A PILOT STUDY TO DEMONSTRATE THE FEASIBILITY OF PROVIDING SUPPLEMENTAL CLINICAL INFORMATION TO CLINICIANS IN AN ADULT INTENSIVE CARE UNIT

by

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ABSTRACT

Study purpose: The purpose of this pilot study was to evaluate the feasibility of the methodology and impact of providing selected, real-time information abstracted from the medical record with severity of illness scores, on resource utilization and outcomes in an ICU.

Methods: The 16 bed adult ICU at Providence St. Vincent Hospital and Medical Center, Portland, Oregon was used as the study site. Patients admitted with a primary respiratory ICU admission diagnosis were utilized as the target population. A Critical Care Intensivist was recruited and provided with baseline admission data and severity of illness scores on all patients admitted to the ICU. Supplemental information regarding length of stay, resource use, complications and variable direct costs were shared with the Intensivist based on historical benchmark patients managed in this same ICU with the same admitting ICU diagnosis one year prior. Based on this supplemental information it was thought that the Intensivist might consider previous management of patients, their outcomes and similarities with the current patient under care.

Results: The historical benchmark supplemental information (1 year prior) provided to the Intensivist during the management of patients with the same ICU admitting diagnosis was found to be more costly and with greater resource utilization than the actual management practices during the study period. The differences in resource use and outcomes between the historical benchmark period and the study period could not be explained by differences in severity of illness or other independent variables based on multiple linear regression analysis.

The 1999 Control and Intervention study groups were not statistically different in resource use or outcomes. Confounding variables of origin prior to admission and severity of illness were identified as

statistically significant and clinically relevant. An important trend was identified with lower variable direct costs in the study group after case mix adjustment.

Conclusion: The pilot study demonstrated the feasibility of implementing a study of this nature utilizing the methodology described. The historical benchmarking group proved to be different than the current practice and therefore would require a much closer time period of perhaps within the last 3 months for a more meaningful comparative data set. A larger sample size and involvement of additional Critical Care Intensivists would add to potential applicability of this study. Other data sets and formats for displaying information should be explored with the Intensivists in an iterative-like process to evaluate the ability to meet their information needs during a period of real-time clinical patient management.

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INTRODUCTION

In a highly competitive managed care environment cost and quality must be controlled and demonstrated by health care organizations to maintain market share. Critical care is one of the most expensive services for a health care organization with relatively little organized clinical data to demonstrate outcomes and identify opportunities for improvement. Quality assurance and utilization monitoring activities are essential due to high cost of intensive care (Knaus et. al., 1991). Intense pressure exists to maintain quality while reducing resource usage (Pearson et. al., 1995). Reducing the length of hospital and intensive care unit (ICU) stay are key strategies for cost containment (Weissman, 1997).

The typical critical care unit offers many opportunities for quality improvement. The lack of "rigorous data in support of new or existing technologies and critical care practices has resulted in significant variation in physician practice patterns in ICU's" (Kollef & Rainey, 1998). Critical care policies and procedures, and practices vary from site to site across the U.S. in terms of admission criteria, management and weaning of mechanically ventilated patients, indwelling vascular catheters protocols, medications, and treatments for diagnoses such as pneumonia and myocardial infarction (Clemmer, et. al., 1998; Kilo et. al., 1998; Kollef & Rainey, 1998). There are well-documented variations in physician practices as well. (Chassin et. al., 1986; Chassin et. al., 1987; Wennberg et. al., 1989; Williams et. al., 1991; Elson et. al., 1995; Pearson et. al., 1995). Variations in patient management are important because the differences could be associated with unnecessary testing and procedures which may impact cost and complications, and may alter patient outcomes (King, 1992).

Most ICU's use individual patient flow sheets as the documentation tool to track vital signs, continuous infusions of vaso-active medications, key laboratory test results, results of continuous monitoring of physiologic parameters, and important events. However, the typical ICU flow sheet provides no information about how the care of the individual patient compares to the care of similar patients. In addition, when using the flow sheet and the medical record, it is difficult to extract information relevant to quality improvement and cost reduction. Information on complication rates, severity of illness and

resource use are not included in the flow sheet view of the patient's experience in the ICU. This flow sheet, as a tool, only provides a running tally of a subset of the data in the ICU. It does not include data on how one patient is progressing compared other patients, with similar presentation and progress, previously cared for in the same ICU.

Individual and aggregate data sets have not been readily available to individual critical care units to describe the patient/population experience. There is lack of knowledge as to what constitutes best practice in the adult intensive care unit. It is difficult to identify key focus areas for continuous quality improvement (CQI) and cost reduction given the lack of organized information for decision making. There is growing pressure for critical care units to measure outcomes to demonstrate the impact of such expensive care.

In 1996, Project Impact, a clinically rich critical care data system with a national registry component, was created by critical care clinicians to support monitoring resource use and patient outcomes. The Project Impact database contains patient demographics, admission data, severity of illness scoring systems, resource utilization tracking and clinical outcomes-- both procedural and non-procedural related.

The best way to implement Project Impact to support patient management, quality improvement and cost reduction initiatives has not been identified. Currently data in the Project Impact database is utilized in the Providence St. Vincent Hospital and Medical Center, Portland, Oregon, Intensive Care Unit on a retrospective basis for descriptive and problem identification purposes, and is not readily available for use during real-time clinical patient management. The use of such data to provide real-time feedback to clinicians in the care of the individual patient has not been evaluated previously in the setting of intensive care.

Objective:

The purpose of this study was to evaluate whether or not selected, real-time information abstracted from the medical record into Project Impact, presented with retrospective group data from Project Impact (for the same primary ICU admission diagnosis) at Providence St. Vincent Hospital and Medical Center during daily critical care physician Intensivist rounds, would have an impact on resource utilization or outcomes during the ICU phase of care. Specifically, the question we asked was, "would a structured report of data abstracted from medical records and financial data from the hospital information system, provided to clinicians during patient management rounds reduce resource utilization and improve performance on specified clinical measures?"

BACKGROUND

There is tremendous pressure in our society, and in health care organizations to make improvements in the quality of health care and at the same time reduce costs. In the United States alone, charges for an average uncomplicated stay in an ICU may run somewhere between $12k and $22k. For those patients with complications, including non-survivors, the overall hospital bill frequently exceeds $100k. Fakhey et. al. (1996) report the ICU portion of the patient charges may account for 10-15% of a critically ill patient's hospital bill. It is expensive to care for patients in an ICU, and even more so if the patient develops a complication (Bell et. al., 1997).

The potential to develop complications in an ICU is high. These patients are at risk for developing complications related to their illness as well as iatrogenic complications. Even after the two decades that critical care units have been in existence in the United States, the effectiveness of ICU care is uncertain (Moskowitz et. al., 1990). Patients who develop complications have a higher mortality and greater length of stay in both the ICU and the hospital (Moskowitz et. al., 1990). It would be appropriate to look for any opportunity to minimize patient complications in the ICU, and thus reduce costs.

The use of certain technology in the ICU generates greater cost and puts the patient at risk for certain complications. A patient who requires mechanical ventilation, for example, to sustain ventilation and oxygenation frequently requires additional nursing and respiratory therapy care and treatments, diagnostic tests and possibly sedative medications to ensure tolerance and comfort. Prolonged mechanical ventilation is also associated with serious complications, such as pneumothorax or infection. The development of these and other complications of intensive care may require additional testing and interventions, including surgical procedures and the use of vaso-active drugs to support blood pressure and cardiac function.

Impact of Severity of Illness

Physicians make decisions about resource utilization and have a direct impact on the cost of care in the ICU. It has been estimated that physicians may directly influence 70% of medical costs for a hospitalized

patient (Harr & Balas, 1994). Whether or not tools, such as severity of illness models, which predict probability of survival, can assist physicians in decision making regarding resource use remains to be demonstrated. Severity of illness scoring systems are used with individual patients, often as a supplement to other information physicians gather, and to study groups of patients for quality or research purposes. It is recommended that a "conservative" approach be taken when using these scoring systems to direct the interventions of physicians on individual patients, or to make definitive decisions about treatments, as there are limitations based on representative patient populations in the initial testing of these models (Lemeshow & Le Gall, 1994). It is fairly common practice, to use scoring systems to quantify the severity of illness when comparing critically ill patients (Franklin et. al., 1990).

Project Impact, includes four severity of illness scoring systems. Two of these scoring systems are the Mortality Prediction Model (MPM0) and Acute Physiology and Chronic Health Evaluation, second version (Apache II). MPM0 is the only adult critical care severity of illness scoring system that calculates on admission to the ICU, the probability of survival to hospital discharge. The higher the probability, the more likely to survive to hospital discharge. Lemeshow et developed this system. al., (1988) using a multiple logistic regression model. The model includes 15 variables associated with admission, past medical history, the patient's condition on admission and treatment variables at the time of admission to the ICU. To validate this model, a study of 2000 consecutive patient admissions to an ICU was conducted. In a review article, Buist et. al. (1994) found the model to have "excellent goodness of fit, correct classification rate (87% at admission), sensitivity and specificity". Further studies of 12, 000 ICU patient admissions have demonstrated the model to have a high degree of calibration and discrimination, with the area under the ROC curve at 0.837 (Lemeshow et. al., 1993). This model was, however, not based on a representative sample of patients from a large number of ICU's. Studies validating the MPM0 model have identified the most important predictor of ICU outcome as whether or not the patient was in a neurological coma or deep stupor on admission.

Knaus et created the Apache severity of illness scoring system. al. (1981), for the purposes of classifying ICU patients into groups based on the risk of in-hospital death. This system was not intended as a

prediction tool to be used for individual patients, but as a tool to compare groups of patients. Certain patient populations were excluded from data analysis as this scoring system was created. Patients with burns, acute myocardial infarctions, and those with a length of stay in the ICU of less than 16 hours were not included in the original analysis, and thus this version of the system was not representative of these patient populations. The this original version of the Apache scoring system was reported to have a false negative rate of 21% and a false positive rate of 10%. (Buist, 1994).

The second version, Apache II, was developed with a similar approach to the first version, a subjective method utilizing a panel of experts to select the variables and assign weights. Only 12 of the original physiological variables were included, and there was re-weighting of the Glasgow Coma Score, creatinine and the patient's age. The Apache II score is converted to a probability of survival at hospital discharge, with the lower probability being least likely to survive, and higher being most likely to survive to hospital discharge.

