
742	EXTRAPERITONEAL C-SECT
743	REM EXTRATUB ECTOP PREG
744	CESAREAN SECTION NEC
7491	HYSTEROTOMY TO TERMIN PG
7499	CESAREAN SECTION NOS
7536	CORRECTION FETAL DEFECT
7550	REPAIR OB LAC UTERUS NOS
7551	REPAIR OB LACERAT CERVIX
7552	REPAIR OB LAC CORP UTERI
7561	REPAIR OB LAC BLAD/URETH
7593	SURG CORR INVERT UTERUS
7599	OBSTETRIC OPERATION NEC
7601	FACIAL BONE SEQUESTRECT
7609	FACIAL BONE INCISION NEC
7611	FACIAL BONE BIOPSY
7619	FACIAL BONE DX PROC NEC
762	DESTRUCT FACIAL BONE LES
7631	PARTIAL MANDIBULECTOMY
7639	PART FACIAL OSTECTOM NEC
7641	TOT MANDIBULEC W RECONST
7642	TOTAL MANDIBULECTOMY NEC
7643	MANDIBULAR RECONST NEC
7644	TOT FACE OSTECT W RECONS
7645	TOT FACE BONE OSTECT NEC
7646	FACIAL BONE RECONSTR NEC
765	TEMPOROMAND ARTHROPLASTY
7661	CL OSTEOPLASTY MAND RAMI
7662	OPEN OSTEOPLAS MAND RAMI
7663	OSTEOPLASTY MANDIBLE BDY
7664	MAND ORTHOGNATHIC OP NEC
7665	SEG OSTEOPLASTY MAXILLA
7666	TOT OSTEOPLASTY MAXILLA
7667	REDUCTION GENIOPLASTY
7668	AUGMENTATION GENIOPLASTY

Code	Description
7669	FACIAL BONE REPAIR NEC
7670	REDUCTION FACIAL FX NOS
7672	OPN REDUCT MALAR/ZYGO FX
7674	OPEN REDUCT MAXILLARY FX
7676	OPEN REDUCT MANDIBLE FX
7677	OPEN REDUCT ALVEOLAR FX
7679	OPEN REDUCT FACE FX NEC
7691	BONE GRAFT TO FACE BONE
7692	SYN IMPLANT TO FACE BONE
7694	OPEN REDUCT TM DISLOCAT
7697	REMOVE INT FIX FACE BONE
7699	FACIAL BONE/JNT OP NEC
7700	SEQUESTRECTOMY NOS
7701	CHEST CAGE SEQUESTREC
7702	HUMERUS SEQUESTRECTOMY
7703	RADIUS & ULNA SEQUESTREC
7704	METACARP/CARP SEQUESTREC
7705	FEMORAL SEQUESTRECTOMY
7706	PATELLAR SEQUESTRECTOMY
7707	TIBIA/FIBULA SEQUESTREC
7708	METATAR/TAR SEQUESTREC
7709	SEQUESTRECTOMY NEC
7710	OTHER BONE INCISION NOS
7711	OTHER CHEST CAGE INCIS
7712	OTHER HUMERUS INCISION
7713	OTHER RADIUS/ULNA INCIS
7714	OTH METACARP/CARP INCIS
7715	OTHER FEMORAL INCISION
7716	OTHER PATELLAR INCISION
7717	OTHER TIBIA/FIBULA INCIS
7718	OTH METATARS/TARS INCIS
7719	BONE INCIS W/O DIV NEC
7720	WEDGE OSTEOTOMY NOS
7721	CHEST CAGE WEDG OSTEOTOM
7722	HUMERUS WEDGE OSTEOTOMY
7723	RADIUS/ULNA WEDG OSTEOTO
7724	METACAR/CAR WEDG OSTEOTO
7725	FEMORAL WEDGE OSTEOTOMY
7726	PATELLAR WEDGE OSTEOTOMY
7727	TIBIA/FIBUL WEDG OSTEOT
7728	METATAR/TAR WEDG OSTEOT
7729	WEDGE OSTEOTOMY NEC
7730	OTHER BONE DIVISION NOS

Code	Description
7731	CHEST CAGE BONE DIV NEC
7732	HUMERUS DIVISION NEC
7733	RADIUS/ULNA DIVISION NEC
7734	METACAR/CAR DIVISION NEC
7735	FEMORAL DIVISION NEC
7736	PATELLAR DIVISION NEC
7737	TIBIA/FIBULA DIV NEC
7738	METATAR/TAR DIVISION NEC
7739	BONE DIVISION NEC
7740	BONE BIOPSY NOS
7741	CHEST CAGE BONE BIOPSY
7742	HUMERUS BIOPSY
7743	RADIUS & ULNA BIOPSY
7744	METACARPAL/CARPAL BIOPSY
7745	FEMORAL BIOPSY
7746	PATELLAR BIOPSY
7747	TIBIA & FIBULA BIOPSY
7748	METATARSAL/TARSAL BIOPSY
7749	BONE BIOPSY NEC
7751	BUNIONECT/SFT/OSTEOTOMY
7752	BUNIONECT/SFT/ARTHRODES
7753	OTH BUNIONECT W SFT CORR
7754	EXC CORRECT BUNIONETTE
7756	REPAIR OF HAMMER TOE
7757	REPAIR OF CLAW TOE
7758	OTH EXC, FUS, REPAIR TOE
7759	BUNIONECTOMY NEC
7760	LOC EXC BONE LESION NOS
7761	EXC CHEST CAGE BONE LES
7762	LOC EXC BONE LES HUMERUS
7763	LOC EXC LES RADIUS/ULNA
7764	LOC EXC LES METACAR/CAR
7765	LOC EXC BONE LES FEMUR
7766	LOC EXC BONE LES PATELLA
7767	LOC EXC LES TIBIA/FIBULA
7768	LOC EXC LES METATAR/TAR
7769	LOC EXC BONE LESION NEC
7770	EXCISE BONE FOR GRFT NOS
7771	EX CHEST CAGE BONE-GFT
7772	EXCISE HUMERUS FOR GRAFT
7773	EXCIS RADIUS/ULNA-GRAFT
7774	EXCIS METACAR/CAR-GRAFT
7775	EXCISE FEMUR FOR GRAFT

Code	Description
7776	EXCISE PATELLA FOR GRAFT
7777	EXCISE TIB/FIB FOR GRAFT
7778	EXCIS METATAR/TAR-GRAFT
7779	EXCISE BONE FOR GFT NEC
7780	OTH PART OSTECTOMY NOS
7781	OTH CHEST CAGE OSTECTOMY
7782	PARTIAL HUMERECTOMY NEC
7783	PART OSTECT-RADIUS/ULNA
7784	PART OSTECT-METACAR/CAR
7785	PART OSTECTOMY-FEMUR
7786	PARTIAL PATELLECTOMY
7787	PART OSTECT-TIBIA/FIBULA
7788	PART OSTECT-METATAR/TAR
7789	PARTIAL OSTECTOMY NEC
7790	TOTAL OSTECTOMY NOS
7791	TOT CHEST CAGE OSTECTOMY
7792	TOTAL OSTECTOMY-HUMERUS
7793	TOT OSTECT-RADIUS/ULNA
7794	TOT OSTECT-METACARP/CARP
7795	TOT OSTECTOMY-FEMUR
7796	TOTAL PATELLECTOMY
7797	TOT OSTECT-TIBIA/FIBULA
7798	TOT OSTECT-METATARS/TARS
7799	TOTAL OSTECTOMY NEC
7800	BONE GRAFT NOS
7801	BONE GRAFT TO CHEST CAGE
7802	BONE GRAFT TO HUMERUS
7803	BONE GRAFT-RADIUS/ULNA
7804	BONE GRFT TO METACAR/CAR
7805	BONE GRAFT TO FEMUR
7806	BONE GRAFT TO PATELLA
7807	BONE GRAFT-TIBIA/FIBULA
7808	BONE GRAFT-METATAR/TAR
7809	BONE GRAFT NEC
7810	APPLIC EXT FIX DEV NOS
7811	APPL EXT FIX-CHEST CAGE
7812	APPLIC EXT FIX-HUMERUS
7813	APPL EXT FIX-RADIUS/ULNA
7814	APPL EXT FIX-METACAR/CAR
7815	APPLIC EXT FIX DEV-FEMUR
7816	APPL EXT FIX DEV-PATELLA
7817	APPL EXT FIX-TIB/FIBULA
7818	APPL EXT FIX-METATAR/TAR

Code	Description
7819	APPLIC EXT FIX DEV NEC
7820	LIMB SHORTEN PROC NOS
7822	LIMB SHORT PROC-HUMERUS
7823	LIMB SHORTEN-RADIUS/ULNA
7824	LIMB SHORTEN-METACAR/CAR
7825	LIMB SHORT PROC-FEMUR
7827	LIMB SHORTEN-TIB/FIBULA
7828	LIMB SHORTEN-METATAR/TAR
7829	LIMB SHORTEN PROC NEC
7830	LIMB LENGTHEN PROC NOS
7831	LIMB LENGTHEN PROC NOS
7832	LIMB LENGTH PROC-HUMERUS
7833	LIMB LENGTH-RADIUS/ULNA
7834	LIMB LENGTH-METACAR/CAR
7835	LIMB LENGTH PROC-FEMUR
7837	LIMB LENGTHEN-TIB/FIBULA
7838	LIMB LENGTHN-METATAR/TAR
7839	LIMB LENGTHEN PROC NEC
7840	OTH BONE REPAIR/PLAST OP
7841	OTH CHEST CAGE REP/PLAST
7842	OTH HUMERUS REPAIR/PLAST
7843	OTH RAD/ULN REPAIR/PLAST
7844	OTH METAC/CARP REP/PLAST
7845	OTH FEMUR REPAIR/PLASTIC
7846	OTH PATELLA REPAIR/PLAST
7847	OTH TIB/FIB REPAIR/PLAST
7848	OTH META/TAR REPA/PLAST
7849	OTH BONE REPA/PLAST NEC
7850	INT FIX W/O FX REDUC NOS
7851	INT FIXATION-CHEST CAGE
7852	INT FIXATION-HUMERUS
7853	INT FIXATION-RADIUS/ULNA
7854	INT FIXATION-METACAR/CAR
7855	INTERNAL FIXATION-FEMUR
7856	INTERNAL FIX-PATELLA
7857	INT FIXATION-TIBIA/FIBUL
7858	INT FIXATION-METATAR/TAR
7859	INT FIX-NO FX REDUCT NEC
7860	REMOVE IMP DEVICE NOS
7861	REMOV IMP DEV-CHEST CAGE
7862	REMOVE IMPL DEV-HUMERUS
7863	REMOV IMP DEV-RADIUS/ULN
7864	REMOV IMP DEV-METAC/CARP

Code	Description
7865	REMOVE IMP DEVICE-FEMUR
7866	REMOV IMP DEVICE-PATELLA
7867	REMOV IMP DEV-TIB/FIBULA
7868	REMOVE IMP DEV-METAT/TAR
7869	REMOVE IMPL DEVICE NEC
7870	OSTEOCLASIS NOS
7871	OSTEOCLASIS-CHEST CAGE
7872	OSTEOCLASIS-HUMERUS
7873	OSTEOCLASIS-RADIUS/ULNA
7874	OSTEOCLASIS-METACAR/CAR
7875	OSTEOCLASIS-FEMUR
7876	OSTEOCLASIS-PATELLA
7877	OSTEOCLASIS-TIBIA/FIBULA
7878	OSTEOCLASIS-METATAR/TAR
7879	OSTEOCLASIS NEC
7880	OTHER BONE DX PROC NOS
7881	OTH DX PROCED-CHEST CAGE
7882	OTH DX PROCED-HUMERUS
7883	OTH DX PROC-RADIUS/ULNA
7884	OTH DX PROC-METACAR/CAR
7885	OTH DX PROCED-FEMUR
7886	OTH DX PROCED-PATELLA
7887	OTH DX PROC-TIBIA/FIBULA
7888	OTH DX PROC-METATAR/TAR
7889	OTHER BONE DX PROC NEC
7890	INSERT BONE STIMUL NOS
7891	INSERT BONE STIMUL-CHEST
7892	INSERT BONE STIM-HUMERUS
7893	INSER BONE STIM-RAD/ULNA
7894	INSER BONE STIM-META/CAR
7895	INSERT BONE STIM-FEMUR
7896	INSERT BONE STIM-PATELLA
7897	INSER BONE STIM-TIB/FIB
7898	INSER BONE STIM-META/TAR
7899	INSERT BONE STIMUL NEC
7910	CL FX REDUC-INT FIX NOS
7911	CLOS RED-INT FIX HUMERUS
7912	CL RED-INT FIX RAD/ULNA
7913	CL RED-INT FIX METAC/CAR
7914	CLOSE RED-INT FIX FINGER
7915	CLOSED RED-INT FIX FEMUR
7916	CL RED-INT FIX TIB/FIBU
7917	CL RED-INT FIX METAT/TAR

Code	Description
7918	CLOSE RED-INT FIX TOE FX
7919	CL FX REDUC-INT FIX NEC
7920	OPEN FX REDUCTION NOS
7921	OPEN REDUC-HUMERUS FX
7922	OPEN REDUC-RADIUS/ULN FX
7923	OPEN REDUC-METAC/CAR FX
7924	OPEN REDUCTION-FINGER FX
7925	OPEN REDUCTION-FEMUR FX
7926	OPEN REDUC-TIBIA/FIB FX
7927	OPEN REDUC-METAT/TARS FX
7928	OPEN REDUCTION-TOE FX
7929	OPEN FX REDUCTION NEC
7930	OPN FX RED W INT FIX NOS
7931	OPEN RED-INT FIX HUMERUS
7932	OP RED-INT FIX RAD/ULNA
7933	OP RED-INT FIX METAC/CAR
7934	OPEN RED-INT FIX FINGER
7935	OPEN REDUC-INT FIX FEMUR
7936	OP RED-INT FIX TIB/FIBUL
7937	OP RED-INT FIX METAT/TAR
7938	OPEN REDUCT-INT FIX TOE
7939	OPN FX RED W INT FIX NEC
7940	CLS REDUC-SEP EPIPHY NOS
7941	CLOSE RED-HUMERUS EPIPHY
7942	CLS RED-RADIUS/UL EPIPHY
7945	CLOSE REDUC-FEMUR EPIPHY
7946	CLS RED-TIBIA/FIB EPIPHY
7949	CLS REDUC-SEP EPIPHY NEC
7950	OPEN RED-SEP EPIPHY NOS
7951	OPN RED-SEP EPIPHY-HUMER
7952	OP RED-RADIUS/ULN EPIPHY
7955	OPN RED-SEP EPIPHY-FEMUR
7956	OP RED-TIBIA/FIB EPIPHYS
7959	OPEN RED-SEP EPIPHY NEC
7960	OPEN FX SITE DEBRIDE NOS
7961	DEBRID OPEN FX-HUMERUS
7962	DEBRID OPN FX-RADIUS/ULN
7963	DEBRID OPN FX-METAC/CAR
7964	DEBRID OPN FX-FINGER
7965	DEBRID OPN FX-FEMUR
7966	DEBRID OPN FX-TIBIA/FIB
7967	DEBRID OPN FX-METAT/TAR
7968	DEBRID OPN FX-TOE

Code	Description
7969	OPEN FX SITE DEBRIDE NEC
7980	OPEN REDUC-DISLOCAT NOS
7981	OPN REDUC DISLOC-SHOULDR
7982	OPEN REDUC-ELBOW DISLOC
7983	OPEN REDUC-WRIST DISLOC
7984	OPN REDUC DISLOC-HAND
7985	OPEN REDUC-HIP DISLOCAT
7986	OPEN REDUC-KNEE DISLOCAT
7987	OPEN REDUC-ANKLE DISLOC
7988	OPN REDUC DISLOC-FT/TOE
7989	OPEN REDUC-DISLOCAT NEC
7990	UNSPEC OP BONE INJ NOS
7991	HUMERUS INJURY OP NOS
7992	RADIUS/ULNA INJ OP NOS
7993	METACARP/CARP INJ OP NOS
7994	FINGER INJURY OP NOS
7995	FEMUR INJURY OP NOS
7996	TIBIA/FIBULA INJ OP NOS
7997	METATARS/TARS INJ OP NOS
7998	TOE INJURY OPERATION NOS
7999	UNSPEC OP-BONE INJ NEC
8000	ARTHROT & PROS REMOV NOS
8001	ARTHROT/PROS REMOV-SHLDR
8002	ARTHROT/PROS REMOV-ELBOW
8003	ARTHROT/PROS REMOV-WRIST
8004	ARTHROT/PROS REMOV-HAND
8005	ARTHROT/PROS REMOV-HIP
8006	ARTHROT/PROS REMOV-KNEE
8007	ARTHROT/PROS REMOV-ANKLE
8008	ARTHROT/PROS REMOV-FOOT
8009	ARTHROT & PROS REMOV NEC
8010	OTHER ARTHROTOMY NOS
8011	OTH ARTHROTOMY-SHOULDER
8012	OTH ARTHROTOMY-ELBOW
8013	OTH ARTHROTOMY-WRIST
8014	OTH ARTHROTOMY-HAND/FNGR
8015	OTH ARTHROTOMY-HIP
8016	OTH ARTHROTOMY-KNEE
8017	OTH ARTHROTOMY-ANKLE
8018	OTH ARTHROTOMY-FOOT/TOE
8019	OTHER ARTHROTOMY NEC
8020	ARTHROSCOPY NOS
8021	SHOULDER ARTHROSCOPY

Code	Description
8022	ELBOW ARTHROSCOPY
8023	WRIST ARTHROSCOPY
8024	HAND & FINGER ARTHROSCOP
8025	HIP ARTHROSCOPY
8026	KNEE ARTHROSCOPY
8027	ANKLE ARTHROSCOPY
8028	FOOT & TOE ARTHROSCOPY
8029	ARTHROSCOPY NEC
8040	JT STRUCTUR DIVISION NOS
8041	SHOULDER STRUCT DIVISION
8042	ELBOW STRUCTURE DIVISION
8043	WRIST STRUCTURE DIVISION
8044	HAND JOINT STRUCT DIVIS
8045	HIP STRUCTURE DIVISION
8046	KNEE STRUCTURE DIVISION
8047	ANKLE STRUCTURE DIVISION
8048	FOOT JOINT STRUCT DIVIS
8049	JT STRUCTUR DIVISION NEC
805	JT STRUCTUR DIVISION NEC
8050	EXC/DEST INTVRT DISC NOS
8051	EXCISION INTERVERT DISC
8053	REP ANULUS FIBROSUS-GRFT OCT08-
8054	REP ANULS FIBROS NEC/NOS OCT08-
8059	OTH EXC/DEST INTVRT DISC
806	EXCIS KNEE SEMILUN CARTL
8070	SYNOVECTOMY-SITE NOS
8071	SHOULDER SYNOVECTOMY
8072	ELBOW SYNOVECTOMY
8073	WRIST SYNOVECTOMY
8074	HAND SYNOVECTOMY
8075	HIP SYNOVECTOMY
8076	KNEE SYNOVECTOMY
8077	ANKLE SYNOVECTOMY
8078	FOOT SYNOVECTOMY
8079	SYNOVECTOMY-SITE NEC
8080	DESTRUCT JOINT LES NOS
8081	DESTRUC-SHOULDER LES NEC
8082	DESTRUC-ELBOW LESION NEC
8083	DESTRUC-WRIST LESION NEC
8084	DESTRUC-HAND JT LES NEC
8085	DESTRUCT-HIP LESION NEC
8086	DESTRUCT-KNEE LESION NEC
8087	DESTRUC-ANKLE LESION NEC

Code	Description
8088	DESTRUC-FOOT JT LES NEC
8089	DESTRUCT JOINT LES NEC
8090	EXCISION OF JOINT NOS
8091	EXCISION OF SHOULDER NEC
8092	EXCISION OF ELBOW NEC
8093	EXCISION OF WRIST NEC
8094	EXCISION HAND JOINT NEC
8095	EXCISION OF HIP NEC
8096	EXCISION OF KNEE NEC
8097	EXCISION OF ANKLE NEC
8098	EXCISION FOOT JOINT NEC
8099	EXCISION OF JOINT NEC
8100	SPINAL FUSION NOS
8101	ATLAS-AXIS FUSION
8102	OTHER CERVICAL FUS ANT
8103	OTHER CERVICAL FUS POST
8104	DORSAL/DORSOLUM FUS ANT
8105	DORSAL/DORSOLUM FUS POST
8106	LUMBAR/LUMBOSAC FUS ANT
8107	LUMBAR/LUMBOSAC FUS LAT
8108	LUMBAR/LUMBOSAC FUS POST
8109	LUMBAR/LUMBOSAC FUS POST
8111	ANKLE FUSION
8112	TRIPLE ARTHRODESIS
8113	SUBTALAR FUSION
8114	MIDTARSAL FUSION
8115	TARSOMETATARSAL FUSION
8116	METATARSOPHALANGEAL FUS
8117	OTHER FUSION OF FOOT
8118	OTHER FUSION OF FOOT
8120	ARTHRODESIS NOS
8121	ARTHRODESIS OF HIP
8122	ARTHRODESIS OF KNEE
8123	ARTHRODESIS OF SHOULDER
8124	ARTHRODESIS OF ELBOW
8125	CARPORADIAL FUSION
8126	METACARPOCARPAL FUSION
8127	METACARPOPHALANGEAL FUS
8128	INTERPHALANGEAL FUSION
8129	ARTHRODESIS NEC 04)
8130	SPINAL REFUSION NOS 04)
8131	REFUSION OF ATLAS-AXIS
8132	REFUSION OF OTH CERV ANT

Code	Description
8133	REFUS OF OTH CERV POST
8134	REFUSION OF DORSAL ANT
8135	REFUSION OF DORSAL POST
8136	REFUSION OF LUMBAR ANT
8137	REFUSION OF LUMBAR LAT
8138	REFUSION OF LUMBAR POST
8139	REFUSION OF SPINE NEC
8140	REPAIR OF HIP, NEC
8141	REPAIR OF HIP, NEC
8142	FIVE-IN-ONE KNEE REPAIR
8143	TRIAD KNEE REPAIR
8144	PATELLAR STABILIZATION
8145	CRUCIATE LIG REPAIR NEC
8146	COLLATERL LIG REPAIR NEC
8147	OTHER REPAIR OF KNEE
8148	OTHER REPAIR OF KNEE
8149	OTHER REPAIR OF ANKLE
8151	TOTAL HIP REPLACEMENT
8152	PARTIAL HIP REPLACEMENT
8153	REVISE HIP REPLACEMENT
8154	TOTAL KNEE REPLACEMENT
8155	REVISE KNEE REPLACEMENT
8156	TOTAL ANKLE REPLACEMENT
8157	REPL JOINT OF FOOT, TOE
8159	REV JT REPL LOW EXT
8161	360 SPINAL FUSION
8162	FUS/REFUS 40577 VERTEBRAE
8163	FUS/REFUS 40641 VERTEBRAE
8164	FUS/REFUS 9 VERTEBRAE
8165	VERTEBROPLASTY (OCT 04)
8166	KYPHOPLASTY (OCT 04)
8169	OTH HIP REPAIR JAN80--SEP89 OCT05-
8171	ARTHROPLAS METACARP WIT
8172	ARTHROPLASTY METACAR W/O
8173	TOTAL WRIST REPLACEMENT
8174	ARTHROPLASTY CARPAL WIT
8175	ARTHROPLASTY CARPAL W/O
8179	OTH REPAIR HAN/FIN/WRIS
8180	TOTAL SHOULDER REPLACE
8181	PARTIAL SHOULDER REPLACE
8182	REP RECUR SHLDER DISLOC
8183	SHOULDER ARTHROPLAST NEC
8184	TOTAL ELBOW REPLACEMENT

Code	Description
8185	ELBOW ARTHROPLASTY NEC
8186	ELBOW ARTHROPLASTY NEC
8187	ELBOW ARTHROPLASTY NEC
8193	SUTUR CAPSUL/LIGAMEN ARM
8194	SUTURE CAPSUL/LIG ANK/FT
8195	SUTUR CAPSUL/LIG LEG NEC
8196	OTHER REPAIR OF JOINT
8197	REV JT REPL UPPER EXTREM
8198	OTHER JOINT DX PROCEDURE
8199	JOINT STRUCTURE OP NEC
8201	EXPLOR TEND SHEATH-HAND
8202	MYOTOMY OF HAND
8203	BURSOTOMY OF HAND
8209	INC SOFT TISSUE HAND NEC
8211	TENOTOMY OF HAND
8212	FASCIOTOMY OF HAND
8219	DIV SOFT TISSUE HAND NEC
8221	EXC LES TEND SHEATH HAND
8222	EXCISION HAND MUSCLE LES
8229	EXC LES SFT TISS HND
8231	BURSECTOMY OF HAND
8232	EXCIS HAND TEND FOR GRFT
8233	HAND TENONECTOMY NEC
8234	EXC HND MUS/FAS FOR GRFT
8235	HAND FASCIECTOMY NEC
8236	OTHER MYECTOMY OF HAND
8239	HAND SOFT TISSUE EXC NEC
8241	SUTURE TENDN SHEATH HAND
8242	DELAY SUT FLEX TEND HAND
8243	DELAY SUT HAND TEND NEC
8244	SUTUR FLEX TEND HAND NEC
8245	SUTURE HAND TENDON NEC
8246	SUTURE HAND MUSCLE/FASC
8251	HAND TENDON ADVANCEMENT
8252	HAND TENDON RECESSION
8253	HAND TENDON REATTACHMENT
8254	HAND MUSCLE REATTACHMENT
8255	CHNG HND MUS/TEN LNG NEC
8256	TRANSPLANT HAND TEND NEC
8257	TRANSPOSIT HAND TEND NEC
8258	TRANSPLANT HAND MUSC NEC
8259	TRANSPOSIT HAND MUSC NEC
8261	POLLICIZATION OPERATION

Code	Description
8269	THUMB RECONSTRUCTION NEC
8271	HAND TEND PULLEY RECONST
8272	PLAST OP HND-MUS/FAS GRF
8279	PLAST OP HAND W GRFT
8281	TRANSFER OF FINGER
8282	REPAIR OF CLEFT HAND
8283	REPAIR OF MACRODACTYLY
8284	REPAIR OF MALLET FINGER
8285	OTHER TENODESIS OF HAND
8286	OTHER TENOPLASTY OF HAND
8289	HAND PLASTIC OP NEC
8291	LYSIS OF HAND ADHESIONS
8299	HAND MUS/TEN/FAS/OPS NEC
8301	TENDON SHEATH EXPLORAT
8302	MYOTOMY
8303	BURSOTOMY
8309	SOFT TISSUE INCISION NEC
8311	ACHILLOTENOTOMY
8312	ADDUCTOR TENOTOMY OF HIP
8313	OTHER TENOTOMY
8314	FASCIOTOMY
8319	SOFT TISSUE DIVISION NEC
8321	SOFT TISSUE BIOPSY
8329	SOFT TISSUE DX PROC NEC
8331	EXCIS LES TENDON SHEATH
8332	EXCIS LESION OF MUSCLE
8339	EXC LES SOFT TISSUE NEC
8341	TENDON EXCISION FOR GRFT
8342	OTHER TENONECTOMY
8343	MUSC/FASC EXCIS FOR GRFT
8344	OTHER FASCIECTOMY
8345	OTHER MYECTOMY
8349	OTHER SOFT TISSUE EXCIS
835	BURSECTOMY
8361	TENDON SHEATH SUTURE
8362	DELAYED TENDON SUTURE
8363	ROTATOR CUFF REPAIR
8364	OTHER SUTURE OF TENDON
8365	OTHER MUSCLE/FASC SUTURE
8371	TENDON ADVANCEMENT
8372	TENDON RECESSION
8373	TENDON REATTACHMENT
8374	MUSCLE REATTACHMENT

Code	Description
8375	TENDON TRNSFR/TRANSPLANT
8376	OTHER TENDON TRANSPOSIT
8377	MUSCLE TRNSFR/TRANSPLANT
8379	OTHER MUSCLE TRANSPOSIT
8381	TENDON GRAFT
8382	MUSCLE OR FASCIA GRAFT
8383	TENDON PULLEY RECONSTRUC
8384	CLUBFOOT RELEASE NEC
8385	MUSC/TEND LNG CHANGE NEC
8386	QUADRICEPSPLASTY
8387	OTHER PLASTIC OPS MUSCLE
8388	OTHER PLASTIC OPS TENDON
8389	OTHER PLASTIC OPS FASCIA
8391	ADHESIOLYSIS MUS/TEN/FAS
8392	INSERT SKEL MUSC STIMULA
8393	REMOV SKEL MUSC STIMULAT
8399	MUS/TEN/FAS/BUR OP NEC
8400	UPPER LIMB AMPUTAT NOS
8401	FINGER AMPUTATION
8402	THUMB AMPUTATION
8403	AMPUTATION THROUGH HAND
8404	DISARTICULATION OF WRIST
8405	AMPUTATION THRU FOREARM
8406	DISARTICULATION OF ELBOW
8407	AMPUTATION THRU HUMERUS
8408	SHOULDER DISARTICULATION
8409	FOREQUARTER AMPUTATION
8410	LOWER LIMB AMPUTAT NOS
8411	TOE AMPUTATION
8412	AMPUTATION THROUGH FOOT
8413	DISARTICULATION OF ANKLE
8414	AMPUTAT THROUGH MALLEOLI
8415	BELOW KNEE AMPUTAT NEC
8416	DISARTICULATION OF KNEE
8417	ABOVE KNEE AMPUTATION
8418	DISARTICULATION OF HIP
8419	HINDQUARTER AMPUTATION
8421	THUMB REATTACHMENT
8422	FINGER REATTACHMENT
8423	FOREARM/WRIST/HAND REATT
8424	UPPER ARM REATTACHMENT
8425	TOE REATTACHMENT
8426	FOOT REATTACHMENT