Testing for Apache II was performed in 13 large U.S. medical centers. These centers had a similar mix of patients and similar utilization of technology. It has been shown that Apache II does not represent the Diabetic keto-acidosis or post-operative surgical patient well, as the physiology portion of the scoring system impacts the overall score resulting in a lower probability of survival than is most often seen in these patient populations (Buist, 1994). Medical centers with clinical protocols, clear admission/discharge policies, and "excellent" communication had the best patient outcomes. Specifically, survival was lower at sites that had no full time medical director supervising practice, ineffective communication among nursing and physician staff, and nursing management problems.

The procedures, definitions and conditions under which data collection should optimally occur for severity of illness scoring systems are not clearly documented for many systems. All too often there is opportunity for subjective interpretation by individual data collectors between facilities. There can be a significant impact on the results of the scoring systems if "ICU-like" care begins prior to admission to the ICU thus altering the physiological variables which contribute to the overall score and probability of survival

calculation for the patient. The result is a less severe score (higher probability of survival) as compared to others who may not have had "ICU- like" interventions prior to ICU admission. Despite the limitations of applying severity scores to individual patients, making them available to clinicians might provide them with insights into their own practice patterns.

Physician Practice Patterns and Change

Variations in physician practice patterns have a big impact on resource use and costs. Bell et. al. (1997) found substantial variation between two ICU's in the use of laboratory and radiology tests. There is a great deal of interest in targeting the decision making of physicians regarding treatment plans and interventions to impact the cost of patient care. Organizationally, physician practice patterns could be viewed as a "constraint" to achieving higher performance and profitability. The approach to change practice patterns of physicians needs to be carefully planned and executed (Scheinkopf, 1999). There is research to demonstrate that physicians do not change their practice styles or patterns based on the implementation of guidelines alone for the care of certain patient populations (Harr & Balas,1994).

Providing feedback to physicians in the form of information regarding quality of care and patient outcomes is one strategy that has been used in the continuous quality improvement arena for many years. In some cases, this feedback has been successful in changing physician practices. The goal is to provide information to the physician which is to encourage a focus on quality improvement, doing the "right thing", how they compare in resource use and outcomes with their peers, and thus have an effect on their treatment plans and orders for patient management. This strategy of providing information to physicians to change their behavior stems from the Diffusion Model of thinking. Typically, when information is provided to physicians, one or more of the following is identified as the goal:

- To reduce knowledge deficits perceived in the physician's knowledge base (maybe the physician doesn't know the information and its importance).
- To assist in making an "informed" or best decision in a particular circumstance.
- Influence or change the physician's behavior in a particular direction.
- Improve the quality of care provided to the patient.

The Diffusion Model assumes that practitioners, such as physicians, actively seek information and want to keep informed of new developments in medicine. It assumes they set aside time to keep up with the changes in medicine and, when they identify new information that might be relevant to their practice they make the necessary changes freely. This model assumes that "the dissemination of clinically relevant information will eventually lead physicians to change their practices" (Kanouse & Jacoby, 1988).

Kanouse & Jacoby (1988) believed that simply giving physicians information that would be perceived as clinically relevant may *not* necessarily result in a change in practice behavior. Certain conditions increase the likelihood that a physician would make a change in behavior. These include:

- "Transforming the information". This means making the information more usable, easier to interpret, "re-packaging it", or formatting it in a more user-friendly way.
- "Practitioner motivation". This targets the individual physician. The concern is why should they change, what is the value, how will it affect them, and are they ready to change.
- "Characteristics of the Clinical Content". Here, the physician must be able to control the situation and have the ability or authority to use the information to make a legitimate change; or are they aware of the possible outcomes initiating the change and are they ready to handle any subsequent situation.

The key, according to Kanouse & Jacoby (1988), relates to the clinical context of the information provided, and the nature of the information presented to better understand what and how new information might affect a change in behavior.

Greco & Eisenberg (1993) reviewed more than 13 studies of methods to change physician practice published before 1993. They found six methods described in the literature:

- Education
- Providing Feedback
- Participation by physicians in efforts to bring about change

- Administrative rules governing practice
- Financial incentives to motivate change
- Financial penalties to motivate change

Greco & Eisenberg (1993) found those strategies that utilized more than one of the methods identified were more likely to result in physician practice changes than those that did not.

In summary, changing physician behavior must be planned and requires much more than simply providing information and waiting for the physician to make the desired change. It's an active, involved process that necessitates the involvement of the physician recipient of the information. The information must be perceived to be of value to the physician and there needs to be willingness on the part of the physician to look at "possibilities". It is clear that information feedback is important, as physicians want to know how they are doing and if they are providing the best possible care for their patients. Information must be presented in a way that is easily understandable, useful and thoughtfully formatted. Any barriers, real or potential, must be removed to have a chance at a possible change in physician practice patterns. With this in mind, an information intervention study directed at physicians was created to test the impact of aggregate historical patient data on the resource use and outcomes of critically ill patients in an ICU.

STUDY DESIGN

I conducted an observational, controlled study to determine whether real-time supplemental clinical information, given to a critical care physician Intensivist, would have an effect on resource use and outcomes, as compared to a control group of same diagnosis patients in the ICU during the same time period. The intervention group consisted of ICU patients who had a respiratory disorder seen by a single critical care physician who received daily supplemental information about severity of illness and patient costs during the intervention period (Jan-June 1999). The control group consisted of ICU patients seen by any physician during the same period. As described below, a separate group of ICU patients seen between January and June 1998, called the "benchmarking group" was also studied. Data from this group was used to derive benchmarks for the real-time supplemental clinical information. In addition, characteristics of the 1998 group were compared to the 1999 control group to determine the relevance of the benchmark data and to estimate changes in resource use and costs unrelated to the study intervention.

The Respiratory Disorder diagnostic category, as defined by the Project Impact database, was selected as the target population for study. This Respiratory Disorder category is composed of 27 separate Respiratory Diagnoses as defined by the Project Impact system. Further grouping of the diagnoses were done in preparation for the study intervention to allow larger sample sizes (Appendix A). For the purposes of this study the Primary ICU Admitting Diagnosis of one of the respiratory disorders was necessary for inclusion in the study. Project Impact database coding for diagnosis is uniquely identified by the Project Impact Steering Committee (Society of Critical Care Medicine), and is different than ICD-9 coding, a more standard coding scheme.

METHODS

Setting

The Adult Intensive Care Unit at Providence St. Vincent Hospital and Medical Center, Portland, Oregon was selected as the study site. The Adult ICU has participated in the Project Impact database system and national registry for benchmarking purposes since July 1996.

Providence St. Vincent Hospital and Medical Center is a 451 licensed bed tertiary care teaching facility. With an Adult ICU, Coronary Care Unit (CCU), and an Open Heart Recovery Unit (CRU). At this hospital, critical care patients are observed after general anesthesia in the critical care units. The ICU is a 16 bed medical/surgical, non-trauma, "open" critical care unit with a full-time Clinical Medical Director. Any physician with admitting privileges to the hospital may admit patients to the ICU within the established admission policies and procedures. Patients are cared for by specially trained critical care nurses in a staffing ratio of 1:1 or 1:2 depending on the acuity of the patient. Board certified Critical Care Intensivist services are available 24 hours per day on a management or consultation-only basis. Respiratory care and Pharmacy services are available 24 hours per day by specially trained clinicians. Critical Care physician Intensivist led rounds with the ICU nursing and physician Resident staff, and the interdisciplinary team are held Monday through Friday of each week. A review of each patient's presenting problems, current plan of care, and any relevant issues for the team to discuss related to patient management or education of the critical care team are covered during these rounds. Four Intensivists from one Intensivist service rotate coverage for this ICU and lead the rounds. There is potentially a different Intensivist on each week from this group.

Inclusion criteria

Patients were included in the study sample if they were

(1) admitted to the St Vincent Hospital ICU in the period January-June, 1999

(2) had only 1 ICU admission within the study period

(3) had a final diagnosis of a respiratory disorder as described above.

The six- month time period January-June was selected as the study period because it seemed likely to have the greatest number of accessible patients with the required primary respiratory ICU admitting diagnosis.

A historical benchmarking group was established for those patients admitted to the ICU between January and June 1998 with a primary respiratory ICU diagnosis as identified by a retrospective query of the Project Impact database. The purpose of this historical benchmarking group was two-fold. It first established the basis for the development of the supplemental information intervention, and secondly served as a control group to compare possible 1999 medical practice pattern changes that had occurred subsequent to the development of the supplemental information data sheets. In reviewing the six- month sample size in 1998, it became clear that utilizing each of the individual 27 respiratory diagnoses in Project Impact would yield sample sizes much too low to determine any significance. The principal investigator, the Clinical Medical Director, and an epidemiologist from the Center for Outcomes Research and Education for the Providence Health System classified Project Impact respiratory diagnosis codes into groups managed in a similar way, utilizing similar resources for study purposes. These groups were: Airway Obstruction (Project Impact Respiratory Diagnoses 2403, 2404 and 2405), Asthma (Project Impact Respiratory Diagnoses 2407 and 2408), Pneumonia (Project Impact Respiratory Diagnoses 2409, 2410, 2411 and 2412), and Other Respiratory Disorders (2499). The Clinical Medical Director did not believe the other respiratory categories of diagnoses could be grouped effectively to reflect similar management or resource use. In addition, he suggested to not include those respiratory diagnoses related to pulmonary edema as they are often not clearly differentiated from the cardiac diagnoses in Project Impact (Appendix A).

Outcome Measures

The outcome variables to be measured to determine impact of the study intervention were selected upon review of the historical benchmarking group 1998 data as well as a review of the literature and discussion with the Clinical Medical Director of the ICU. These outcome variables, identified from the Project Impact database, included: medical treatments and procedures performed during the ICU phase of care, non-procedure complications which could be attributed to the ICU phase of care, ICU length of stay (LOS), Hospital LOS, and functional status on discharge. In addition, we measured variable direct costs incurred

during the ICU phase of care. Variable direct costs (VDC's) are those costs that are attributed to testing, usage or numbers of items utilized in care and treatment. Examples are number of chest x-rays, numbers of blood gases, central supply items, days in bed in an ICU, and numbers of interventions by type from a Respiratory Therapist. The cost for nursing care may be incurred in a variety of ways from one hospital to another, so it was important to identify the system in use at the hospital selected as the study site. At the hospital selected as the study site, the cost for nursing care is incorporated into the ICU cost.

Preparation of the Database for the Historical Benchmarking Group

In order to obtain variable direct costs for each patient in the ICU for the study period January through June, the hospital financial decision support system was utilized. Once the financial data was obtained, it was imported into a MS Access database and linked with the Project Impact clinical data utilizing the patient account number for that hospitalization as the unique identifier. This portion of the study preparation was particularly challenging as several problems with data from the financial decision support system were discovered. First, records identified in Project Impact did not always match those from the financial database for the same time period. Second, those patients with multiple admissions to the ICU during the same hospitalization had the entire hospitalization ICU costs attached to each ICU admission. Third, ICU charges were not recorded correctly for patients who had an ICU stay but were not in an ICU bed during the midnight census (when the financial charge was captured for bed location).