Code	Description
8427	LOWER LEG/ANKLE REATTACH
8428	THIGH REATTACHMENT
8429	REATTACHMENT NEC
843	AMPUTATION STUMP REVIS
8440	IMPLNT/FIT PROS LIMB NOS
8444	IMPLANT ARM PROSTHESIS
8448	IMPLANT LEG PROSTHESIS
8458	IMP INTRSPINE DECOMP DEV OCT05-
8459	INSERT OTH SPIN DEVICE
8460	INSERT DISC PROS NOS (OCT
8461	INS PART DISC PROS CERV
8462	INS TOT DISC PROST CERV
8463	INS SPIN DISC PROS THOR
8464	INS PART DISC PROS LUMB
8465	INS TOTL DISC PROS LUMB
8466	REVISE DISC PROST CERV (OCT
8467	REVISE DISC PROST THORA (OCT
8468	REVISE DISC PROSTH LUMB (OCT
8469	REVISE DISC PROSTH NOS (OCT
8480	INS/REPL INTERSPINE DEV OCT08- OCT08-
8481	REV INTERSPINE DEVICE OCT08-
8482	INS/REPL PDCL STABIL DEV OCT08-
8483	REV PEDCL DYN STABIL DEV
8484	INS/REPL FACET REPLC DEV OCT08-
8485	REV FACET REPLACE DEVICE OCT08-
8491	AMPUTATION NOS
8492	SEPARAT EQUAL JOIN TWIN
8493	SEPARAT UNEQUL JOIN TWIN
8499	MUSCULOSKELETAL OP NEC
8512	OPEN BREAST BIOPSY
8520	BREAST TISSU DESTRUC NOS
8521	LOCAL EXCIS BREAST LES
8522	QUADRANT RESECT BREAST
8523	SUBTOTAL MASTECTOMY
8524	EXC ECTOPIC BREAST TISSU
8525	EXCISION OF NIPPLE
8531	UNILAT REDUCT MAMMOPLAST
8532	BILAT REDUCT MAMMOPLASTY
8533	UNIL SUBQ MAMMECT-IMPLNT
8534	UNILAT SUBQ MAMMECT NEC
8535	BIL SUBQ MAMMECT-IMPLANT
8536	BILAT SUBQ MAMMECTOM NEC
8541	UNILAT SIMPLE MASTECTOMY

Code	Description
8542	BILAT SIMPLE MASTECTOMY
8543	UNILAT EXTEN SIMP MASTEC
8544	BILAT EXTEND SIMP MASTEC
8545	UNILAT RADICAL MASTECTOM
8546	BILAT RADICAL MASTECTOMY
8547	UNIL EXT RAD MASTECTOMY
8548	BIL EXTEN RAD MASTECTOMY
8550	AUGMENT MAMMOPLASTY NOS
8553	UNILAT BREAST IMPLANT
8554	BILATERAL BREAST IMPLANT
856	MASTOPEXY
857	TOTAL BREAST RECONSTRUCT
8570	TOTL RECONSTC BREAST NOS OCT09-
8571	LATISS DORSI MYOCUT FLAP OCT08-
8572	TRAM FLAP, PEDICLED OCT08-
8573	TRAM FLAP, FREE OCT08-
8574	DIEP FLAP, FREE OCT08-
8575	SIEA FLAP, FREE OCT08-
8576	GAP FLAP, FREE OCT08-
8579	TOTL RECONST BREAST NEC OCT08-
8582	BREAST SPLIT-THICK GRAFT
8583	BREAST FULL-THICK GRAFT
8584	BREAST PEDICLE GRAFT
8585	BREAST MUSCLE FLAP GRAFT
8586	TRANSPOSITION OF NIPPLE
8587	NIPPLE REPAIR NEC
8589	MAMMOPLASTY NEC
8593	BREAST IMPLANT REVISION
8594	BREAST IMPLANT REMOVAL
8595	INSER BREAST TISSU EXPAN
8596	REMOV BREAST TISSU EXPAN
8599	BREAST OPERATION NEC
8606	INSERT INFUSION PUMP
8621	EXCISION OF PILONID CYST
8622	EXC WOUND DEBRIDEMENT
8625	DERMABRASION
864	RADICAL EXCIS SKIN LES
8660	FREE SKIN GRAFT NOS
8661	FULL-THICK HAND SKIN GRF
8662	HAND SKIN GRAFT NEC
8663	FULL-THICK SKIN GRFT NEC
8665	HETEROGRAFT TO SKIN
8666	HOMOGRAFT TO SKIN

Code	Description
8667	DERMAL REGENER GRAFT
8669	FREE SKIN GRAFT NEC
8670	PEDICLE GRAFT/FLAP NOS
8671	CUT & PREP PEDICLE GRAFT
8672	PEDICLE GRAFT ADVANCEMEN
8673	ATTACH PEDICLE TO HAND
8674	ATTACH PEDICLE GRAFT NEC
8675	REVISION OF PEDICLE GRFT
8681	REPAIR FACIAL WEAKNESS
8682	FACIAL RHYTIDECTOMY
8683	SIZE REDUCT PLASTIC OP
8684	RELAXATION OF SCAR
8685	SYNDACTYLY CORRECTION
8686	ONYCHOPLASTY
8689	SKIN REPAIR & PLASTY NEC
8691	SKIN EXCISION FOR GRAFT
8693	INSERT TISSUE EXPANDER
8694	INS/REPL SINGLE PUL GEN (OCT
8695	INS/REPL DUAL PULSE GEN (OCT
8696	INSERT/REPL OTH NEUROST (OCT 04)
8697	INS/REP 1 PUL GEN OCT05-
8698	INS/REP 2 PUL GEN OCT05-
8753	INTRAOPER CHOLANGIOGRAM
9227	RADIOACTIVE ELEM IMPLANT OCT09-
9504	ANESTHETIZED EYE EXAM

Appendix C

Supplemental Pneumonia Methodology Tables

Table 136**.** AHRQ IQI-20: Pneumonia Mortality Definitions, ICD-9-CM Diagnosis Codes

Code	Description
00322	SALMONELLA PNEUMONIA
0212	PULMONARY TULAREMIA
0391	PULMONARY ACTINOMYCOSIS
0521	VARICELLA PNEUMONITIS
0551	POSTMEASLES PNEUMONIA
0730	ORNITHOSIS PNEUMONIA
1124	CANDIDIASIS OF LUNG
1140	PRIMARY COCCIDIOIDOMYCOS
1144	CHRONIC PULMONCOCCIDIOIDOMYCOSIS
1145	UNSPEC PULMON COCCIDIOIDOMYCOSIS
11505	HISTOPLASM CAPS PNEUMON
11515	HISTOPLASM DUB PNEUMONIA
11595	HISTOPLASMOSIS PNEUMONIA
1304	TOXOPLASMA PNEUMONITIS
1363	PNEUMOCYSTOSIS
4800	ADENOVIRAL PNEUMONIA
4801	RESP SYNCYT VIRAL PNEUM
4802	PARINFLUENZA VIRAL PNEUM
4803	PNEUMONIA DUE TO SARS OCT03-
4808	VIRAL PNEUMONIA NEC
4809	VIRAL PNEUMONIA NOS
481	PNEUMOCOCCAL PNEUMONIA
4820	K. PNEUMONIAE PNEUMONIA
4821	PSEUDOMONAL PNEUMONIA
4822	H.INFLUENZAE PNEUMONIA
4824	STAPHYLOCOCCAL PNEUMONIA
4831	CHLAMYDIA PNEUMONIA OCT96-
4838	OTH SPEC ORG PNEUMONIA
4841	PNEUM W CYTOMEG INCL DIS
4829	BACTERIAL PNEUMONIA NOS

Code	Description
4830	MYCOPLASMA PNEUMONIA
4843	PNEUMONIA IN WHOOP COUGH
4845	PNEUMONIA IN ANTHRAX
4846	PNEUM IN ASPERGILLOSIS
4847	PNEUM IN OTH SYS MYCOSES
4848	PNEUM IN INFECT DIS NEC
485	BRONCOPNEUMONIA ORG NOS
486	PNEUMONIA, ORGANISM NOS
48230	STREP PNEUMONIA, UNSPEC
48231	GRP A STREP PNEUMONIA
48232	GRP B STREP PNEUMONIA
48239	OTH STREP PNEUMONIA
48240	STAPH PNEUMONIA UNSP OCT98-
48241	METICILLIN SUSCEPTIBLE PNEUMONIA DUE TO STAPHYLOCOCCUS AUREUS OCT08-
48242	METHICILLIN RESISTANT PNEUMONIA DUE TO STAPHYLOCOCCUS AUREUS OCT08-
42249	STAPH PNEUMON OTH OCT98-
48281	ANAEROBIC PNEUMONIA
48282	E COLI PNEUMONIA
48283	OTH GRAM NEG PNEUMONIA
48284	LEGIONNAIRES DX OCT97-
48289	BACT PNEUMONIA NEC
4870	INFLUENZA WITH PNEUMONIA

Exclude cases:

• Missing discharge disposition (DISP = missing), sex (SEX = missing), age (AGE = missing), quarter (DQTR = missing), year (YEAR = missing) or principal diagnosis (DX1 = missing)

• Transferring to another short-term hospital (DISP = 2)

• MDC 14 (pregnancy, childbirth, and puerperium).

Table 137. Monthly Utilization of Pneumonia Order Sets

Category	Hospital Code	Order Set Title	Catalog ID	Year Available	Monthly Utilization Average (Aug 2010)
Pneumonia	CMC	Community Acquired Pneumonia Adult Order Set CMC	33166393	2007	2
Pneumonia	GSAM	Pneumonia Adult Order Set GSA	48577863	2007	7
Pneumonia	IMMC	Community Acquired Pneumonia (CAP) Order Set IMC	32342226	2007	20
Pneumonia	SSUB	Pneumonia Inpatient Adult Order Set SSH	139008712	2007	4
	TRIN	Community Acquired Pneumonia Order Set TRI	483701535	2010	6

Table 138. Pneumonia Order Set Content

Order Set Title	Facility	Catalog Number	Content
Community Acquired Pneumonia Adult Order Set CMC	CMC	33166393	Activity Patient Admit Patient - full inpatient Azithromycin Blood Culture [BLC] Blood Gas Cardiac Diet CBC with differential [CBCA] Ceftriaxone Comprehensive Metabolic Panel [CPNL] Dextrose 5% - 0.45% NaCl Diabetic 1800 Cal diet Discharge planning Evaluation Adult Doxycycline

Order Set Title	Facility	Catalog Number	Content
			General diet Gram smear [GRAS] Influenza Rapid AG [FLUAG] Influenza virus vaccine, inactivated Lactated ringers Legionella AG urine [LEGEIA] Mini BAL Moxifloxacin NPO Nursing Communication Order Oxygen Place in 23hr observation Pneumococcal 23-valent vaccine Pulse Ox spot check Saline Lock insertion Sodium Chloride 0.9% Sputum Culture/Smear Vancomycin Vital signs per unit routine XR Chest PA, Lateral 2V Zosyn
Pneumonia Adult Order Set GSA	GSAM	48577863	Azithromycin Aztreonam Blood Culture [BLC] Bronchodilator protocol CBC with Differential [CBCA] Cefepime Ceftriaxone Ciprofloxacin CMP Levofloxacin Medical/Surgical General Admission Order Set GSA Moxifloxacin O2 protocol Pharmacist to dose: Vancomycin (consult) Social work weferral adult XR chest PA, Lateral 2V

Order Set Title	Facility	Catalog Number	Content
Community Acquired Pneumonia (CAP) Order Set IMC	IMMC	32342226	AFB culture/smear Blood Culture [BLC] CAP Standard Antibiotic Regimen Order Set IMC CAP suspected gram Neg/Aspiration/NH Admit Order Set IMC Gram smear [GRAS] HIV I/II AB SCR-ELISA [HIVABS] Isolation Legionella AG urine [LEGEIA] Nursing communication order Pulse Ox spot check S Pneumonia Antigen [USTREP] Sputum culture/smear
Pneumonia Inpatient Adult Order Set SSH	SSUB	139008712	Avelox Azactam Blood Culture [BLC] BMP CBC with differential [CBCA] Cleocin EKG 12 Lead SSH Maxipime MetroNIDAZOLE Oxygen Pulse Ox spot check Rocephin Saline (sodium chloride) IV lock flush injection Saline Lock Insertion UA complete W C/S IF IND Vancomycin - pharmacist to dose (consult) Vancomycin XR chest PA, Lateral 2V Zithromax Zosyn
Community Acquired Pneumonia Order Set TRI	TRIN	483701535	ABG Admit patient - full inpatient AFB culture/smear Azithromycin Aztreonam

Order Set Title	Facility	Catalog Number	Content
			B Type Natriuretic Peptide [BNPEP]
			Basic metabolic panel [BPNL]
			Bedside swallow adult evaluation and TX
			Blood culture [BLC]
			CBC with differential [CBCA]
			Ceftriaxone
			Ciprofloxacin
			Consult physician
			CT chest high resolution WO consultation
			Discharge planning evaluation - adult
			HIV I/II AB SCR-ELISA [HIVABS]
			Influenza virus vaccine, inactivated
			Intake and output
			Isolation
			Legionella AB [LEGA]
			Linezolid
			Moxifloxacin
			Mycoplasma Pneumoniae IGG
			Mycoplasma Pneumoniae IGM
			NM Lung VQ scan
			Nursing communication order
			Patient activity
			Piperacillin-tazobactam
			Place in 23hr observation
			Pneumococcal 23-valent vaccine
			Pulse Ox spot check
			RBC SED rate [RESR]
			Respiratory assessment nursing
			Respiratory therapy communication order
			S Pneumoniae Antigen [USTREP]
			Saline lock insertion
			Smoking cessation education - nursing
			Sputum culture/smear
			Sputum induction
			Swallow adult evaluation and TX
			Vancomycin
			Vital signs
			XR chest PA, Lateral 2V

Table 139. Randomly Generated Patient Race Codes – Pneumonia Study

Race Description	**Randomly Generated Code**
African American / Black	10
American Indian / Alaska Native	11
Asian/Filipino	12
Caucasian/White	13
Declined	14
Eastern Indian	15
Hispanic	16
Middle East	17
Other	18
Pacific Islander / Hawaiian	19
Unknown	20

Appendix D

Supplemental CHF Methodology Tables

Table 140. AHRQ IQI-16: CHF Mortality Definitions, ICD-9-CM Diagnosis Codes

Code	Description
39891	RHEUMATIC HEART FAILURE
40201	MAL HYPERT HRT DIS W CHF
40211	BENIGN HYP HRT DIS W CHF
40291	HYPERTEN HEART DIS W CHF
40401	MAL HYPER HRT/REN W CHF
40403	MAL HYP HRT/REN W CHF&RF
40411	BEN HYPER HRT/REN W CHF
40413	BEN HYP HRT/REN W CHF&RF
40491	HYPER HRT/REN NOS W CHF
40493	HYP HT/REN NOS W CHF&RF
4280	CONGESTIVE HEART FAILURE
4281	LEFT HEART FAILURE
42820	SYSTOLIC HEART FAILURE NOS (OCT02)
42821	AC SYSTOLIC HRT FAILURE (OCT02)
42822	CHR SYSTOLIC HRT FAILURE (OCT02)
42823	AC ON CHR SYST HRT FAIL (OCT02)
4289	HEART FAILURE NOS
42830	DIASTOLIC HRT FAILURE NOS (OCT02)
42831	AC DIASTOLIC HRT FAILURE (OCT02)
42832	CHR DIASTOLIC HRT FAIL (OCT02)
42833	AC ON CHR DIAST HRT FAIL (OCT02)
42840	SYST/DIAST HRT FAIL NOS (OCT02)
42841	AC SYST/DIASTOL HRT FAIL (OCT02)
42842	CHR SYST/DIASTL HRT FAIL (OCT02)
42843	AC/CHR SYST/DIA HRT FAIL (OCT02)

Exclude cases:

- Transferring to another short-term hospital (Disposition=2)
- MDC 14 (pregnancy, childbirth, and puerperium)

- With missing discharge disposition (Disposition=missing), sex (Sex=missing), age (Age=missing), quarter (DQTR=missing), year (Year=missing), or principal diagnosis (DX1=missing).