We could not establish a reliable procedure to identify the variable direct costs for each specific ICU admission for patients with multiple admissions to the ICU during the same hospitalization, so these patients were eliminated from the historical benchmarking group, and thus from the study. As a result, only patients with a Primary ICU Admission diagnosis of a Respiratory Disorder and a single admission to the ICU during the hospitalization were eligible for study inclusion.

Records for patients in the ICU less than 24 hours and those not in an ICU bed at midnight were looked up in the financial database on a case by case basis, and the desired information was entered manually into the Access database. A problem was identified with partial day charges for ICU care not being input into the

financial system for 9 cases during the January-June 1998 time period. This finding was shared with the manager of the critical care service for follow-up auditing. These 9 cases were eliminated from the historical benchmarking group because of incomplete data for future analysis.

The MS ACCESS database was then queried to obtain all patients with a Primary ICU Admitting diagnosis of Respiratory Disorder. The selected records were imported into a MS Excel spreadsheet. Patients with multiple admissions during the same hospitalization were identified and eliminated. This established the final group for historical benchmarking.

The next task was to categorize all 27 Respiratory Disorder diagnoses based on the Project Impact coding scheme and summarize each based on resource use and outcome variables as previously identified. In addition, several important and potentially confounding variables were included in the summaries. These included age, origin prior to ICU admission, condition on admission to the ICU (stable, critical/unstable or moribund, as defined by Project Impact), and severity of illness measures. For the purposes of this study, only two of these scoring systems were included for classification purposes and, in the supplemental information intervention provided. The available literature on these scoring systems and their intended use were made available to the critical care physician Intensivist as part of the preparations before the supplemental information intervention was provided. These two were selected based on the time period they provided the probability of survival score, and the frequency of use in the medical literature as classification tools and predictors of survival for critically ill patients meeting the criteria for the scoring system use.

Development of Format and Content for Feedback

The Clinical Medical Director of the ICU and one other Intensivist were asked to participate in the design of the supplemental information data form. The Clinical Medical Director, also an Intensivist, also agreed to be the subject of the pilot study of its use. The study Intensivist was provided education by this investigator regarding Project Impact as a data system, the national registry and most recent national registry report comparing this ICU to other like ICU's in the U. S. based on participation in Project Impact. In addition, supplemental articles on severity of illness scoring systems for adult critically ill patients, and

the 1998 historical benchmarking group data for this ICU related to resource use and outcomes of patients with the ICU admission diagnosis selected for this study were shared with this Intensivist.

The Intensivist wanted to be able to quickly look at the historical portion of the information presented during the study to get a visual cue as to how the current patient differed in terms of severity of illness scores from the group, and what were the most frequently used resources were for the group of patients. In addition, there was interest in what complications had occurred so as to be on the look out for any adverse situations, or potentially intervene to avoid problems later. Once the information and formatting were pilot-tested, and agreed upon, additional information was added for the current study patient. The additional information placed on each supplemental information sheet was an overview of the study patient. This information included severity of illness scores as available, origin, condition on admission, lengths of stay, diagnosis, ICU and hospital days, and whether there was an Intensivist on the case, all identified as important by the study Intensivist. An example of the final format and contents of one of the supplemental information sheets is presented in Appendix B.

Change in Approach to Data Collection

The study protocol required that Project Impact data be available to the Intensivist within 24 hours. Prior to this study, the Project Impact data coordinator (also the study data coordinator for this project) abstracted data from the medical record after patients were discharged from the hospital.

A single study data coordinator began in December 1998 piloting the most efficient way to obtain the desired information within 24 hours of the patient's admission to the ICU. Ultimately, it made the most sense to have the study coordinator change her work hours and priorities for data collection projects. It was necessary to abstract the patient data from the patient charts in the ICU well before rounding time so that the supplemental information sheets could be completed and ready for the Intensivist review prior to the daily rounds Monday through Friday. The supplemental information sheets were provided to the study Intensivist only, with a report of all newly admitted patients to the ICU with the diagnosis, origin, ICU Primary diagnosis, severity of illness scores as available, and whether the patient was mechanically

ventilated, on vaso-active medications or Propofol for heavy sedation (Appendix C example). This additional information was requested by the Intensivist to become more familiar with severity of illness scores, and the complexity of care required for the patients in the ICU. This information was particularly desired prior to the ICU multidisciplinary rounds. The information intervention (supplemental information sheets for the Primary ICU admitting diagnosis of a Respiratory Disorder, and the report listing of all newly admitted patients information sheet) were provided only to the Intensivist participating in the study.

Those patients admitted to the ICU who met the study inclusion criteria but were not completely managed by the study Intensivist, were excluded from the study group for purposes of analysis. In addition, if the supplemental information sheet about a particular patient was not provided to the study Intensivist (ie. No information intervention), the patient was excluded from the study group. In both of these situations, the patient became part of the 1999 control group where no intervention occurred, for the purposes of analysis. Situations that interfered with the intervention included vacations, inability to provide the supplemental information due to unavailability of the study data coordinator, and the inability to provide the information intervention prior to the ICU rounds.

The 1999 study period was extended for one month, into July, in the hopes of adding additional patients to the sample. All patients meeting the study inclusion criteria for the period January through July 1999, managed by the study Intensivist, and the supplemental information intervention was provided were considered the study group. The 1999 control group was compared to the 1998 historical benchmarking group to identify significant medical practice changes that could be reflected in the resource and outcome variables selected for analysis. This analysis was necessary to determine whether any significant changes in the supplemental information intervention study group would be based on the information intervention alone, or if there had been medical practice changes that might explain any variations since the supplemental information sheets were developed using data from 1998.

Supplemental Information Intervention

The supplemental information sheets included:

- **Baseline Patient Data**: Patient ID, age, hospital admission date and diagnosis, hospital day, ICU admission date and primary diagnosis, ICU hours or days, location of the patient prior to admission to the ICU (origin), condition on admission to the ICU, and if there was an Intensivist on the case at the time of reporting. Severity of illness scores MPM 0 and Apache II, were provided with each patient if they met inclusion criteria for the scoring systems by the morning of each data submission to the Intensivist.
- **Comparative Group Data**: January through June 1998 historical benchmark data was abstracted from Project Impact, as previously described. The financial data, variable direct costs associated with the ICU portion of the hospitalization (ICU phase of care), grouped by department, were provided as well. The comparative data were summarized as follows:
  - Number of patients in the data set,
  - Average age,
  - MPM 0 and Apache II average scores,
  - Ventilator use, Propofol drug use, vaso-active drug use, and specialty bed use.
  - Resources such as medical treatments and procedures based on the interest of the Clinical Medical Director and information gleaned from the medical literature on resource use in costs associated with the management of critically ill patients.
  - Major complications that could be attributed to the ICU phase of care.
  - Average ICU length of stay,
  - Hospital length of stay,
  - Functional status on discharge, and the
  - Average total ICU variable direct cost

In addition to the supplemental information presented, a report listing all newly admitted patients to the ICU with age, origin, condition on admission, primary ICU admission diagnosis, severity of illness scores,

and use of mechanical ventilation, Propofol for heavy sedation, or vasoactive medications to support blood pressure was provided on a daily basis.

Survey Data

A brief survey was presented to the study Intensivist at periodic intervals, or at his request. This short set of questions was provided to determine interest or value in the supplemental information provided, and if the supplemental information about specific patients and the comparison to previously managed patients in this ICU provided any value in management (Appendix D).

Additional data collection for Outcome Analysis

The following information was collected after transfer from the ICU for the purpose of analysis to determine whether there had been an impact from the intervention:

- **Utilization data**: ICU length of stay, Propofol drug use, mechanical ventilation use, vaso-active drug use, specialty bed use, and other treatments or procedures performed during the ICU stay which might suggest an impact on length of stay or cost.
- **Outcome data**: ICU complications, ICU LOS, Hospital LOS, Functional Status at hospital discharge, variable direct costs for ICU, Pharmacy, Respiratory Therapy, Laboratory, and Radiology departments, and Total variable direct cost for the entire ICU phase of care.

ANALYSIS

This pilot study demonstrated the feasibility of the study methodology and examined the potential for reducing resource use and costs in an intensive care unit when supplemental clinical information about previous management of patients with a similar diagnosis was presented to an Intensivist. In addition, concurrent data with severity of illness scores on all patients admitted to the ICU was provided to the Intensivist during the course of patient management.

The analysis was conducted in two phases. In phase one, for each of the four clinical subgroups (Airway Obstruction, Asthma, Pneumonia and Other Respiratory Disorder), we examined whether there were significant baseline differences in physician practices, resource use, and cost between the 1998 benchmarking group and the 1999 *control* group. The purpose of this analysis was to examine whether or not the 1998 benchmarks were relevant to practice in 1999. We were trying to pinpoint whether the differences between the two time periods could be attributed to certain independent variables or subgroups. We used the Student's t-test or a chi-square test to determine whether there were statistically significant differences in individual baseline characteristics between the 1998 benchmarking and 1999 control groups. Because we found systematic differences in origin, resource use and outcomes, we performed multiple linear regression analyses to better understand potential predictors and to better communicate the variances between these two time periods. The independent variables were identified as origin and MPM0, and the dependent variable as variable direct cost.

In the second phase, we compared the 1999 intervention group to the 1999 control group. Specifically, we examined whether or not there was a difference in resource use or outcomes with the supplemental intervention, versus usual care. As in the first phase analysis, the plan was to compare the overall groups, then stratify by clinical subgroup and analyze results for each clinical subgroup separately. Student's two-tailed *t* tests, Chi Square tests, and comparison of proportions (z tests) for treatment and procedures were used as appropriate to determine whether or not there had been any differences between 1998 and 1999, and whether or not there had been any an impact on study patient outcomes based on the supplemental

information intervention to the Intensivist during the study period. Our goal was to see if there was a difference in variable direct cost after adjusting for known confounding variables.