Table 141. Monthly Utilization of CHF Order Sets

Category	**Hospital Code**	**Order Set Title**	**Catalog ID**	**Year Available**	**Monthly Utilization Average (Aug 2010)**
CHF	CMC	CHF Unit Admission Order Set CMC	13026418	2004	3
CHF	GSHP	Congestive Heart Failure Order Admission Set GSH	49502942	2005	2
CHF	IMMC	Congestive Heart Failure Order Admission Set IMC	24458894	2005	26
CHF	SSUB	Heart Failure Order Set SSH	173004691	2007	4
CHF	LGH	Heart Failure Management Order Set LGH	369504735	2008	6

Table 142. CHF Order Set Content

Order Set Title	Facility	Catalog Number	Content
CHF Unit Admission Order Set CMC	CMC	13026418	ACE Contraindications Activity Patient Admit Patient - Full Inpatient albuterol inhalation 0.083% 2.5 mg/3 mL solution. Altace Antiembolytic Hose ARB Contraindications Avapro B TYPE NATRIURETIC PEPTIDE [BNPEP] BASIC METABOLIC PANEL [BPNL] Bioimpedance Test BIPAP Capoten Cardiac Diet Cardiac Rehab Inpatient CBC WITH DIFFERENTIAL [CBCA] CD DOPPLER ECHOCARDIO; COMPLETE CD ECG 12 LEAD; TRACING ONLY CHF Nurse Consult CK-MB [MMB] Consult Physician Coreg Cozaar CPAP Demadex Diabetic 1800 Cal Diet Diabetic 2000 Cal Diet DIGOXIN LEVEL [DIG] Diovan Discharge Planning Evaluation Adult DOBUTamine 1,000 mg/250 mL D5W IV premix Ecotrin Furosemide 1,000 mg/250 mL D5W IV Heparin Weight Based Protocol Cardiac Order Set CMC heparin. hydrALAZINE. HydroDIURIL.

	Imdur. influenza virus vaccine, inactivated Intake and Output K-Dur 20 Lanoxin Lasix LIPID PANEL W/O REFLEX [LIPDPL] Lovenox. MAGNESIUM LEVEL [MG] Magnesium sulfate Mag-Ox 400 Milrinone 20 mg/100 mL D5W IV premix Milrinone bolus Natrecor 0.75 mg/125 mL D5W IV Natrecor bolus NitroGLYCERIN 50 mg/250 mL D5W IV premix NitroGLYCERIN topical 2% ointment. Nitroglycerin Topical Patch Order Set Nitrostat NPO Nursing Communication Order Nutrition Consult Adult Oxygen Plavix Pneumococcal 23-valent vaccine Prinivil / Zestril PROTHROMBIN TIME [PTINR] Pulse Ox Spot check Saline (sodium chloride) IV lock flush injection. Saline Lock Insertion Sequential Compression Device Toprol XL TROPONIN I ULTRASENSITIVE [TROPI] TSH URINALYSIS SCREEN (USCR) Vasotec Vital Signs Vital Signs per Unit Routine Weigh Patient XR CHEST PA, LATERAL 2V Zaroxolyn. Zebeta

Congestive Heart Failure Order Admission Set GSH	GSHP	49502942	Aldactone Altace Aspirin Atenolol Avapro B TYPE NATRIURETIC PEPTIDE [BNPEP] BASIC METABOLIC PANEL [BPNL] BIPAP Bumex Capoten Cardiac Monitoring Carvedilol Catheter Urinary Insertion CBC WITH DIFFERENTIAL [CBCA] CHF Nurse Consult CK-MB [MMB] Coreg Cozaar CPAP DIGOXIN LEVEL [DIG] Digoxin Diovan Discharge Planning Evaluation Adult DOBUTamine 500 mg/250 mL D5W IV premix DuoNeb inhalation 2.5-0.5 mg/3 mL solution DVT Prophylaxis Order Set GSH Echocardiogram 2D w Doppler Adult GSH EKG Adult - GSH Heparin Hydralazine Hydrodiuril Imdur Intake and Output Lanoxin Lasix LIPID PANEL W/O REFLEX [LIPDPL] Lisinopril Lopressor Lovenox - Pharmacist to Dose (consult) MAGNESIUM LEVEL [MG] Magnesium oxide Magnesium sulfate Milrinone 20 mg/100 mL D5W IV premix Milrinone bolus injection

			Nesiritide - Pharmacist to Dose (consult) Nitro-Bid topical 2% ointment NitroGLYCERIN 50 mg/250 mL D5W IV premix Nitroglycerin Topical Patch Order Set Nitroglycerin Notify Physician Nursing Communication Order Nutrition Consult Adult Oxygen Pharmacist to Dose: Coumadin (consult) Pharmacist to Dose: Heparin (consult) Physical Therapy Adult Evaluation and Treatment Plavix Potassium CHLORIDE. Proventil inhalation 0.083% 2.5 mg/3 mL solution Respiratory Therapy Communication Order Sleep Apnea Risk Assessment Toprol XL TROPONIN I ULTRASENSITIVE [TROPI] TSH WITH REFLEX [THSR] Vasotec Vital Signs per Unit Routine Warfarin Weigh Patient XR CHEST 1V XR CHEST PA, LATERAL 2V Zaroxolyn
Congestive Heart Failure Order Admission Set IMC	IMMC	24458894	Admit Order IMC Albuterol inhalation 0.5% 2.5 mg/0.5 mL solution. Aldactone Antiembolytic Hose Aspirin Avapro. B TYPE NATRIURETIC PEPTIDE [BNPEP] BASIC METABOLIC PANEL [BPNL] BIPAP Capoten Cardiac Monitoring Catheter Urinary Insertion CBC WITH DIFFERENTIAL [CBCA]

	CK-MB [MMB]
	Consult CHF Clinic Evaluation
	Coreg
	Cozaar
	CPAP
	Demadex
	DIGOXIN LEVEL [DIG]
	Diovan
	Echocardiogram 2D w Doppler Adult IMC
	EKG Adult IMC
	Furosemide 200 mg/100 mL D5W IV
	Hydrodiuril
	Intake and Output
	Isosorbide mononitrate
	Lanoxin.
	Lasix.
	LIPID PANEL W/O REFLEX [LIPDPL]
	Lopressor
	MAGNESIUM LEVEL [MG]
	Magnesium oxide
	Nitroglycerin sublingual.
	Nitroglycerin topical 2% ointment.
	Nursing Communication Order
	Nutrition Consult Adult
	Potassium chloride
	Prinivil / Zestril
	Toprol XL
	TROPONIN I ULTRASENSITIVE [TROPI]
	TSH WITH REFLEX [THSR]
	URINE COMPLETE [UCOM]
	Vasotec
	Vital Signs per Unit Routine
	Weigh Patient
	XR CHEST PA, LATERAL 2V
	Zaroxolyn

Heart Failure Order Set SSH	SSUB	173004691	Activity Patient Admit Patient - Full Inpatient Admitting Diagnosis B TYPE NATRIURETIC PEPTIDE [BNPEP] BASIC METABOLIC PANEL [BPNL] BIPAP Cardiac Diet Cardiac Rehab Inpatient CBC WITH DIFFERENTIAL [CBCA] CHF Nurse Consult COMPREHENSIVE METABOLIC PANEL [CPNL] Consult Physician CPAP DIGOXIN LEVEL [DIG] Discharge Planning Evaluation Adult Echocardio 2D With Doppler SSH Intake and Output LIPID PANEL W/O REFLEX [LIPDPL] MAGNESIUM LEVEL [MG] Nursing Communication Order Nutrition Consult Adult Old Charts to Floor Oxygen PT/INR Pulse Ox Spot check Saline (sodium chloride) IV lock flush injection Saline Lock Insertion Telemetry PCU Protocol Order Set SSH TROPONIN I ULTRASENSITIVE [TROPI] TSH Vital Signs per Unit Routine Weigh Patient XR CHEST 1V XR CHEST PA, LATERAL 2V

Heart Failure Management Order Set LGH	LGH	369504735	ACE Contraindications ALBUMIN LEVEL [ALB] ARB Contraindications BNP Cardiac Rehab Inpatient CBC WITH DIFFERENTIAL [CBCA] CD ECHO 2D COMPLETE-ADULT CHF Nurse Consult EKG - Adult LGH EKG STAT Adult LGH Heart Failure History HEPATIC FUNCTION PANEL [LIVPNL] HYPERAL PROFILE [HYPRL] Intake and Output LIPID PANEL W/O REFLEX [LIPDPL] Patient Education Sodium 2-3 GM Diet Sodium 4 GM Diet Telemetry TROPONIN I ULTRASENSITIVE [TROPI] TSH URINALYSIS SCREEN (USCR) Weigh Patient XR CHEST PORTABLE 1V

Table 143. Randomly Generated Patient Race Codes – CHF Study

Race Description	**Randomly Generated Code**
African American / Black	10
American Indian / Alaska Native	11
Asian/Filipino	12
Caucasian/White	13
Declined	14
Eastern Indian	15
Hispanic	16
Middle East	17
Other	18
Pacific Islander / Hawaiian	19
Unknown	20

Appendix E

Supplemental AMI Methodology Tables

Table 144. AHRQ IQI-15: AMI Mortality Definitions, ICD-9-CM Diagnosis Codes

Code	Description
41000	AMI ANTEROLATERAL, UNSPECIFIED
41001	AMI ANTEROLATERAL, INITIAL
41010	AMI ANTERIOR WALL, UNSPECIFIED
41011	AMI ANTERIOR WALL, INITIAL
41020	AMI INFEROLATERAL, UNSPECIFIED
41021	AMI INFEROLATERAL, INITIAL
41030	AMI INFEROPOST, UNSPECIFIED
41031	AMI INFEROPOST, INITIAL
41040	AMI INFERIOR WALL, UNSPECIFIED
41041	AMI INFERIOR WALL, INITIAL
41050	AMI LATERAL NEC, UNSPECIFIED
41051	AMI LATERAL NEC, INITIAL
41060	TRUE POST INFARCT, UNSPECIFIED
41061	TRUE POST INFARCT, INITIAL
41070	SUBENDO INFARCT, UNSPECIFIED
41071	SUBENDO INFARCT, INITIAL
41080	AMI NEC, UNSPECIFIED
41081	AMI NEC, INITIAL
41090	AMI NOS, UNSPECIFIED
41091	AMI NOS, INITIAL

Exclude cases:

- Transferring to another short-term hospital (Disposition=2)
- MDC 14 (pregnancy, childbirth, and puerperium)
- With missing discharge disposition (Disposition=missing), sex (Sex=missing), age (Age=missing), quarter (DQTR=missing), year (Year=missing), or principal diagnosis (DX1=missing)

Table 145. Monthly Utilization of AMI Order Sets

Category	Hospital Code	Order Set Title	Catalog ID	Year Available	Monthly Utilization Average (Aug 2010)
AMI	GSHP	Acute Coronary Syndrome Order Set GSH	49493862	2008	4
AMI	TRIN	Chest Pain Orders Order Set TRI	483944189	2009	36

Table 146. AMI Order Set Content

Order Set Title	Facility	Catalog Number	Content
Acute Coronary Syndrome Order Set GSH	GSHP	49493862	Altace Aspirin CK-MB [MMB] DIGOXIN LEVEL [DIG] EKG Adult - GSH Eptifibatide 75 mg/100 mL IV premix Eptifibatide bolus GLYCOHEMOGLOBIN LEVEL [GLYH] Heparin - Pharmacist to Dose (consult) Integrilin - Pharmacist to Dose (consult) Lasix LIPID PANEL W/O REFLEX [LIPDPL] Lipitor Lopressor Lovenox Morphine Nitro-Bid topical 2% ointment NitroGLYCERIN 50 mg/250 mL D5W IV Premix nitroGLYCERIN sublingual Nitroglycerin Topical Patch Order Set Nursing Communication Order OCCULT BLOOD [STBLD] Physician Consult Plavix PT/INR PTT

			Telemetry TROPONIN I ULTRASENSITIVE [TROPI] Vasotec
Chest Pain Orders Order Set TRI	TRIN	483944189	Admit Patient - Full Inpatient Admitting Diagnosis Aspirin Cardiac Rehab Inpatient CBC WITH DIFFERENTIAL [CBCA] CK-MB [MMB] Clear Liquid Diet Colace COMPREHENSIVE METABOLIC PANEL [CPNL] Coreg Diovan Discharge Planning Eval Adult EKG 12 Lead Routine-TRI EKG 12 Lead Stat-TRI Enoxaparin Fragmin Heparin Intake and Output Integrilin 200 mg/100 mL IV premix Isolation LIPID PANEL W/O REFLEX [LIPDPL] Lipitor Lisinopril Metoprolol Morphine Nitro-Bid topical 2% ointment. NitroGLYCERIN 50 mg/250 mL D5W IV Premix NitroGLYCERIN sublingual. Notify Physician If NPO Nursing Communication Order Nutrition Consult Adult Oxygen Patient Activity Physician Consult Place in 23hr Observation Plavix PROTHROMBIN TIME [PTINR]

	PTT Pulse Oximetry Saline Lock Insertion Smoking Cessation Education - Nursing Smoking Cessation Education - RT Sodium 2 GM Diet Sodium Chloride 0.45% Sodium Chloride 0.9% Telemetry temazepam. TROPONIN I ULTRASENSITIVE [TROPI] Tylenol Vital Signs per Unit Routine Weigh Patient Xanax Zocor

Table 147. Randomly Generated Patient Race Codes – AMI Study

Race Description	**Randomly Generated Code**
African American / Black	10
American Indian / Alaska Native	11
Asian/Filipino	12
Caucasian/White	13
Declined	14
Eastern Indian	15
Hispanic	16
Middle East	17
Other	18
Pacific Islander / Hawaiian	19
Unknown	20
Multi-Racial	21

Appendix F

Supplemental VTE Results

Relationship Between Utilization of the VTE Order Sets, Acute VTE, and Charlson Comorbidity Index

IMMC Surgical Calculations

Table 148. One-Way ANOVA – Surgical IMMC VTE Patients, CCI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1192.029	3	397.343	87.429	.000
Within Groups	46524.452	10237	4.545		
Total	47716.482	10240			

Table 149. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Surgical IMMC VTE Patients, CCI

	(I) VTE_ Combination	(J) VTE_ Combition	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	.870	.358	.072	-.05	1.79
		3	1.152*	.424	.033	.06	2.24
		4	1.666*	.356	.000	.75	2.58
	2	1	-.870	.358	.072	-1.79	.05
		3	.282	.236	.629	-.32	.89
		4	.796*	.051	.000	.66	.93
	3	1	-1.152*	.424	.033	-2.24	-.06

		2	-.282	.236	.629	-.89	.32
		4	.514	.232	.120	-.08	1.11
	4	1	-1.666*	.356	.000	-2.58	-.75
		2	-.796*	.051	.000	-.93	-.66
		3	-.514	.232	.120	-1.11	.08
Bonferroni	1	2	.870	.358	.091	-.07	1.82
		3	1.152*	.424	.040	.03	2.27
		4	1.666*	.356	.000	.73	2.61
	2	1	-.870	.358	.091	-1.82	.07
		3	.282	.236	1.000	-.34	.90
		4	.796*	.051	.000	.66	.93
	3	1	-1.152*	.424	.040	-2.27	-.03
		2	-.282	.236	1.000	-.90	.34
		4	.514	.232	.162	-.10	1.13
	4	1	-1.666*	.356	.000	-2.61	-.73
		2	-.796*	.051	.000	-.93	-.66
		3	-.514	.232	.162	-1.13	.10
*. The mean difference is significant at the 0.05 level.							

Table 150. One-Way ANOVA Descriptive Statistics – Surgical IMMC VTE Patients, CCI

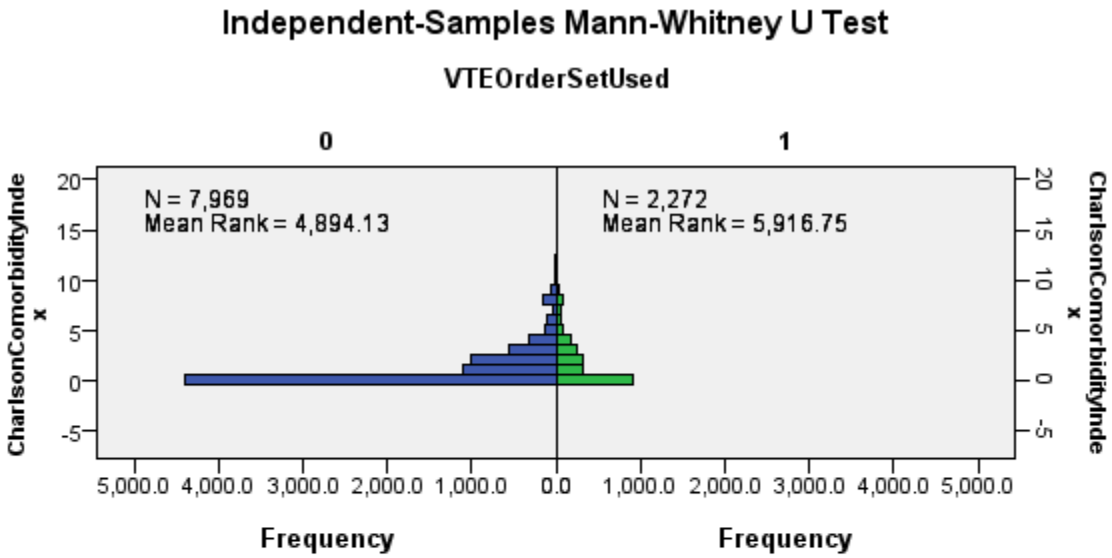
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	36	2.92	3.102	.517	1.87	3.97	0	13
2	2236	2.05	2.512	.053	1.94	2.15	0	15
3	85	1.76	2.644	.287	1.19	2.34	0	11
4	7884	1.25	1.999	.023	1.21	1.29	0	15
Total	10241	1.43	2.159	.021	1.39	1.48	0	15

Table 151. One-Way ANOVA Post-Hoc Dunnett T-Tests – Surgical IMMC VTE Patients, CCI

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	1.666*	.356	.000	.82	2.52
2	4	.796*	.051	.000	.67	.92
3	4	.514	.232	.079	-.04	1.07

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 1. Mann-Whitney U Test of Independent Samples – Surgical IMMC VTE Patients, CCI



Total N	10,241
Mann-Whitney U	10,860,731.500
Wilcoxon W	13,442,859.500
Test Statistic	10,860,731.500
Standard Error	114,972.223
Standardized Test Statistic	15.725
Asymptotic Sig. (2-sided test)	.000

IMMC Non-Surgical Calculations

Table 152. One-Way ANOVA – Non-Surgical IMMC VTE Patients, CCI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9248.485	3	3082.828	172.499	.000
Within Groups	505247.753	28271	17.872		
Total	514496.238	28274			

Table 153. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Non-Surgical IMMC VTE Patients, CCI

	(I) VTE_ Combination	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	3.707*	.246	.000	3.07	4.34
		3	.415	.310	.537	-.38	1.21
		4	3.737*	.246	.000	3.10	4.37
	2	1	-3.707*	.246	.000	-4.34	-3.07
		3	-3.292*	.195	.000	-3.79	-2.79
		4	.030	.051	.938	-.10	.16
	3	1	-.415	.310	.537	-1.21	.38
		2	3.292*	.195	.000	2.79	3.79
		4	3.321*	.195	.000	2.82	3.82
	4	1	-3.737*	.246	.000	-4.37	-3.10
		2	-.030	.051	.938	-.16	.10
		3	-3.321*	.195	.000	-3.82	-2.82
Bonferroni	1	2	3.707*	.246	.000	3.06	4.36
		3	.415	.310	1.000	-.40	1.23
		4	3.737*	.246	.000	3.09	4.39
	2	1	-3.707*	.246	.000	-4.36	-3.06
		3	-3.292*	.195	.000	-3.81	-2.78
		4	.030	.051	1.000	-.11	.16
	3	1	-.415	.310	1.000	-1.23	.40
		2	3.292*	.195	.000	2.78	3.81
		4	3.321*	.195	.000	2.81	3.84
	4	1	-3.737*	.246	.000	-4.39	-3.09
		2	-.030	.051	1.000	-.16	.11
		3	-3.321*	.195	.000	-3.84	-2.81

*. The mean difference is significant at the 0.05 level.

Table 154. One-Way ANOVA Descriptive Statistics – Non-Surgical IMMC VTE Patients, CCI

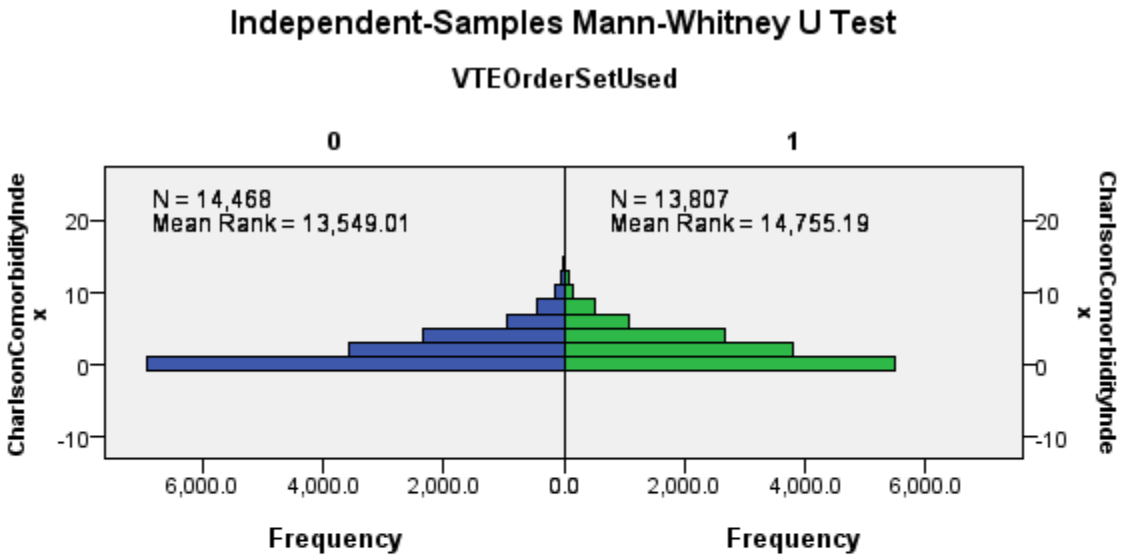
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	301	7.17	8.288	.478	6.23	8.11	0	72
2	13506	3.46	3.792	.033	3.40	3.53	0	82
3	488	6.75	7.007	.317	6.13	7.38	0	47
4	13980	3.43	4.367	.037	3.36	3.51	0	190
Total	28275	3.54	4.266	.025	3.49	3.59	0	190

Table 155. One-Way ANOVA Post-Hoc Dunnett T-Tests – Non-Surgical IMMC VTE Patients, CCI

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	3.737*	.246	.000	3.15	4.32
2	4	.030	.051	.915	-.09	.15
3	4	3.321*	.195	.000	2.86	3.79

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 2. Mann-Whitney U Test of Independent Samples – Non-Surgical IMMC VTE Patients, CCI



Total N	28,275
Mann-Whitney U	108,401,386.500
Wilcoxon W	203,724,914.500
Test Statistic	108,401,386.500
Standard Error	654,218.049
Standardized Test Statistic	13.026
Asymptotic Sig. (2-sided test)	.000

LGH Surgical Calculations

Table 156. One-Way ANOVA – Surgical LGH VTE Patients, CCI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	69932.001	3	23310.667	686.291	.000
Within Groups	588599.537	17329	33.966		
Total	658531.539	17332			

Table 157. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Surgical LGH VTE Patients, CCI

	(I) VTE_ Combination	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	12.321*	.685	.000	10.56	14.08
		3	3.572*	.763	.000	1.61	5.53
		4	15.512*	.675	.000	13.78	17.25
	2	1	-12.321*	.685	.000	-14.08	-10.56
		3	-8.749*	.382	.000	-9.73	-7.77
		4	3.192*	.135	.000	2.84	3.54
	3	1	-3.572*	.763	.000	-5.53	-1.61
		2	8.749*	.382	.000	7.77	9.73
		4	11.941*	.363	.000	11.01	12.87
	4	1	-15.512*	.675	.000	-17.25	-13.78
		2	-3.192*	.135	.000	-3.54	-2.84
		3	-11.941*	.363	.000	-12.87	-11.01
Bonferroni	1	2	12.321*	.685	.000	10.51	14.13
		3	3.572*	.763	.000	1.56	5.59
		4	15.512*	.675	.000	13.73	17.29
	2	1	-12.321*	.685	.000	-14.13	-10.51
		3	-8.749*	.382	.000	-9.76	-7.74
		4	3.192*	.135	.000	2.83	3.55
	3	1	-3.572*	.763	.000	-5.59	-1.56
		2	8.749*	.382	.000	7.74	9.76
		4	11.941*	.363	.000	10.98	12.90
	4	1	-15.512*	.675	.000	-17.29	-13.73
		2	-3.192*	.135	.000	-3.55	-2.83
		3	-11.941*	.363	.000	-12.90	-10.98

*. The mean difference is significant at the 0.05 level.

Table 158. One-Way ANOVA Descriptive Statistics – Surgical LGH VTE Patients, CCI

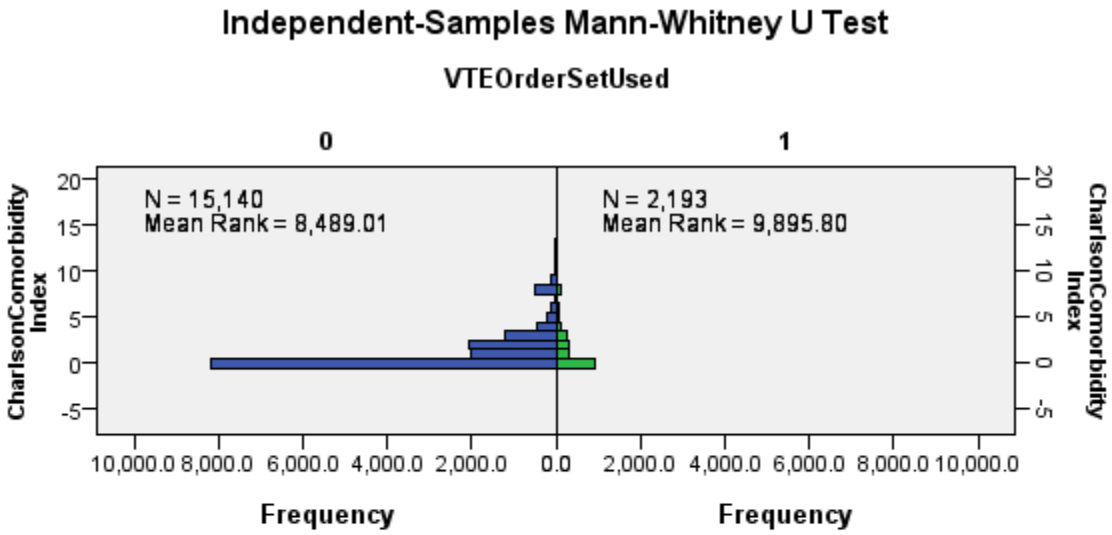
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	75	20.35	12.520	1.446	17.47	23.23	2	63
2	2118	8.03	7.437	.162	7.71	8.34	0	79
3	262	16.77	13.658	.844	15.11	18.44	1	77
4	14878	4.83	5.257	.043	4.75	4.92	0	101
Total	17333	5.47	6.164	.047	5.38	5.56	0	101