RESULTS

There were 906 patient admissions to the ICU during the 1998 historical benchmarking period, and 1006 patient admissions to the ICU during the 1999 study period. In 1998, 75 of the 906 patients had a single admission to the ICU and fell into one of the four groupings for analysis (Airway Obstruction, Asthma, Pneumonia and Other Respiratory Disorder) and thus served as the historical benchmarking group for this study. In 1999, 104 patients of the 1006 patients admitted fell into one of the four groupings for analysis and served as the sample for the 1999 study period. Of these 104 patient admissions in 1999, 20 met all of the criteria for inclusion and analysis for the intervention group, and 64 patients met the criteria for inclusion in the 1999 control group. Table #1 shows the reasons for exclusion of the remaining 1999 patients. In the intervention group, 8 patients were excluded because they had a change in the primary ICU admission diagnosis after the information had been presented to the study Intensivist, and therefore did not have a final diagnosis of one of the respiratory disorders. Six patients had a final diagnosis that did not fit one of the 4 clinical subgroups included in the study (non-study diagnosis); and six patients had re-admissions to the ICU during the same hospitalization.

Table # 1

1999 Intervention Group: Reasons for Exclusion

Study #	Reason for Exclusion	Initial Primary ICU Admission Diagnosis	Final Primary ICU Admission Diagnosis
6	Non-Study Diagnosis	Pulmonary Edema-Non-cardiac (2418)	Pulmonary Edema-Non-cardiac (2418)
7	Readmission	Other Respiratory Disorder (2499)	Other Respiratory Disorder (2499)
9	Non-Study Diagnosis	Pulmonary Edema-Cardiac (2416)	Unchanged
17	Change in Primary Diagnosis	Pneumonia-Viral (2409)	Cardiogenic Shock (2101)
18	Change in Primary Diagnosis	Other Respiratory Disorder (2499)	Hypothyroidism (2808)
19	Change in Primary Diagnosis	Other Respiratory Disorder (2499)	Pulmonary Edema-Cardiac (2416)
20	Readmission	Pneumothorax/Hemopneumothorax-spontaneous (2426)	Unchanged
21	Readmission	Airway Obstruction-Other Cause (2405)	Unchanged
22	Readmission	Pneumonia-Viral (2409)	Unchanged
23	Change in Primary Diagnosis	Pneumonia-Viral (2409)	Septic Shock (2102)
26	Non-Study Diagnosis	Pulmonary Edema-Cardiac (2416)	Unchanged
28	Change in Primary Diagnosis	Status Asthmaticus (2408)	Congestive Heart Failure w/o Pul. Edema (2213)
30	Readmission	Pneumonia-Viral (2409)	Unchanged
32	Change in Primary Diagnosis	Pneumonia-Viral (2409)	Unchanged
33	Non-Study Diagnosis	Pulmonary Embolism (2413)	Unchanged
34	Non-Study Diagnosis	Pulmonary Edema-Cardiac (2416)	Unchanged
36	Non-Study Diagnosis	Pulmonary Edema-Unclear/Unspecified (2419)	Unchanged
37	Change in Primary Diagnosis	Pneumonia-Viral (2409)	Bleeding-Lung/Bronchi/Hemoptysis (3702)
38	Change in Primary Diagnosis	Pneumonia- Unclear/Organism Not Specified (2412)	Other Acute Neurologic/Spinal/Psychiatric Disorder (2099)
40	Readmission	Other Respiratory Disorder (2499)	Unchanged

Table #2 shows demographic and clinical characteristics of the final 1998 historical benchmarking, 1999 control, and 1999 intervention samples.

Table #2
Final Demographic and Clinical Characteristics

	1998 Historical Benchmark Group	1999 Control Group	1999 Intervention Group	p value
Sample Size	N = 75	N = 64	N = 20	
Mean Age	61.6 years	62.8 years	60.9 years	p =0.89
Clinical Diagnostic Groups				p =0.20
% Airway Obstruction	21% (N = 16)	14% (N = 9)	15% (N = 3)	
% Asthma	12% (N = 9)	6% (N = 4)	10% (N = 2)	
% Pneumonia	52% (N = 39)	53% (N = 34)	35% (N = 7)	
% Other Respiratory	15% (N = 11)	27% (N = 17)	40% (N =8)	
Severity of Illness				
MPM 0	0.83 (N= 68)	0.85 (N= 57)	0.78 (N= 20)	p=0.44
Apache II	0.76 (N= 61)	0.71 (N= 51)	0.78 (N=17)	p=0.32

There were no statistically significant differences in age, clinical diagnostic groups, or severity of illness between the 1998 Historical Benchmark, 1999 Control or 1999 Intervention Groups.

PHASE ONE ANALYSIS

The first phase of analysis was to evaluate whether or not there had been any significant changes in medical management from 1998 historical benchmarking group and the 1999 control group. Patients that received the study supplemental information intervention were not included in this analysis.

The results of this analysis indicated a greater number of patients admitted from the floor to the ICU in 1998. Otherwise the two groups were comparable at baseline (Table #3). There were statistically significant greater Complications, ICU LOS, Hospital LOS, and all Variable Direct Costs in 1998 as compared to 1999. The 1998 Benchmark group utilized more antibiotics, Specialty beds, BIPAP and Oxygen at rates greater than 60% as compared to the 1999 Control group (Table #4).

Table #3
Group Comparisons 1998 &1999
All Diagnostic Group Comparisons-Baseline

Variables		1998 Benchmark (N = 75)	1999 Control (N = 64)	p value
Mean Age		61.6 years	62.8 years	p =0.706
Origin				p =0.070
	ER	35	39	
	Floor	21	8	
	Other	19	17	
Condition on Admit				p =0.266
	Stable	13	17	
	Critical/Unstable	62	47	
MPM0		0.83 (N=68)	0.85 (N=57)	p =0.428
Apache II		0.76 (N=61)	0.71 (N=51)	p =0.994

Table #4
Group Comparisons 1998 &1999
All Diagnostic Groups: Outcome Measures and Resource Use

Variables	1998 Benchmark (N=75)	1999 Control (N =64)	p value
Outcome Measures			
Complications*	25	7	**p =0.004***
Mean ICU LOS*	4.86	1.9	**p <0.001***
Mean Hospital LOS*	9.7	5.12	**p <0.001***
Functional Status on D/C			p =0.250
Return to Baseline	40	43	
Partially/Totally Dependent	4	14	
Dead	11	7	
Mean ICU VDC in $ *	3625	1395	**p <0.001***
Mean RX VDC in $ *	626	347	**p =0.014***
Mean RT VDC in $ *	920	352	**p <0.001***
Mean LAB VDC in $ *	271	129	**p =0.005***
Mean RAD VDC in $ *	200	75	**p <0.001***
Mean TOTAL ICU VDC in $ *	6366	2784	**p <0.001***
Medical Treatments*			
Major/Heavy Sedation	45	38	p =0.957
NM Blockade	6	1	p =0.230
Vaso-Active Medications	18	10	p =0.339
Antibiotic Use	33	45	**p =0.004***
Steroid Use	35	37	p =0.261
Specialty Bed Use	9	0	**p =0.012***
Bronchodilator Use	37	38	p =0.314
Procedures*			
Ventilator Use	33	31	p =0.763
Intubation	25	22	p =0.956
BiPap/CPAP use	20	2	**p <0.001***
Echocardiogram	18	11	p =0.421
Oxygen use > 60%	14	2	**p =0.008***
Tracheostomy	7	4	p =0.731

Further analysis involved the stratification by respiratory diagnostic group to better understand these findings. The diagnostic groups, as defined by the Intensivist, were then individually examined to determine differences between the two years.

Airway Obstruction: 1998 & 1999

There were no statistically significant differences found in the age, origin, condition on admission, MPM0 or Apache II variables for the Airway Obstruction group. Clinically, the Apache II probability of survival to hospital discharge was lower for the 1999 group which would be an indication of a sicker patient

population at 24 hours in the ICU. There was one significant outlier in 1999, with a hospital length of stay of 90 days. After eliminating this patient from the analysis of hospital length of stay, and reviewing the variable direct costs associated with the ICU stay, there was quite a difference in the outlier impact on the costs. This patient was thus removed from the study analysis. There was a statistically significant lower hospital length of stay for the 1999 group (5 days). The ICU LOS was decreased by ½ day in 1999. The variable direct costs for the ICU were lower by $1200/case in 1999, as well as Pharmacy by $250/case, Respiratory Therapy by $350/case, Laboratory by $30/case, Radiology by $70/case, and total ICU VDC by $1800/case. There was no ventilator use, intubations, or BIPAP use in 1999. There were no patients in the 1999 group requiring oxygen at levels greater than 60%, as there were six patients in 1998. The 1998 medical treatment and procedure data suggest a greater complexity of patients managed in 1998 as compared to 1999, however the severity of illness was not significantly different (Appendix E).

Asthma: 1998 & 1999

There were no statistically significant differences found in the age, origin, condition on admission, MPM0 or Apache II variables for the Asthma group. There were no statistically significant differences in outcomes or resource use between the two groups. There was a 2 day lower length of stay in the ICU, a 4 ½ day lower length of stay in the Hospital. The variable direct costs in ICU in 1999 were lower by $1600/case, Pharmacy by $200/case, Respiratory Therapy by $400/case, Laboratory by $70/case, Radiology by $100/case, and total ICU VDC by $2500/case as compared to 1998. Clinically, there was less vaso-active medication and ventilator use, and no intubations in 1999. There were no complications reported in 1999, as there were two patients classified as Other Neuro (confusion) in 1998 (Appendix F).

Pneumonia: 1998 & 1999

There were no statistically significant differences found in the age, origin, condition on admission, MPM0 or Apache II variables for the Pneumonia group. There were greater numbers of patients admitted from the floor in 1998 as compared to 1999. There was a statistically significant lower length of stay in the ICU (3 days), lower ICU VDC ($2400/case), Respiratory Therapy VDC ($670/case), Radiology VDC ($125/case) and Total ICU VDC ($3700/case). The hospital length of stay was 2 days shorter in 1999 and there were

half as many complications in 1999. There was a statistically significant increase in antibiotic use in 1999, and decrease in Specialty bed use (Appendix G).

Other Respiratory Disorders: 1998 & 1999

There were no statistically significant differences in the age, condition on admission, MPM0 or Apache II variables for the Other Respiratory Disorders group. There was however, a statistically significant difference in the pattern of distribution for the origin of patients prior to admission to the ICU. In 1998 there were greater numbers of patients admitted from the floor; in 1999 greater numbers from the ER. There was a statistically significant reduction in complications in 1999, as well as almost a 1½ day lower length of stay in the ICU and 1 day lower length of stay in the hospital. The ICU VDC was $1300/case lower in 1999, as well as Pharmacy by $120/case, Respiratory Therapy by $200/case, Laboratory by $280/case, Radiology by $70/case, and total ICU variable direct costs by $2400/case. There was a statistically significant increase in Bronchodilator use in 1999 as well (Appendix H).

Multiple Linear Regression Analysis

To further understand what variables may have contributed to these findings and to be able to inform physicians about the quality of the comparisons, multiple linear regression analyses were performed looking specifically at key outcome measures: ICU LOS and ICU VDC. In the stepwise approach to finding a regression model, the Origin and MPM0 were identified as candidate variables. The origin alone had no effect on the conclusion that there was a significant difference between the two years. Severity of illness (MPM0) alone had no effect on the conclusion as well. When age, origin, condition on admission to the ICU, diagnostic group and severity of illness were entered into the regression equation, there was no effect on the conclusion that there were differences between the two years that could not be explained by other differences in the case mix.

Further stratification by medical treatments and procedures may be warranted in the future studies to identify medical practice changes between the two year time period as the regression analysis performed could not satisfactorily identify independent predictors which would be useful to clinicians. The 1998

Benchmark and the 1999 Control group were different enough that the 1998 Benchmark group did not reflect a meaningful standard for care in 1999.

B. PHASE TWO ANALYSIS

Phase Two analysis compared the 1999 Control with the 1999 Intervention group to evaluate the impact of the supplemental information intervention on the outcome measures and resource use. Table #5 compares the baseline characteristics of these two groups. Patients in the control group were more likely to be admitted to the ICU from the emergency room or from outside the hospital (p=.022). They also had a higher MPM0 probability of survival than patients in the study group (p=.016). As mentioned in previously, this may have had an impact on prior interventions, severity of illness scores, and subsequent resource use and outcomes of these patients (Table #5). There was a statistically significant lower MPM0 probability of survival in the Study group.

Table #5

Group Comparisons 1999
All Diagnostic Groups-Baseline

Variables	Control Group (N = 64)	Study Group (N = 20)	p value
Mean Age	62.8	60.9	p = 0.662
Origin*			p =0.022*
ER	39	12	
Floor	8	7	
Other	17	1	
Condition on Admit			p =0.448
Stable	17	3	
Critical/Unstable	47	17	
MPM0*	0.85 (N=57)	0.78 (N=20)	p =0.016*
Apache II	0.79 (N=56)	0.78 (N=17)	p =0.794

In terms of outcome measures, there was a statistically significant lower Radiology VDC ($40/case) in the Control group as compared to the Study group. In addition, the Control group had lower costs for ICU

VDC $430/case; Pharmacy VDC $250/case; Respiratory Therapy VDC $100/ case; Laboratory VDC $20/case; and total ICU VDC $800/case as compared to the Study group. There were half as many complications in the Study group as compared to the Control group. There was a statistically significant greater use of vaso-active medications in the Study group (Table #6).

Table #6

Group Comparisons 1999
All Study Diagnostic Groups
Outcome Measures and Resource Use

Variables	Control Group (N = 64)	Study Group (N = 20)	p value
Outcome Measures			
Complications	7	5	p =0.232
Mean ICU LOS	1.9	1.79	p =0.706
Mean Hospital LOS	5.12	3.9	p =0.135
Functional Status on D/C			p =0.473
Return to Baseline	43	16	
Partially/Totally Dependent	14	2	
Dead	7	2	
Mean ICU VDC in $	1395	1521	p =0.539
Mean RX VDC in $	347	455	p =0.080
Mean RT VDC in $	352	419	p =0.275
Mean LAB VDC in $	129	120	p =0.744
Mean RAD VDC in $	75	95	p =0.186
Mean TOTAL ICU VDC in $	2784	3060	p =0.442
Medical Treatments*			
Major/Heavy Sedation	38	11	p = 0.955
NM Blockade	1	1	p =0.946
Vaso-Active Medications	10	8	p =0.05*
Antibiotic Use	45	15	p =0.767
Steroid Use	17	8	p =0.408
Bronchodilator Use	15	6	p =0.736
Procedures			
Ventilator Use	31	12	p =0.496
Intubation	22	9	p =0.532
BiPap/CPAP use	2	3	p =0.147
Echocardiogram	11	1	p =0.329
Tracheostomy	4	1	p =0.702

Further analysis involved the stratification by respiratory diagnostic groups as described previously, to better understand the differences between the Control and Study groups.

Airway Obstruction: 1999 Control Group and Study Group

There were no statistically significant differences in the demographics or clinical characteristics between these two groups. There were a greater number of patients admitted from other facilities to the ICU in the Control Group. The Study group had a lower Apache II score at 24 hours in the ICU, which translates to a lower probability of survival to hospital discharge. The Control group data included a patient with a 90-day hospital length of stay. The Control group data were evaluated with this outlier and without this outlier to determine whether or not there was a large difference in any of the variable categories that would suggest this patient was different from the others. This outlier impacted hospital length of stay and ICU variable direct costs, and therefore was eliminated from the entire analysis in this study. Financially, there were greater ICU VDC in the Study group ($150/case), and lower Laboratory VDC ($25/case) and Total ICU VDC ($25/case) in the Study group.

The Control group had a greater proportion of major/heavy sedation and steroid use than the Study group. The Study group had a higher proportion of complications as compared to the Control group. There was one patient in the Study group requiring intubation and mechanical ventilation as compared to none in the Control group (Appendix I).

Asthma: 1999 Control Group and Study Group

The Apache II severity of illness at 24 hours in the ICU was slightly lower in the Study group as compared to the Control group. There was a statistically significant increase in Pharmacy VDC ($400/case) and Respiratory Therapy VDC ($340/case) in the Study group. . The ICU length of stay was greater in the Study group (1/2 day), yet the Control group had a longer Hospital length of stay. The Hospital length of

stay is determined from the hospital financial system based on the type of bed occupied at midnight. The ICU length of stay is calculated in Project Impact based on actual hours in the ICU. The low sample size and method of deriving the length of stay can explain the incongruence in the mean ICU length of stay and the Mean Hospital length of stay for the Study group. The Study group had greater antibiotic use, major/heavy sedation, neuromuscular blockade use, and ventilator use as compared to the Control group. There were fewer intubation procedures in the Study group (Appendix J).

Pneumonia: 1999 Control Group and Study Group

There was a statistically significant difference in the pattern of distribution for origin on admission to the ICU for the control group and study group. There were a greater proportion of Study patients from the floor, and a greater proportion of patients in the Control group admitted to the ICU from other facilities. There was also a statistically significant lower Apache II probability of survival in the Control group.

Length of stay and costs for the Study group were lower in the following areas: ICU VDC by 1 day/case, Hospital LOS by 2 ½ days/case, ICU VDC by $600/case, Pharmacy VDC by $300/case, Respiratory Therapy by $200/case, and Total ICU VDC by $1300/case. In addition, there were no complications in the Study group, and a lower mortality as compared to the Control group.

There was a statistically significant greater proportion of vaso-active medication and BIPAP use in the Study group. There were echocardiogram and tracheostomy procedures performed in the Control group that were not performed in the Study group (Appendix K).

Other Respiratory Disorder: 1999 Control Group and Study Group

There was a statistically significant lower MPM0 probability of survival for the Study group. The Study group had a lower Hospital LOS by 1½ days as compared to the Control group. There were greater costs in the Study group in the following areas: ICU VDC by $700/case, Pharmacy VDC by $350/case, Respiratory Therapy by $100/case, and Total ICU VDC by $1500/case. A higher proportion of ventilator use was noted in the Study group (Appendix L).

Multivariate Analysis

We identified a baseline difference between the control and study groups in severity of illness (MPM0). A regression analysis was necessary because there were known baseline differences in the groups. Even if there had been a trend toward lower cost in the study group, the regression would have been needed because we identified a case mix difference at baseline. Sex, age, origin, condition on admission, MPM0 and diagnostic category were candidate independent variables. The dependent variable was total variable direct cost. The regression model identified only the Origin and the MPM0 as an important predictor of total variable costs. After adjustment for origin and MPM0 severity, there was no statistically significant difference in costs between the control group and study group. Analysis of the ICU LOS included the diagnostic group, origin, and severity of illness. Only the Origin and MPM0 entered into the regression equation for this part of the analysis. There was no significant difference in ICU LOS after adjustment. Functional Status on discharge from the hospital was also analyzed. Only age and MPM0 entered into the regression equation. There were no differences between the Study and Control groups. Severity of illness entered into the regression equation with all VDC's. There was no significant difference between the two groups, but there was a trend toward lower ICU VDC for the Study group. After adjustment for severity of illness, ICU VDC was lower in the Study group by $275/case, Pharmacy VDC by $90/case, and Total ICU VDC by $475/case. A trend toward lower probably of survival was identified for the Study group after case mix adjustment. Without this case mix adjustment, the mean values for the variable direct costs in the Study group were higher than those in the Control group.

Survey Results

It was important to identify how useful the Intensivist found the supplemental information, not only in terms of the format of the material presented, but whether it contained data that may have been of value to the Intensivist. As there was only one Intensivist participating, the results are only summarized, with averages calculated for the final and cumulative results. At three different times during the study period the

Intensivist was asked to complete the short questionnaire with a Likert rating scale (1-strongly disagree, 5-strongly agree) regarding the usefulness of the supplemental information provided (Appendix K).
The Intensivist recruited for the study reported greater than 15 years experience managing critically ill patients. He had not previously used severity of illness scores to assist in the management of patients. His familiarity with severity of illness scores was from literature and study reviews. He had some exposure to severity of illness systems, as he was involved with the Project Impact database committee at the study hospital. He had prior exposure to reviewing the quarterly reports from the national registry for benchmarking purposes. He actively participated in variable selection and design of the supplemental information data sheets and daily reports of new patients admitted to the ICU prior to the beginning of the study. He provided regular feedback regarding changes to the format of the daily information provided which would help him visualize the data more clearly. One such needed change was the removal of the primary admission diagnosis codes and replacement with the text to explain exactly what the Project Impact diagnosis was for a certain patient. He monitored the coding of the primary ICU admission diagnoses to ensure his agreement with the coding.

To summarize the responses to the survey, the study Intensivist reported an average score of 3 (neutral/uncertain) for the question related to whether the supplemental information assisted in the management of patients. Of interest was that the initial score, as the beginning of the study period was a 2 (disagree) and finished as a 4 (agree). With regard to the information being presented in a useful way, the Intensivist was in agreement (4) for two of the surveys, and finished with a 5, as strongly agree. The Intensivist was neutral/uncertain throughout the study period regarding whether the supplemental information provided the right data to support patient care decisions. Initially, the Intensivist did not agree that the project Impact database provided useful information to clinicians on a daily basis. This score gradually moved from a disagree (2), to a neutral/uncertain (3), and at the conclusion, a response of strongly agree (5). The final question on the survey related to whether the severity of illness scores provided information that the Intensivist had not previously considered. The Intensivist was neutral/uncertain initially, and finished the study with a strongly agree (5) response to this question.