Table 159. One-Way ANOVA Post-Hoc Dunnett T-Tests – Surgical LGH VTE Patients, CCI

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	15.512*	.675	.000	13.90	17.12
2	4	3.192*	.135	.000	2.87	3.51
3	4	11.941*	.363	.000	11.07	12.81

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 3. Mann-Whitney U Test of Independent Samples – Surgical LGH VTE Patients, CCI



Total N	17,333
Mann-Whitney U	19,295,760.000
Wilcoxon W	21,701,481.000
Test Statistic	19,295,760.000
Standard Error	201,827.472
Standardized Test Statistic	13.352
Asymptotic Sig. (2-sided test)	.000

LGH Non-Surgical Calculations

Table 160. One-Way ANOVA – Non-Surgical LGH VTE Patients, CCI

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24710.266	3	8236.755	410.373	.000
Within Groups	779029.917	38813	20.071		
Total	803740.184	38816			

Table 161. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Non-Surgical LGH VTE Patients, CCI

	(I) VTE_ Combination	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	7.071*	.296	.000	6.31	7.83
		3	5.524*	.326	.000	4.69	6.36
		4	8.012*	.293	.000	7.26	8.77
	2	1	-7.071*	.296	.000	-7.83	-6.31
		3	-1.547*	.152	.000	-1.94	-1.16
		4	.941*	.055	.000	.80	1.08
	3	1	-5.524*	.326	.000	-6.36	-4.69
		2	1.547*	.152	.000	1.16	1.94
		4	2.488*	.146	.000	2.11	2.86
	4	1	-8.012*	.293	.000	-8.77	-7.26
		2	-.941*	.055	.000	-1.08	-.80
		3	-2.488*	.146	.000	-2.86	-2.11
Bonferroni	1	2	7.071*	.296	.000	6.29	7.85
		3	5.524*	.326	.000	4.66	6.38
		4	8.012*	.293	.000	7.24	8.79
	2	1	-7.071*	.296	.000	-7.85	-6.29
		3	-1.547*	.152	.000	-1.95	-1.15
		4	.941*	.055	.000	.80	1.09
	3	1	-5.524*	.326	.000	-6.38	-4.66
		2	1.547*	.152	.000	1.15	1.95
		4	2.488*	.146	.000	2.10	2.87
	4	1	-8.012*	.293	.000	-8.79	-7.24
		2	-.941*	.055	.000	-1.09	-.80
		3	-2.488*	.146	.000	-2.87	-2.10
*. The mean difference is significant at the 0.05 level.							

Table 162. One-Way ANOVA Descriptive Statistics – Non-Surgical LGH VTE Patients, CCI

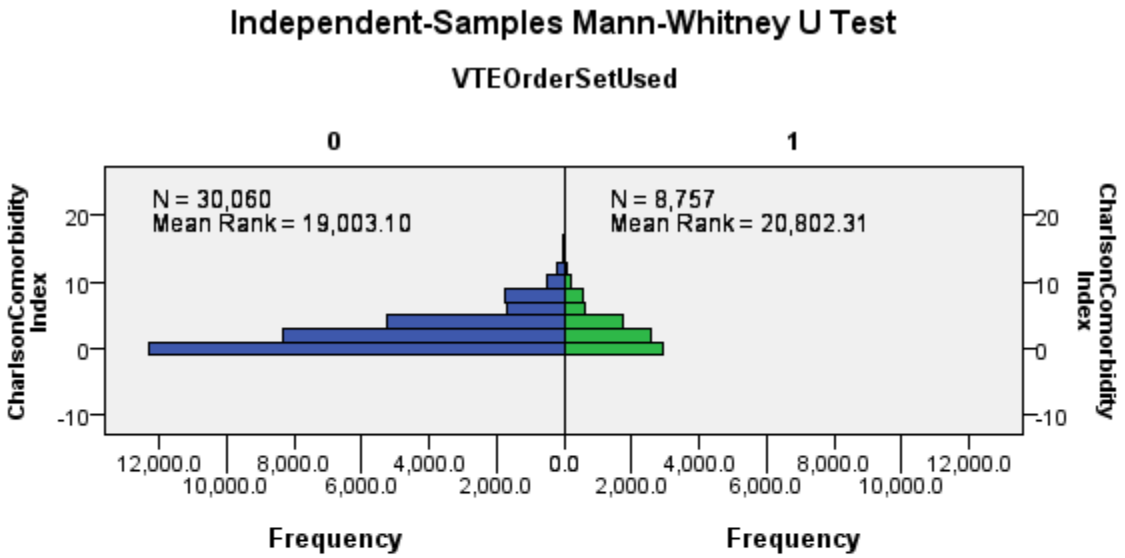
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	235	12.01	15.474	1.009	10.02	14.00	0	183
2	8522	4.94	4.825	.052	4.84	5.04	0	75
3	967	6.49	6.841	.220	6.06	6.92	0	66
4	29093	4.00	4.059	.024	3.95	4.05	0	295
Total	38817	4.32	4.550	.023	4.27	4.36	0	295

Table 163. One-Way ANOVA Post-Hoc Dunnett T-Tests – Non-Surgical LGH VTE Patients, CCI

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	8.012*	.293	.000	7.31	8.71
2	4	.941*	.055	.000	.81	1.07
3	4	2.488*	.146	.000	2.14	2.84

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 4. Mann-Whitney U Test of Independent Samples – Non-Surgical LGH VTE Patients, CCI



Total N	38,817
Mann-Whitney U	143,818,946.500
Wilcoxon W	182,165,849.500
Test Statistic	143,818,946.500
Standard Error	890,680.524
Standardized Test Statistic	13.699
Asymptotic Sig. (2-sided test)	.000

Relationship Between Utilization of the VTE Order Sets, Acute VTE, and Length of Stay

IMMC Surgical Calculations

Table 164. One-Way ANOVA – Surgical IMMC VTE Patients, LOS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23466.811	3	7822.270	101.509	.000
Within Groups	788860.010	10237	77.060		
Total	812326.821	10240			

Table 165. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Surgical IMMC VTE Patients, LOS

	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.		95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	11.370*	1.475	.000	7.58	15.16
		3	2.148	1.746	.607	-2.34	6.63
		4	13.455*	1.466	.000	9.69	17.22
	2	1	-11.370*	1.475	.000	-15.16	-7.58
		3	-9.222*	.970	.000	-11.71	-6.73
		4	2.085*	.210	.000	1.55	2.63
	3	1	-2.148	1.746	.607	-6.63	2.34
		2	9.222*	.970	.000	6.73	11.71
		4	11.307*	.957	.000	8.85	13.77
	4	1	-13.455*	1.466	.000	-17.22	-9.69

		2	-2.085*	.210	.000	-2.63	-1.55
		3	-11.307*	.957	.000	-13.77	-8.85
Bonferroni	1	2	11.370*	1.475	.000	7.48	15.26
		3	2.148	1.746	1.000	-2.46	6.75
		4	13.455*	1.466	.000	9.59	17.32
	2	1	-11.370*	1.475	.000	-15.26	-7.48
		3	-9.222*	.970	.000	-11.78	-6.66
		4	2.085*	.210	.000	1.53	2.64
	3	1	-2.148	1.746	1.000	-6.75	2.46
		2	9.222*	.970	.000	6.66	11.78
		4	11.307*	.957	.000	8.78	13.83
	4	1	-13.455*	1.466	.000	-17.32	-9.59
		2	-2.085*	.210	.000	-2.64	-1.53
		3	-11.307*	.957	.000	-13.83	-8.78

Table 166. One-Way ANOVA Descriptive Statistics – Surgical IMMC VTE Patients, LOS

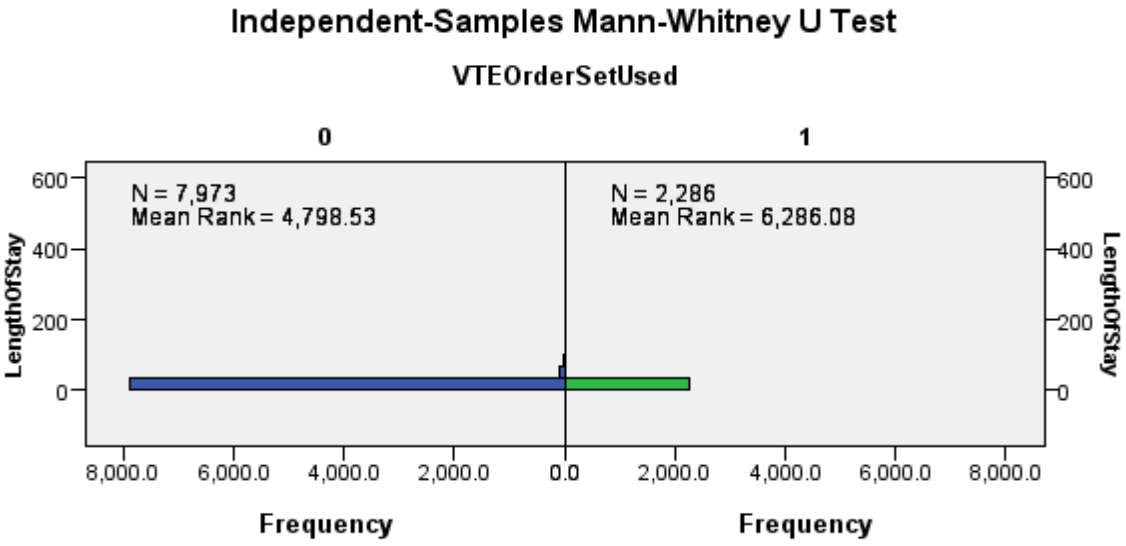
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
1	36	18.58	12.749	2.125	14.27	22.90	2	59
2	2236	7.21	7.916	.167	6.89	7.54	0	134
3	85	16.44	11.911	1.292	13.87	19.00	1	59
4	7884	5.13	8.948	.101	4.93	5.33	0	486
Total	10241	5.72	8.907	.088	5.55	5.90	0	486

Table 167. One-Way ANOVA Post-Hoc Dunnett T-Tests – Surgical IMMC VTE Patients, LOS

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	13.455*	1.466	.000	9.95	16.96
2	4	2.085*	.210	.000	1.58	2.59
3	4	11.307*	.957	.000	9.02	13.59

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 5. Mann-Whitney U Test of Independent Samples – Surgical IMMC VTE Patients, LOS



Total N	10,259
Mann-Whitney U	11,755,933.500
Wilcoxon W	14,369,974.500
Test Statistic	11,755,933.500
Standard Error	123,750.007
Standardized Test Statistic	21.356
Asymptotic Sig. (2-sided test)	.000

IMMC Non-Surgical Calculations

Table 168. One-Way ANOVA – Non-Surgical IMMC VTE Patients, LOS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9248.485	3	3082.828	172.499	.000
Within Groups	505247.753	28271	17.872		
Total	514496.238	28274			

Table 169. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Non-Surgical IMMC VTE Patients, LOS

	(I) VTE_ Combination	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	3.707*	.246	.000	3.07	4.34
		3	.415	.310	.537	-.38	1.21
		4	3.737*	.246	.000	3.10	4.37
	2	1	-3.707*	.246	.000	-4.34	-3.07
		3	-3.292*	.195	.000	-3.79	-2.79
		4	.030	.051	.938	-.10	.16
	3	1	-.415	.310	.537	-1.21	.38
		2	3.292*	.195	.000	2.79	3.79
		4	3.321*	.195	.000	2.82	3.82
	4	1	-3.737*	.246	.000	-4.37	-3.10
		2	-.030	.051	.938	-.16	.10
		3	-3.321*	.195	.000	-3.82	-2.82
Bonferroni	1	2	3.707*	.246	.000	3.06	4.36
		3	.415	.310	1.000	-.40	1.23
		4	3.737*	.246	.000	3.09	4.39
	2	1	-3.707*	.246	.000	-4.36	-3.06
		3	-3.292*	.195	.000	-3.81	-2.78
		4	.030	.051	1.000	-.11	.16
	3	1	-.415	.310	1.000	-1.23	.40
		2	3.292*	.195	.000	2.78	3.81
		4	3.321*	.195	.000	2.81	3.84
	4	1	-3.737*	.246	.000	-4.39	-3.09
		2	-.030	.051	1.000	-.16	.11
		3	-3.321*	.195	.000	-3.84	-2.81

*. The mean difference is significant at the 0.05 level.

Table 170. One-Way ANOVA Descriptive Statistics – Non-Surgical IMMC VTE Patients, LOS

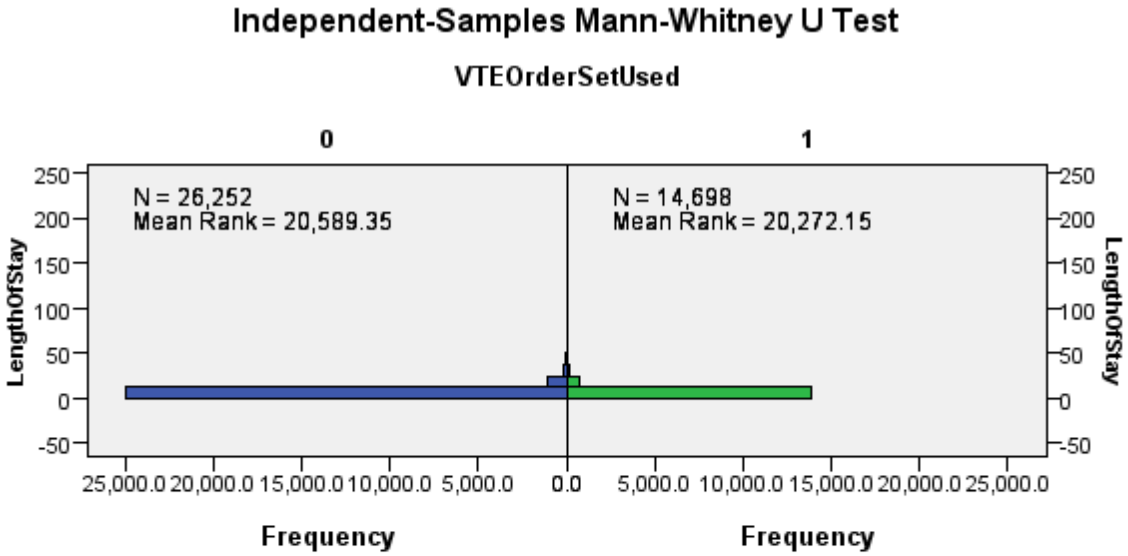
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	301	7.17	8.288	.478	6.23	8.11	0	72
2	13506	3.46	3.792	.033	3.40	3.53	0	82
3	488	6.75	7.007	.317	6.13	7.38	0	47
4	13980	3.43	4.367	.037	3.36	3.51	0	190
Total	28275	3.54	4.266	.025	3.49	3.59	0	190

Table 171. One-Way ANOVA Post-Hoc Dunnett T-Tests – Non-Surgical IMMC VTE Patients, LOS

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	3.737*	.246	.000	3.15	4.32
2	4	.030	.051	.915	-.09	.15
3	4	3.321*	.195	.000	2.86	3.79

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 6. Mann-Whitney U Test of Independent Samples – Non-Surgical IMMC VTE Patients, LOS



Total N	40,950
Mann-Whitney U	189,937,128.500
Wilcoxon W	297,960,079.500
Test Statistic	189,937,128.500
Standard Error	1,131,645.853
Standardized Test Statistic	-2.641
Asymptotic Sig. (2-sided test)	.008

LGH Surgical Calculations

Table 172. One-Way ANOVA – Surgical LGH VTE Patients, LOS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	69932.001	3	23310.667	686.291	.000
Within Groups	588599.537	17329	33.966		
Total	658531.539	17332			

Table 173. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Surgical LGH VTE Patients, LOS

	(I) VTE_ Combination	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	12.321*	.685	.000	10.56	14.08
		3	3.572*	.763	.000	1.61	5.53
		4	15.512*	.675	.000	13.78	17.25
	2	1	-12.321*	.685	.000	-14.08	-10.56
		3	-8.749*	.382	.000	-9.73	-7.77
		4	3.192*	.135	.000	2.84	3.54
	3	1	-3.572*	.763	.000	-5.53	-1.61
		2	8.749*	.382	.000	7.77	9.73
		4	11.941*	.363	.000	11.01	12.87
	4	1	-15.512*	.675	.000	-17.25	-13.78
		2	-3.192*	.135	.000	-3.54	-2.84
		3	-11.941*	.363	.000	-12.87	-11.01
Bonferroni	1	2	12.321*	.685	.000	10.51	14.13
		3	3.572*	.763	.000	1.56	5.59
		4	15.512*	.675	.000	13.73	17.29
	2	1	-12.321*	.685	.000	-14.13	-10.51
		3	-8.749*	.382	.000	-9.76	-7.74
		4	3.192*	.135	.000	2.83	3.55
	3	1	-3.572*	.763	.000	-5.59	-1.56
		2	8.749*	.382	.000	7.74	9.76
		4	11.941*	.363	.000	10.98	12.90
	4	1	-15.512*	.675	.000	-17.29	-13.73
		2	-3.192*	.135	.000	-3.55	-2.83
		3	-11.941*	.363	.000	-12.90	-10.98

*. The mean difference is significant at the 0.05 level.

Table 174. One-Way ANOVA Descriptive Statistics – Surgical LGH VTE Patients, LOS

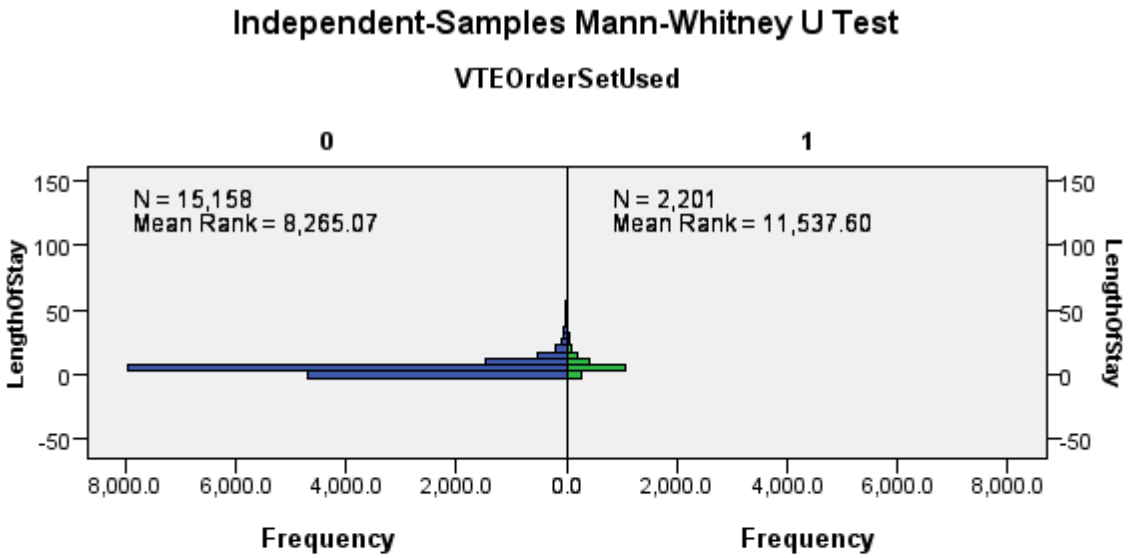
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	75	20.35	12.520	1.446	17.47	23.23	2	63
2	2118	8.03	7.437	.162	7.71	8.34	0	79
3	262	16.77	13.658	.844	15.11	18.44	1	77
4	14878	4.83	5.257	.043	4.75	4.92	0	101
Total	17333	5.47	6.164	.047	5.38	5.56	0	101

Table 175. One-Way ANOVA Post-Hoc Dunnett T-Tests – Surgical LGH VTE Patients, LOS

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	15.512*	.675	.000	13.90	17.12
2	4	3.192*	.135	.000	2.87	3.51
3	4	11.941*	.363	.000	11.07	12.81

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 7. Mann-Whitney U Test of Independent Samples – Surgical LGH VTE Patients, LOS



Total N	17,359
Mann-Whitney U	22,970,959.500
Wilcoxon W	25,394,260.500
Test Statistic	22,970,959.500
Standard Error	217,959.212
Standardized Test Statistic	28.857
Asymptotic Sig. (2-sided test)	.000

LGH Non-Surgical Calculations

Table 176. One-Way ANOVA – Non-Surgical LGH VTE Patients, LOS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	24710.266	3	8236.755	410.373	.000
Within Groups	779029.917	38813	20.071		
Total	803740.184	38816			

Table 177. One-Way ANOVA Post-Hoc Bonferroni and Tukey Tests – Non-Surgical LGH VTE Patients, LOS

	(I) VTE_ Combination	(J) VTE_ Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	1	2	7.071*	.296	.000	6.31	7.83
		3	5.524*	.326	.000	4.69	6.36
		4	8.012*	.293	.000	7.26	8.77
	2	1	-7.071*	.296	.000	-7.83	-6.31
		3	-1.547*	.152	.000	-1.94	-1.16
		4	.941*	.055	.000	.80	1.08
	3	1	-5.524*	.326	.000	-6.36	-4.69
		2	1.547*	.152	.000	1.16	1.94
		4	2.488*	.146	.000	2.11	2.86
	4	1	-8.012*	.293	.000	-8.77	-7.26
		2	-.941*	.055	.000	-1.08	-.80
		3	-2.488*	.146	.000	-2.86	-2.11
Bonferroni	1	2	7.071*	.296	.000	6.29	7.85
		3	5.524*	.326	.000	4.66	6.38
		4	8.012*	.293	.000	7.24	8.79
	2	1	-7.071*	.296	.000	-7.85	-6.29
		3	-1.547*	.152	.000	-1.95	-1.15
		4	.941*	.055	.000	.80	1.09
	3	1	-5.524*	.326	.000	-6.38	-4.66
		2	1.547*	.152	.000	1.15	1.95
		4	2.488*	.146	.000	2.10	2.87
	4	1	-8.012*	.293	.000	-8.79	-7.24
		2	-.941*	.055	.000	-1.09	-.80
		3	-2.488*	.146	.000	-2.87	-2.10

*. The mean difference is significant at the 0.05 level.

Table 178. One-Way ANOVA Descriptive Statistics – Non-Surgical LGH VTE Patients, LOS

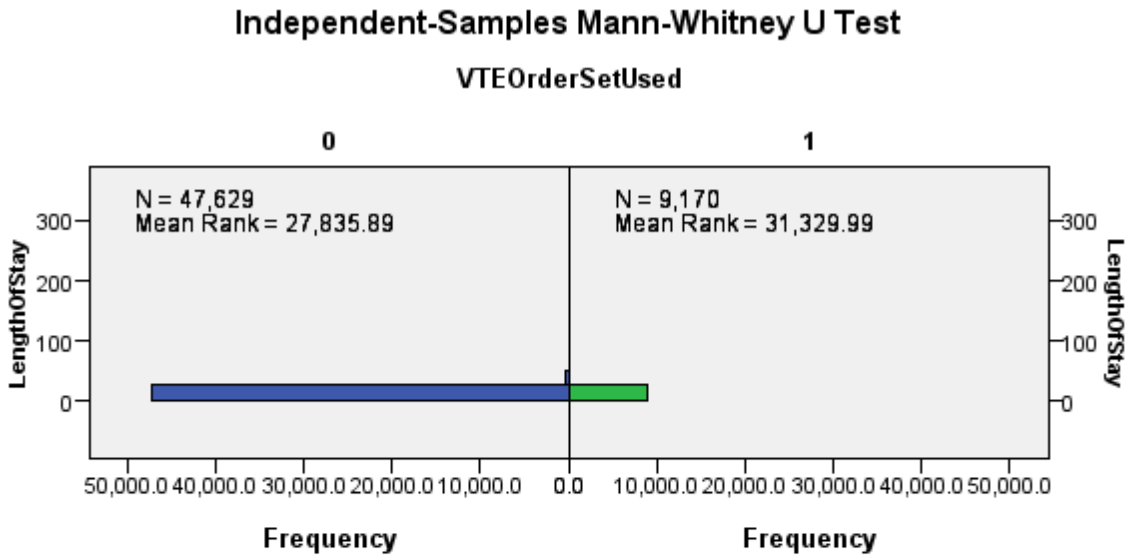
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	235	12.01	15.474	1.009	10.02	14.00	0	183
2	8522	4.94	4.825	.052	4.84	5.04	0	75
3	967	6.49	6.841	.220	6.06	6.92	0	66
4	29093	4.00	4.059	.024	3.95	4.05	0	295
Total	38817	4.32	4.550	.023	4.27	4.36	0	295

Table 179. One-Way ANOVA Post-Hoc Dunnett T-Tests – Non-Surgical LGH VTE Patients, LOS

(I) VTE_Combination	(J) VTE_Combination	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	4	8.012*	.293	.000	7.31	8.71
2	4	.941*	.055	.000	.81	1.07
3	4	2.488*	.146	.000	2.14	2.84

a. Dunnett *t*-tests treat one group as a control, and compare all other groups against it.
*. The mean difference is significant at the 0.05 level.

Figure 8. Mann-Whitney U Test of Independent Samples – Non-Surgical LGH VTE Patients, LOS



Total N	56,799
Mann-Whitney U	245,247,010.500
Wilcoxon W	287,296,045.500
Test Statistic	245,247,010.500
Standard Error	1,421,074.854
Standardized Test Statistic	18.907
Asymptotic Sig. (2-sided test)	.000

VTE Study Descriptive Statistics

Table 180. VTE Patient Statistics, by Sex and Order Set Utilization – IMMC

Sex	No Order Set	Order Set	Total
F	20581	8448	29029
M	13726	8466	22192

Table 181. VTE Patient Statistics, by Sex and Order Set Utilization – LGH

Sex	No Order Set	Order Set	Total
F	39801	5744	45545
M	23007	5128	28135

Table 182. VTE Patient Statistics, by Sex and Acute VTE – IMMC

Sex	Acute VTE	No VTE	Total
F	447	18904	19351
M	460	18664	19124

Table 183. VTE Patient Statistics, by Sex and Acute VTE – LGH

Sex	Acute VTE	No VTE	Total
F	813	29758	30571
M	685	24406	25091

Table 184. VTE Patient Statistics, by Race and Order Set Utilization – IMMC

Race Description	No Order Set	Order Set	Total
African American / Black	7263	4432	11695
American Indian / Alaska Native	78	47	125
Asian/Filipino	1063	447	1510
Caucasian/White	12998	6933	19931
Declined	None	None	None
Eastern Indian	113	58	171
Hispanic	9862	3528	13390
Middle East	124	44	168
Other	1876	1060	2936
Pacific Islander / Hawaiian	15	7	22
Unknown	815	306	1121
Totals	34207	16862	

Table 185. VTE Patient Statistics, by Race and Order Set Utilization – LGH

Race Description	No Order Set	Order Set	Total
African American / Black	1463	323	1786
American Indian / Alaska Native	143	27	170
Asian/Filipino	2876	448	3324
Caucasian/White	51279	9185	60464
Declined	None	None	None
Eastern Indian	1016	132	1148
Hispanic	3920	392	4312
Middle East	624	98	722
Other	1071	198	1269
Pacific Islander / Hawaiian	47	4	51
Unknown	334	59	393
Totals	62773	10866	73639

Appendix G

Supplemental Pneumonia Results

Pneumonia Study Descriptive Statistics

Table 186. Pneumonia Patient Statistics, by Sex and Order Set Utilization

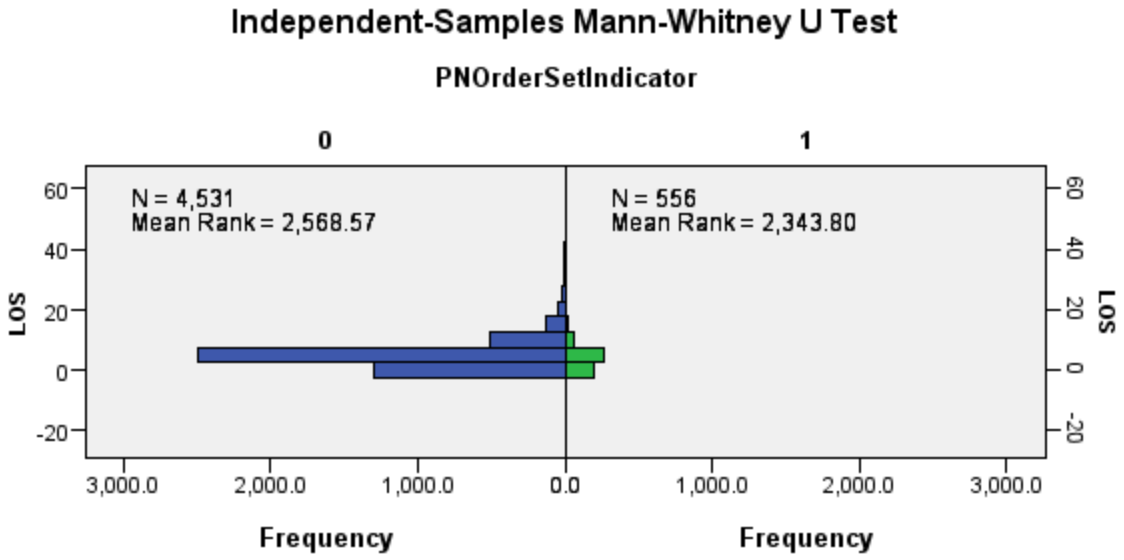
Sex	No Order Set	Order Set	Total
F	2455	260	2715
M	2076	296	2372