The average overall score on the first survey was 2.8. The second survey overall average score was 3.4. The final survey average score was 4.4. This suggested to this investigator that the Intensivist may have become more familiar with the data over time, and perhaps had incorporated some of the components of the supplemental information into his rounding with the multidisciplinary team as well. It is also possible that some "learning" had occurred over the course of the study period that assisted the Intensivist in becoming more familiar with the data presented (Appendix S).

According to the comments submitted by the Intensivist on the surveys, initially he was not convincing that the supplemental information had a role in the management of patients at the bedside, but was keeping "an open mind". The comments on the second survey suggested that the MPM0 scores could be misleading on surgical patients, and complications that occurred in patients may lead to severity of illness in medical patients that was not accounted for in the scoring systems. In addition, it did not appear that scores correlated for the intensity of care required for a given patient. In the final review, the Intensivist commented that the use of the severity of illness scores on a real time basis was interesting, particularly with the Medical Residents and Staff nurses. "The team felt often they could beat the statistics and expressed pride in the management of patients who lived despite poor predictors". There were times when it seemed that the two ICU Resident teams "competed for the sickest patients as defined by the severity of illness scores. Overall, the Intensivist reported that he liked the concurrent data provided by the supplemental information, and the historic comparisons, but was unsure of how to use the cost data provided on variable direct costs when managing patients in real time. It seemed there was an education impact on the multidisciplinary team that he found beneficial.

By the end of the study, the Study Intensivist strongly agreed with the statement that Project Impact data was useful and that the format in which it was provided was useful. Recalling that the Intensivist had input into the formatting of the supplemental information data forms, the strong agreement that the format was useful was not surprising. This finding reinforces the importance of Clinician involvement in the display of data for use.

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

In this study, concurrent supplemental information about severity of illness, baseline demographics, complications, and resource utilization did not result in better outcomes or lower costs than usual care. As a pilot study, the sample sizes were too small to make any conclusions on the impact of the supplemental information intervention on resource use or outcomes. Several confounding variables were identified as significant and clinically relevant (origin and severity of illness) when comparing the Study group and the Control group. Of particular interest was the origin of the patient prior to admission to the ICU. It is postulated that this would have an impact on the medical plan of care, resource use and potential outcomes in the patient groupings studied, thus altering any conclusions that might be made without further analysis. An important trend was identified with lower costs in the Study group after case mix adjustment.

It was not anticipated that there would be a difference in the 1998 historical benchmarking group and the 1999 control group when all data were pooled for analysis. It appears that the sample group of all primary respiratory ICU admission diagnosis patients in 1999 was indeed different from the 1998 historical benchmarking group. Cumulatively, there was evidence of less resource use and improved outcomes overall in the 1999 Control as compared to the 1998 Benchmark. Further, analysis by subgroups and stepwise multiple regression analysis did not change this finding, that indeed 1998 was not a good reflection of the standard for care in 1999.

It was surprisingly difficult to collect the data for the supplemental information sheets in time for morning rounds. By the morning, the study data coordinator had to collect, review, and enter information from the previous day's chart. We did not anticipate the difficulty of concurrent coding of patient admission diagnoses. Retrospective coding is fairly straightforward because the data is already in the chart for interpretation and decision making. This was not the case with concurrent data collection.

A second problem arose related to coding of the diagnoses. There were several instances where the study Intensivist did not agree with the coding of the primary ICU admission diagnosis by the study data coordinator. The resolution to these situations was a brief meeting to review the patient's medical record together, and share information that might not be accounted for in the documentation. If a change resulted from the meeting related to any of the study patients, they were eliminated from further data collection and analysis as described previously.

It was not possible to investigate patients with multiple admissions to the ICU. It is thought that these patients would be most expensive, with the poorest outcomes based on exposure to the hospital environment and the risks associated with the use of technology. Once the financial system is further refined, as a future study, it would be important to investigate the resource use and outcomes of the patients who are re-admitted to the ICU with a primary respiratory disorder. This type of investigation would require a different approach from the one described in this paper. It may be a continued respiratory problem that necessitates a patient's readmission to the ICU during the same hospitalization, or it may be as a complication of some other multi-system process.

The pilot study, as presented in this paper, would require some revisions to the methods in order to move forward with a larger, full-scale investigation. The historical comparison of one period of time in the ICU as compared to another period is very useful in determining the impact, if any, on medication usage, tests or procedures, or if the implementation of certain guidelines or protocols have demonstrated a difference in selected patient populations. The historical benchmark period would need to be identified as a period of time actually closer to the study period to glean practices that may much more closely reflect current management of patients (perhaps 3 months prior). The collection of concurrent data as described in the methods, although possible, may not be the best way to analyze or provide Intensivists with information. It is likely, that the data and information abstracted was not the most useful to the Intensivist. This would be further reinforced based on the survey results where the Intensivist remained neutral/uncertain regarding the type of data provided to assist in managing patients. Further work with the Intensivist would be important to determine whether other data sets, or the collection of all resource use and complications for

example, might be more useful. There is very little in the literature about how a patient's severity of illness may change over the course of the first several days in the ICU, and this type of investigation may be of value as well.

Overall, the pilot study is feasible, and did result in positive comments and responses by the study Intensivist. The model utilized for this study is applicable to other diagnosis groupings in the ICU as well. There were reports of education with the multidisciplinary team regarding severity of illness scores, the use of resources, anticipating complications, and the costs of care in the ICU. It is unclear what long-term impact, if any this may have on the ICU team.

The study provided an opportunity to test one method of attempting to influence an Intensivist's practice by providing information that was clinically relevant, new, and of interest to both the Intensivist, and the hospital. It would be reasonable to continue concurrent data collection and the provision of the supplemental information intervention to the current Intensivist. In addition, greater organizational support is needed to further recruit additional Intensivists,. A re-design of the supplemental information with additional Intensivists participating would be important to influence practice change. Monitoring the impact of this study on a larger scale over time, with potentially adding additional ICU sites within the healthcare organization would be useful to gain a larger sample size. In addition, further opportunities are needed to explore perhaps other, better ways to integrate databases such as Project Impact and a focus on outcomes and cost to the clinical arena. A re-evaluation of the strict criteria for inclusion in study analysis would be reasonable as well.

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Appendix A

Project Impact Defined Respiratory Disorders

2401	Acute Sinusitis	
2402	Peritonsillar or Retropharyngeal Abscess	
2403	Airway Obstruction-Tumor	**AIRWAY OBSTRUCTION GROUP**
2404	Airway Obstruction-Abscess	
2405	Airway Obstruction-Other	
2406	Epistaxis	
2407	Asthma, Acute Wheezing	**ASTHMA GROUP**
2408	Status Asthmaticus	
2409	Pneumonia-Viral	**PNEUMONIA GROUP**
2410	Pneumonia-Bacterial	
2411	Pneumonia-Parasitic/Protozoan (Pneumocystis, PCP)	
2412	Pneumonia-Unclear/Organism Not Specified	
2413	Pulmonary Embolism	
2414	Fat Embolism Syndrome	
2415	Amniotic Fluid or Air Embolism	
2416	Pulmonary Edema-Cardiac (Congestive Heart Failure with Pulmonary Edema	
2417	Pulmonary Edema-ARDS	
2418	Pulmonary Edema-Non-Cardiac (Fluid Overload without Congestive Heart Failure)	
2419	Pulmonary Edema-Unclear, Unspecified	
2420	Atelectasis	
2421	Lung Abscess	
2422	Pulmonary Hypertension	
2423	Pleural Effusion	
2424	Empyema	
2425	Mediastinitis/Mediastinal Abscess	
2426	Pneumothorax/Hemopneumothorax-Spontaneous	
2427	Pneumothorax/Hemopneumothorax-Iatrogenic	
2499	Other Acute Respiratory Disorder	**OTHER RESPIRATORY DISORDER GROUP**

Source: Project Impact Critical Care Database, Society of Critical Care Medicine. Used with permission.

The Airway Obstruction, Asthma, Pneumonia and Other Respiratory Disorder groupings were identified by the critical care Intensivist during study preparations.

APPENDIX B

PROJECT IMPACT DATA

SUPPLEMENTAL INFORMATION STUDY SHEET-Example

PATIENT:	**AGE:**	**DATE:**	**STUDY ID#**
HOSPITAL ADMIT DATE/DX			**HOSP. DAY#**
ICU ADMIT DATE/DX:			**ICU HOURS/DAYS:**
ORIGIN:	**CONDITION ON ADMIT:**		**INTENSIVIST/DATE:**

PATIENT DATA:

COMPARATIVE GROUP SUMMARY DATA:
January-June 1998, N = 11, Average Age = 68 years

SEVERITY OF ILLNESS SCORES:

SEVERITY OF ILLNESS SCORES:

MPM 0:		**MPM 0:**	0.40-0.60	(N =1)
		(N = 10)	0.80-1.00	(N = 9)
APACHE II:		**APACHE II:**	0.40-0.60	(N = 1)
		(N = 9)	0.60-0.80	(N = 4)
			0.80-1.00	(N = 4)

Mean = 0.88

Mean = 0.79

Resource Use:

VENT. USE:	N = 2 (1--I:E)
PROPOFOL USE:	N = 2
VASOACTIVE DRUG USE:	N = 1
SPECIALTY BED USE:	N = 2

OTHER:
(vertical * is same patient)
(2 patients are 34 & 23yrs.)

Major Tranquilizer, cont	*
Cont. Analgesia	**
Cont. Benzo.	**
NM Blockade	**
Antiarrhythmic	*
Chest tube insert	* *
Trach-OR	*
Echo	* * *

COMPLICATIONS:

Hypothermia-septic/other	*
Skin Breakdown	*
Other Neuro	*
Hypothermia-post-op	*
Delirium/Acute Psychosis	*
Swelling after Extubation	*

OUTCOMES:

AVE. ICU LOS:(<4hr-11.2d) **4 days**

AVE. HOSPITAL LOS:(2-14) **8.2 days**

FUNCTIONAL STATUS ON D/C:
Baseline (6)
Partially/Totally Dependent (2)
Dead (3)

Ave.Total VDC ($1040-$17,942) **$5,669.00**

Appendix C

Example Daily Report with New Admissions to the ICU

AGE	H_DATE	I_DATE	I_TIME	HOSPDX	ICU PRIMARY ADMISSION DIAGNOSIS	CONDITION	ORIGIN	CC MD	MPM0	APACHE2
67	1/1/99	1/1/99	16:00	3707	Bleeding - Upper Gastrointestinal, Other	1	9	1	0.8621	0.8663
75	12/19/98	1/1/99	00:20	3304	Pneumonia - Unclear/Organism Not Specifi	2	2	1	0.9599	0.8347
86	1/2/99	1/2/99	19:00	2599	Other Acute Gastrointestinal Disorder, A	2	5	1	0.7021	0.6392
50	1/2/99	1/2/99	02:30	3510	Ethanol, , , , , ,	1	1	1	0.9399	
64	1/2/99	1/2/99	02:30	2019	Seizure Disorder, , , , , ,	2	1	11	0.9106	
90	1/2/99	1/3/99	19:45	1605	Long Bone Fracture (Femur, Tibia, Fibula	2	4	1	0.6142	0.7471
73	1/3/99	1/3/99	13:25	2412	Pneumonia - Unclear/Organism Not Specifi	2	1	12	0.7280	0.5032
72	1/4/99	1/4/99	19:05	2399	Other Acute Vascular Disorder, , , , , ,	1	5	1	0.9633	
70	1/4/99	1/4/99	12:55	2499	Other Acute Respiratory Disorder, , , ,	1	12	1		0.7239
67	1/4/99	1/5/99	05:13	2102	Septic Shock, Pneumonia - Unclear/Organi	2	2	11	0.6684	0.1956
76	1/5/99	1/5/99	07:40	3702	Bleeding - Lung/Bronchi/Hemoptysis, , ,	2	1	12	0.7619	0.4995
75	1/5/99	1/5/99	10:10	2399	Other Acute Vascular Disorder, , , , , ,	1	5	1	0.9599	
81	1/5/99	1/5/99	16:10	2006	Intracerebral/Intraventricular Hemorrhag	3	1	11	0.1744	
46	1/4/99	1/5/99	14:30	2423	Empyema, , , , , ,	1	5	11	0.9464	0.8847
74	1/5/99	1/5/99	16:55	2008	Chronic Subdural Hematoma, , , , , ,	1	5	1	0.9611	
89	1/4/99	1/5/99	20:27	1605	Pulmonary Embolism, Acute Myocardial Inf	2	4	12	0.4266	0.2276
72	1/3/99	1/5/99	17:00	2009	Other Acute Vascular Disorder, Transient	1	5	1	0.8886	
49	12/30/98	1/5/99	20:15	3414	Neoplasm - Ovary, , , , , ,	1	5	1	0.8479	0.8458
67	1/5/99	1/5/99	19:25	2302	Abdominal Aortic Aneurysm, Not Ruptured	1	5	1	0.9683	0.9618

Appendix D
Supplemental Information Study
Clinician Survey

Name: _____ Date: _____

How many years have you provided care for Critical Care patients? _____

How have you used Severity of Illness scores in the past? _____

Please indicate your perception/thoughts about the Supplemental Information provided during the ICU rounds for the Project Impact study:

Key: (strongly disagree(1), disagree(2), neutral(3), agree(4), strongly agree(5))

	1	2	3	4	5
1. The Supplemental information provided from Project Impact assisted in the management of the patients.	○	○	○	○	○
2. The Supplemental information was presented in a useful way.	○	○	○	○	○
3. The Supplemental information provided the right data to support patient care decisions.	○	○	○	○	○
4. The information Project Impact provides is useful to clinicians on a daily basis.	○	○	○	○	○
5. The severity of illness scores provided information that I had not considered previously.	○	○	○	○	○

Comments: _____

Thank you for your time!
Your responses will be coded and remain confidential.

Appendix E

Group Comparisons 1998 & 1999 Diagnosis: Other Airway Obstruction (2403-2405) Variables	1998 Group	1999 Group	p value
	(N = 16)	(N = 9)	
Baseline			
Mean Age	55.4	52	p = 0.460
Origin			p = 0.539
ER	5	3	
Floor	2	0	
Other	9	6	
Condition on Admit			p =0.349
Stable	8	7	
Critical/Unstable	8	2	
MPM0	0.9 (N=13)	0.93 (N=8)	p =0.482
Apache II	0.85 (N= 8)	0.74 (N=8)	p =0.400
Outcomes			
Complications	2	0	p =0.358
Mean ICU LOS	2.3	0.84	p =0.242
Mean Hospital LOS*	7.5	2.36	p <0.001*
Functional Status on D/C			p =0.344
Return to Baseline	10	8	
Partially/Totally Dependent	6	1	
Dead	0	0	
Mean ICU VDC in $	1908	670	p =0.169
Mean RX VDC in $	402	156	p =0.379
Mean RT VDC in $	449	90	p =0.203
Mean LAB VDC in $	73	44	p =0.491
Mean RAD VDC in $	85	17	p =0.107
Mean TOTAL ICU VDC in $	3414	1608	p =0.261
Resources			
Medical Treatments			
Major/Heavy Sedation	3	2	p =0.734
NM Blockade	1	0	p =0.449
Vaso-Active Medications	2	0	p =0.707
Antibiotic Use	6	3	p =0.854
Steroid Use	7	4	p =0.675
Procedures			
Ventilator Use	6	0	p =0.101
Intubation	6	0	p =0.101
BiPap/CPAP use	7	0	p =0.059
Echocardiogram	3	0	p =0.449
Oxygen use > 60%	6	0	p =0.101
Tracheostomy	2	1	p =0.625

Appendix F

Group Comparisons 1998 & 1999 Diagnosis: Asthma (2407-2408)			
Variables	**1998 Group**	**1999 Group**	**p value**
	(N = 9)	(N = 4)	
Baseline			
Mean Age	43.9	33.75	p =0.358
Origin			p =0.591
ER	7	4	
Floor	1	0	
Other	1	0	
Condition on Admit			p =0.665
Stable	0	1	
Critical/Unstable	9	3	
MPM0	0.83 (N=8)	0.88 (N=4)	p =0.571
Apache II	0.98 (N=8)	0.98 (N=2)	p =1.000
Outcomes			
Complications	2	0	p =0.855
Mean ICU LOS	3.2	0.88	p =0.205
Mean Hospital LOS	6.9	2.25	p =0.149
Functional Status on D/C			p =0.546
Return to Baseline	6	4	
Partially/Totally Dependent	3	0	
Dead	0	0	
Mean ICU VDC in $	2411	792	p =0.222
Mean RX VDC in $	392	179	p =0.440
Mean RT VDC in $	636	232	p =0.340
Mean LAB VDC in $	159	74	p =0.375
Mean RAD VDC in $	143	44	p =0.346
Mean TOTAL ICU VDC in $	4270	1701	p =0.295
Resources			
Medical Treatments			
Propofol use	3	3	p =0.424
Major/Heavy Sedation	6	1	p =0.424
NM Blockade	1	0	p =0.658
Vaso-Active Medications	2	0	p =0.855
Procedures			
Ventilator Use	7	4	p =0.855
Intubation	6	0	p =0.102
Echocardiogram	2	2	p =0.720

Appendix G

Group Comparisons 1998 & 1999 Diagnosis: Pneumonia (2409-2412)			
Variables	**1998 Group**	**1999 Group**	**p value**
	(N = 60)	(N = 34)	
Baseline			
Mean Age	66.5	69.35	p =0.422
Origin			p =0.141
ER	30	21	
Floor	20	5	
Other	10	8	
Condition on Admit			p =0.762
Stable	5	3	
Critical/Unstable	55	31	
MPM0	0.8 (N=57)	0.77 (N=30)	p =0.357
Apache II	0.69 (N=54)	0.64 (N=30)	p =0.207
Outcomes			
Complications	23	7	p =0.142
ICU LOS*	5.5	3.24	p =0.050*
Hospital LOS	10	8.85	p =0.504
Functional Status on D/C			p =0.606
Return to Baseline	29	19	
Partially/Totally Dependent	20	8	
Dead	11	7	
Mean ICU VDC in $	3997	2385	p =0.059
Mean RX VDC in $	635	612	p =0.897
Mean RT VDC in $	999	556	p =0.084
Mean LAB VDC in $	296	295	p =0.995
Mean RAD VDC in $ *	238	151	p =0.044*
Mean TOTAL ICU VDC in $	6818	4546	p =0.130
Resources			
Medical Treatments*			
Major/Heavy Sedation	36	22	p =0.796
NM Blockade	2	0	p =0.813
Vaso-Active Medications	18	9	p =0.861
Antibiotic Use	36	30	p =0.009*
Specialty Bed Use	10	0	p =0.028*
Procedures*			
Ventilator Use	23	19	p =0.141
Intubation	18	14	p =0.392
BiPap/CPAP use	16	2	p =0.028*
Echocardiogram	19	6	p =0.219
Tracheostomy	4	3	p =0.958

Appendix H

Group Comparisons 1998 & 1999 Diagnosis: Other Respiratory Disorders (2499) Variables	1998 Group	1999 Group	p value
	(N = 11)	(N = 17)	
Baseline			
Mean Age	68	62.4	p =0.342
Origin*			p =0.044*
ER	2	11	
Floor	6	3	
Other	3	3	
Condition on Admit			p =0.583
Stable	2	6	
Critical/Unstable	9	11	
MPM0	0.88 (N=10)	0.82 (N=15)	p =0.279
Apache II	0.79 (N=9)	0.81 (N=16)	p =0.696
Outcome Measures			
Complications*	6	0	p =0.003*
Mean ICU LOS	4	2.65	p =0.175
Mean Hospital LOS	8	7	p= 0.647
Functional Status on D/C			p =0.073
Return to Baseline	6	12	
Partially/Totally Dependent	2	5	
Dead	3	0	
Mean ICU VDC in $	2978	1731	p =0.138
Mean RX VDC in $	561	440	p =0.575
Mean RT VDC in $	710	528	p =0.493
Mean LAB VDC in $	384	101	p =0.147
Mean RAD VDC in $	159	89	p =0.194
Mean TOTAL ICU VDC in $	5669	3281	p =0.144
Resources			
Medical Treatments*			
Major/Heavy Sedation	7	10	p =0.895
NM Blockade	2	1	p =0.706
Vaso-Active Medications	2	1	p =0.706
Antibiotic Use	6	12	p =0.645
Steroid Use	5	13	p =0.206
Bronchodilator Use	5	15	p =0.043*
Procedures			
Ventilator Use	5	8	p= 0.776
Intubation	3	8	p =0.508
Echocardiogram	3	3	p =0.924
Tracheostomy	1	1	p =0.653