Table 187. Pneumonia Patient Statistics, by Race and Order Set Utilization

Race Description	No Order Set	Order Set	Total
African American / Black	1	0	1
American Indian / Alaska Native	19	1	20
Asian/Filipino	79	15	94
Caucasian/White	2637	283	2920
Declined	2	0	2
Eastern Indian	33	1	34
Hispanic	186	60	246
Middle East	3	0	3
Other	171	47	218
Pacific Islander / Hawaiian	3	1	4
Unknown	33	5	38
Totals	4531	556	5087

Pneumonia Study – Length of Stay Independent Samples Report

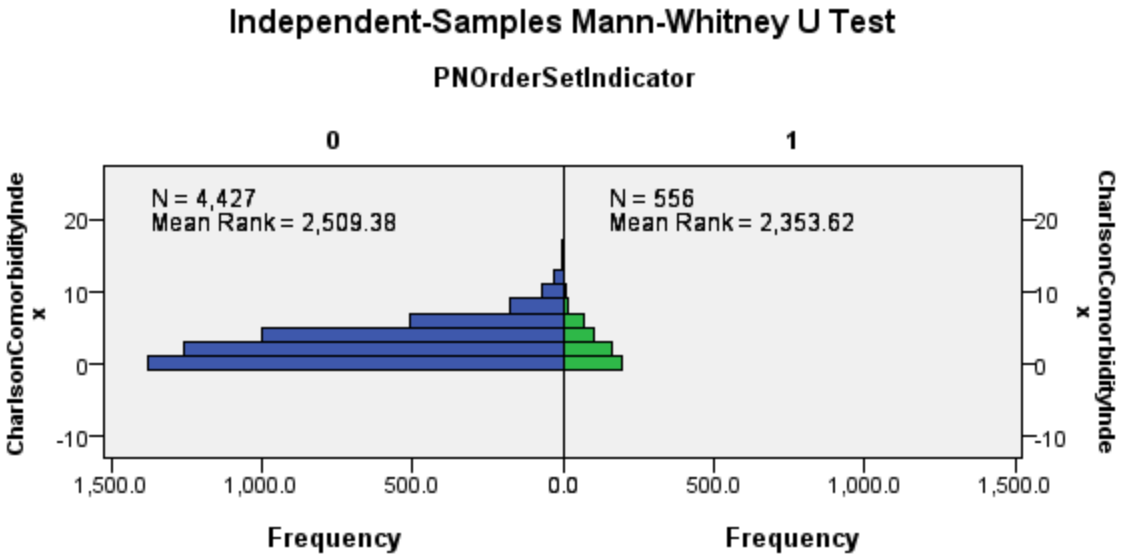
Figure 9. Mann-Whitney U Test of Independent Samples – All Pneumonia Patients, LOS



Total N	5,087
Mann-Whitney U	1,148,309.000
Wilcoxon W	1,303,155.000
Test Statistic	1,148,309.000
Standard Error	32,420.610
Standardized Test Statistic	-3.433
Asymptotic Sig. (2-sided test)	.001

Pneumonia Study – Patient Complications Independent Samples Report

Figure 10. Mann-Whitney U Test of Independent Samples – All Pneumonia Patients, CCI



Total N	4,983
Mann-Whitney U	1,153,767.500
Wilcoxon W	1,308,613.500
Test Statistic	1,153,767.500
Standard Error	31,293.357
Standardized Test Statistic	-2.459
Asymptotic Sig. (2-sided test)	.014

Appendix H

Supplemental CHF Results

CHF Study Descriptive Statistics

Table 188. CHF Patient Statistics, by Sex and Order Set Utilization

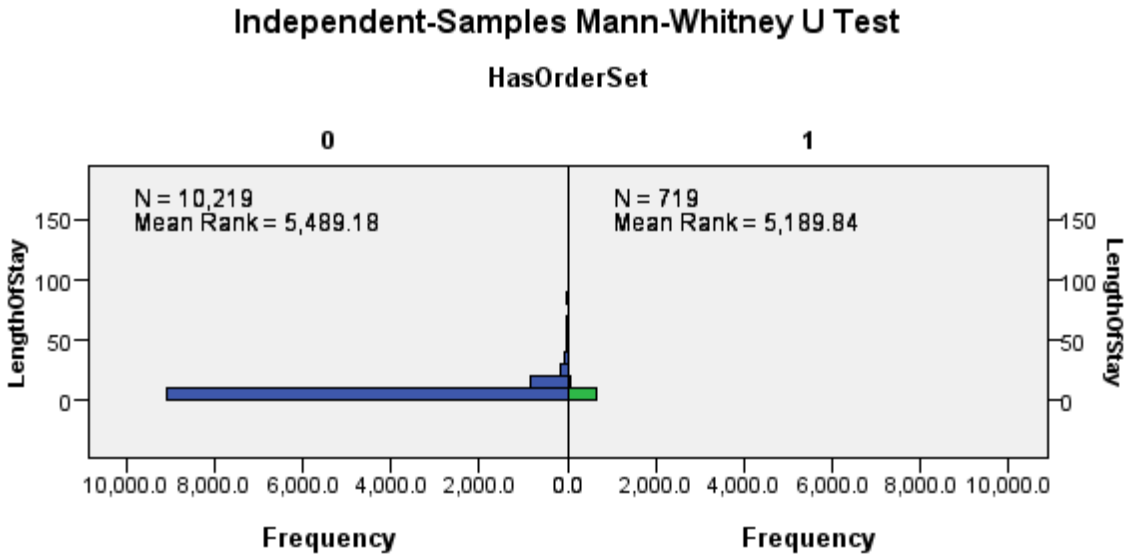
Sex	No Order Set	Order Set	Total
F	5233	356	5589
M	4986	363	5349

Table 189. CHF Patient Statistics, by Race and Order Set Utilization

Race Description	No Order Set	Order Set	Total
African American / Black	3396	242	3638
American Indian / Alaska Native	29	2	31
Asian/Filipino	119	11	130
Caucasian/White	6070	322	6392
Declined	7	0	7
Eastern Indian	14	2	16
Hispanic	181	50	231
Middle East	59	2	61
Other	291	82	373
Pacific Islander / Hawaiian	1	1	2
Unknown	48	5	53
Null	4	0	4
Totals	10219	719	10938

CHF Study – Length of Stay Independent Samples Report

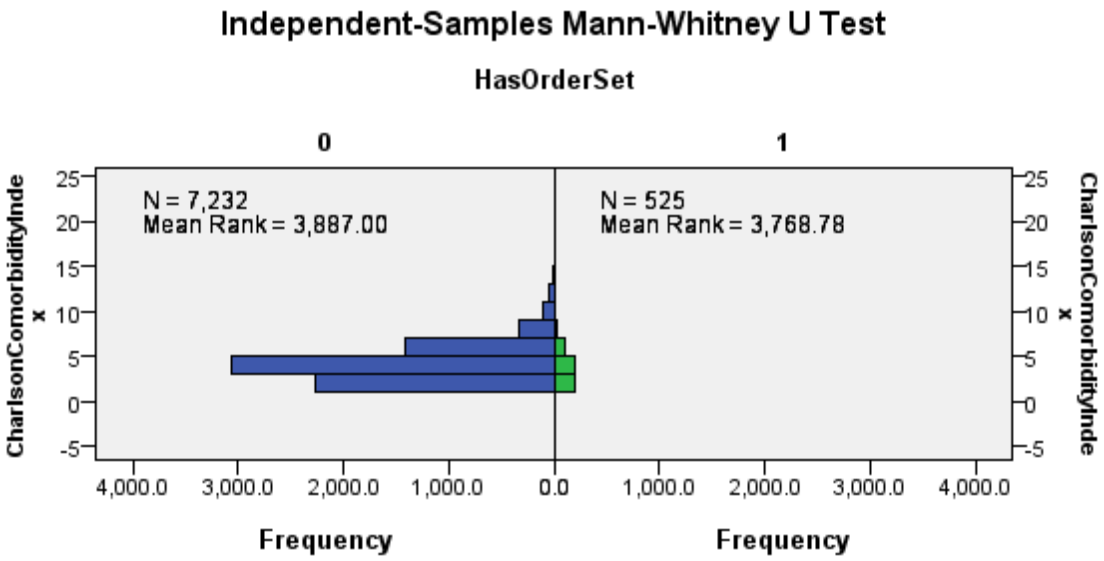
Figure 11. Mann-Whitney U Test of Independent Samples – All CHF Patients, LOS



Total N	10,938
Mann-Whitney U	3,472,652.000
Wilcoxon W	3,731,492.000
Test Statistic	3,472,652.000
Standard Error	81,223.765
Standardized Test Statistic	-2.476
Asymptotic Sig. (2-sided test)	.013

CHF Study – Charlson Comorbidity Index of Complications Independent Samples Report

Figure 12. Mann-Whitney U Test of Independent Samples – All CHF Patients, CCI



Total N	7,757
Mann-Whitney U	1,840,535.500
Wilcoxon W	1,978,610.500
Test Statistic	1,840,535.500
Standard Error	48,189.915
Standardized Test Statistic	-1.201
Asymptotic Sig. (2-sided test)	.230

Appendix I

Supplemental AMI Results

AMI Study Descriptive Statistics

Table 190. AMI Patient Statistics, by Sex and Order Set Utilization

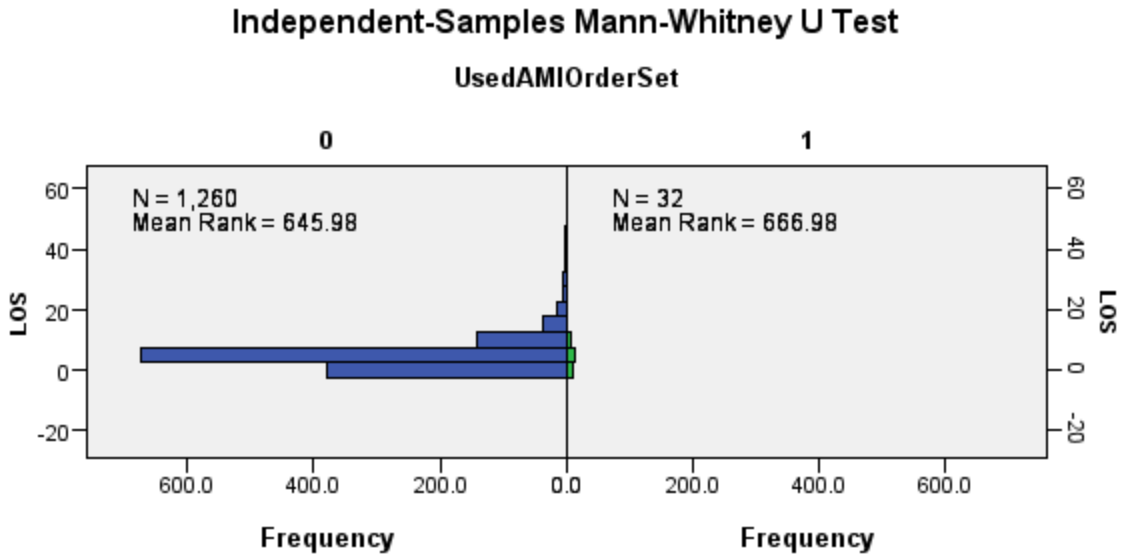
Sex	No Order Set	Order Set	Total
F	564	17	581
M	696	15	711

Table 191. AMI Patient Statistics, by Race and Order Set Utilization

Race	No Order Set	Order Set	Total
African American / Black	323	9	332
American Indian / Alaska Native	1	0	1
Asian/Filipino	9	0	9
Caucasian/White	868	21	889
Declined	0	0	0
Eastern Indian	3	0	3
Hispanic	21	0	21
Middle East	2	0	2
Other	26	2	28
Pacific Islander / Hawaiian	1	0	1
Unknown	5	0	5
Multi-Race	1	0	1
Totals	1260	32	1292

AMI Study – Length of Stay Independent Samples Report

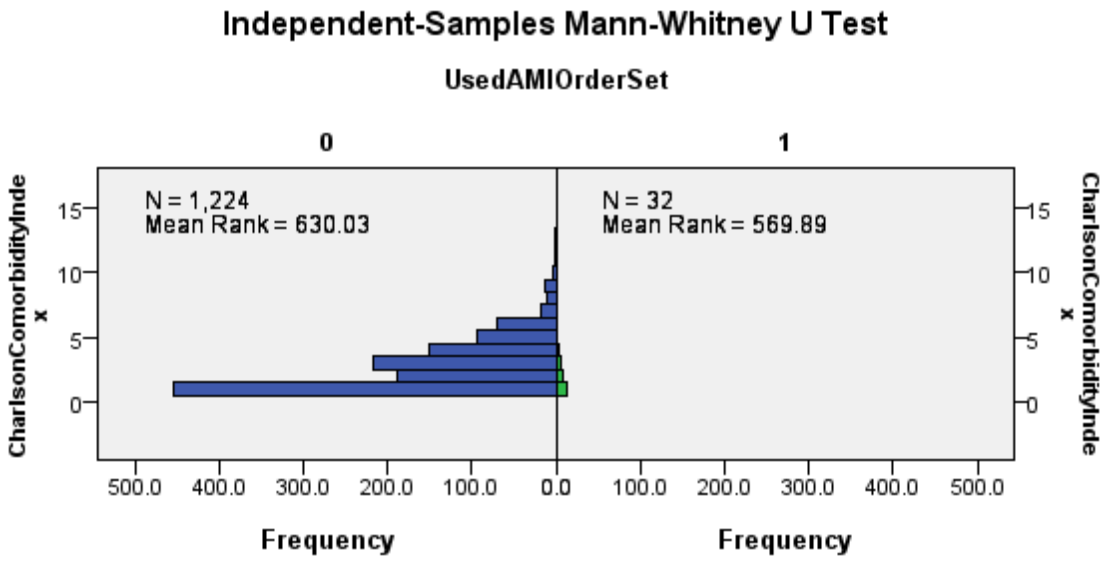
Figure 13. Mann-Whitney U Test of Independent Samples – All AMI Patients, LOS



Total N	1,292
Mann-Whitney U	20,815.500
Wilcoxon W	21,343.500
Test Statistic	20,815.500
Standard Error	2,061.172
Standardized Test Statistic	.318
Asymptotic Sig. (2-sided test)	.750

AMI Study – Charlson Comorbidity Index of Complications Independent Samples Report

Figure 14. Mann-Whitney U Test of Independent Samples – All AMI Patients, CCI



Total N	1,256
Mann-Whitney U	17,708.500
Wilcoxon W	18,236.500
Test Statistic	17,708.500
Standard Error	1,960.795
Standardized Test Statistic	-.956
Asymptotic Sig. (2-sided test)	.339

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