Appendix I

Group Comparisons 1999 Diagnosis: Airway Obstruction (2403-2405) Variables	Control Group	Study Group	p value
	(N = 9)	(N = 3)	
Mean Age	52	57	p =0.665
Origin			p =0.061
ER	3	2	
Floor	0	1	
Other	6	0	
Condition on Admit			p =0.700
Stable	7	2	
Critical/Unstable	2	1	
MPM0	0.93 (N=8)	0.93 (N=3)	p =0.955
Apache II	0.74 (N=8)	0.62 (N=2)	p =0.677
Outcome Measures			
Complications	0	2	0.072
Mean ICU LOS	0.84	0.9	p =0.854
Mean Hospital LOS	2.36	2.67	p =0.754
Functional Status on D/C			p =0.546
Return to Baseline	8	3	
Partially/Totally Dependent	1	0	
Dead	0	0	
Mean ICU VDC in $	670	812	p =0.519
Mean RX VDC in $	156	124	p =0.666
Mean RT VDC in $	90	72	p =0.792
Mean LAB VDC in $	44	18	p =0.346
Mean RAD VDC in $	17	19	p =0.890
Mean TOTAL ICU VDC in $	1608	1411	p =0.640
Medical Treatments			
Major/Heavy Sedation	2	0	p =0.993
Antibiotic Use	3	3	p =0.179
Steroid Use	4	2	p =0.981
Procedures			
Ventilator Use	0	1	p =0.541
Intubation	0	1	p =0.541
Tracheostomy	1	1	p =0.993

Appendix J

Group Comparisons 1999 Diagnosis: Asthma (2407-2408) Variables	Control Group	Study Group	p value
	(N = 4)	(N = 2)	
Mean Age	33.75	38.85	p =0.716
Origin			
ER	4	2	N/A
Floor	0	0	
Other	0	0	
Condition on Admit			p =0.699
Stable	1	0	
Critical/Unstable	3	2	
MPM0	0.88 (N= 4)	0.88 (N= 2)	p =0.934
Apache II	0.98 (N=2)	0.87 (N=2)	p =0.412
Outcome Measures			
Complications	0	0	N/A
Mean ICU LOS	0.88	1.5	p =0.379
Mean Hospital LOS	2.25	1	p =0.157
Functional Status on D/C			N/A
Return to Baseline	4	2	
Partially/Totally Dependent	0	0	
Dead	0	0	
Mean ICU VDC in $	792	1030	p =0.645
Mean RX VDC in $*	179	564	p =0.042*
Mean RT VDC in $*	232	571	p =0.021*
Mean LAB VDC in $	74	102	p =0.700
Mean RAD VDC in $	44	89	p =0.105
Mean TOTAL ICU VDC in $	1701	2846	p =0.162
Medical Treatments			
Major/Heavy Sedation	3	3	p =0.699
NM Blockade	1	1	p =0.759
Antibiotic Use	0	2	p =0.126
Procedures			
Ventilator Use	2	2	p =0.759
Intubation	4	1	p =0.386

Appendix K

Group Comparisons 1999 Diagnosis: Pneumonia (2409-2412) Variables	Control Group	Study Group	p value
	(N = 34)	(N = 7)	
Mean Age	69.4	63.1	p =0.369
Origin*			p =0.034*
ER	21	3	
Floor	5	4	
Other	8	0	
Condition on Admit			p =0.798
Stable	3	1	
Critical/Unstable	31	6	
MPM0	0.77 (N=30)	0.79 (N= 6)	p =0.757
Apache II*	0.64 (N=30)	0.82 (N= 7)	p =0.051*
Outcome Measures			
Complications	7	0	p =0.431
ICU LOS	3.24	2.3	p =0.452
Hospital LOS	8.85	6.29	p =0.322
Functional Status on D/C			p =0.271
Return to Baseline	19	6	
Partially/Totally Dependent	8	0	
Dead	7	1	
Mean ICU VDC in $	2385	1798	p =0.528
Mean RX VDC in $	612	330	p =0.373
Mean RT VDC in $	556	365	p =0.484
Mean LAB VDC in $	295	224	p =0.751
Mean RAD VDC in $	151	117	p =0.578
Mean TOTAL ICU VDC in $	4546	3263	p =0.476
Medical Treatments*			
Major/Heavy Sedation	22	2	p =0.180
Vaso-Active Medications	9	6	p =0.010*
Antibiotic Use	30	6	p =0.628
Procedures*			
Ventilator Use	19	2	p =0.375
Intubation	14	2	p =0.867
BiPap/CPAP use	2	3	p =0.037*
Echocardiogram	6	0	p =0.526
Tracheostomy	3	0	p =0.972

Appendix L

Variables	Group Comparisons 1999 Diagnosis: Other Respiratory Disorders (2499) Control Group	Study Group	p value
	(N = 17)	(N = 8)	
Mean Age	62.4	66.1	p =0.408
Origin			p =0.886
ER	11	5	
Floor	3	2	
Other	3	1	
Condition on Admit			p =0.154
Stable	6	0	
Critical/Unstable	11	8	
MPM0	0.82 (N=15)	0.68 (N=8)*	p =0.054*
Apache II	0.81 (N=16)	0.76 (N=6)	p =0.372
Outcome Measures			
Complications	0	3	p =0.585
Mean ICU LOS	2.65	2.46	p =0.859
Mean Hosptial LOS	7	5.63	p =0.591
Functional Status on D/C			p =0.330
Return to Baseline	12	5	
Partially/Totally Dependent	5	2	
Dead	0	1	
Mean ICU VDC in $	1731	2444	p =0.369
Mean RX VDC in $	440	801	p =0.197
Mean RT VDC in $	528	666	p =0.626
Mean LAB VDC in $	101	137	p =0.363
Mean RAD VDC in $	89	155	p =0.164
Mean TOTAL ICU VDC in $	3281	4720	p =0.343
Medical Treatments			
Major/Heavy Sedation	10	6	p =0.741
NM Blockade	1	0	p =0.678
Vaso-Active Medications	1	2	p =0.483
Antibiotic Use	12	4	p =0.565
Steroid Use	13	6	p =0.656
Bronchodilator Use	15	6	p =0.809
Procedures			
Ventilator Use	8	7	p =0.130
Intubation	8	5	p =0.751
Echocardiogram	3	1	p =0.792
Tracheostomy	1	0	p =0.678

Appendix M

Summary Results of Statistical Analysis 1998 & 1999

Variable	Student two-tailed *t* and Chi Square Statistical Test Results $p < 0.05$			
	2403-2405	2407-2408	2409-2412	2499
Age	t=0.751; p=0.460	t=0.959; p= 0.358	t= -0.765; p= 0.447	t=0.968; p= 0.342
Origin	X2=1.237; p= 0.539	X2= 1.051;p= 0.591	X2=2.839;p=0.242	X2=6.231; p=0.044
Condition on Admit	X2=0.875; p=0.349	X2=0.188; p=0.665	X2=0.063; p=0.801	X2=0.303; p=0.583
ICU LOS	t= -1.202; p= 0.242	t=1.347; p= 0.205	t=2.459; p= 0.016*	t=1.396; p= 0.175
Hospital LOS	t= 6.224; p= 0.000	t=1.551; p= 0.149	t=1.440; p= 0.154	t=0.464; p=0.647
Functional Status on D/C	X2= 0.896; p= 0.344	X2=0.364;p= 0.546	X2=0.946; p=0.623	X2=5.241; p=0.073
Mean MPM0	t= -0.717; p= 0.482	t= -0.586; p=0.571	t=0.543; p= 0.589	t= 1.109; p= 0.279
Mean Apache II	t=0.868; p= 0.400	t=0.00; p= 1.00	t=0.854; p= 0.397	t= -0.396; p=0.696
ICU VDC	t=1.42 ; p= 0.169	t=1.293; p=0.222	t=2.418; p= 0.018*	t=1.529; p=0.138
Pharmacy VDC	t=0.897; p= 0.379	t= 0.802; p= 0.440	t=0.844; p=0.402	t=0.568; p=0.575
Respiratory Therapy VDC	t=1.311; p= 0.203	t=0.997; p= 0.340	t=2.244; p= 0.028*	t=0.695; p=0.493
Laboratory VDC	t= 0.699 ; p= 0.491	t=0.925; p= 0.375	t=0.470; p= 0.639	t=1.494; p= 0.147
Radiology VDC	t=1.675; p= 0.107	t=0.984; p=0.346	t=2.563; p= 0.013*	t=1.334; p= 0.194
Total ICU VDC	t=1.153; p=0.261	t=1.099; p= 0.295	t=2.109; p=0.039*	t=1.506; p= 0.144

APPENDIX N

Summary Results of Statistical Analysis 1998 & 1999

Variable	Comparison of two proportions (z test)			
	2403-2405	2407-2408	2409-2412	2499
Medical Treatments				
Major/Heavy Sedation	z= -0.34; p= 0.734	z= 0.800; p= 0.424*	z= -0.068; p= 0.946	z= -0.32; p= 0.895
(Propofol separated*)		z= 0.800; p= 0.424*		
Vaso-active Medications	z= 0.375; p= 0.707	z= 0.183; p= 0.855	z= 0.212; p= 0.832	z= 0.377; p= 0.706
NeuroMusc. Blockade	z= 0.758; p= 0.449	z= -0.443; p= 0.658	z= 0.594; p= 0.552	z= 0.377; p=0.706
Specialty Bed	N/A	N/A	z= 2.204; p= 0.028*	z= 1.060; p=0.289
Antibiotic Use	N/A	N/A	z= 2.902; p=0.004*	z= 0.460; p= 0.645
Bronchodilator Use	N/A	N/A	N/A	z= 2.025; p= 0.043
Steroid Use	z= -0.420; p= 0.675	N/A	N/A	z= 1.265; p=0.206
Procedures				
Ventilator use	z= 1.64; p= 0.101	z= 0.183; p= 0.855	z= 1.303; p= 0.193	z= -0.284; p= 0.776
Intubation	z= 1.64; p= 0.101	z= 1.633; p= 0.102	z= 1.110; p= 0.267	z= 0.663; p= 0.508
Echocardiogram	z= 0.758; p= 0.449	z= 0.359; p= 0.720	z= 0.537; p= 0.591	z= 0.095; p= 0.924
Oxygen >60%	z= 1.64; p= 0.101	N/A	N/A	N/A
BIPAP/CPAP use	z= 1.885; p= 0.059	N/A	z= 1.195; p= 0.232	N/A
Tracheostomy	Z= -0.489; p= 0.625	N/A	z= -0.254; p= 0.799	z= -0.449; p= 0.653

* Propofol separated out with the Asthma group as high proportion of different types of major/ heavy sedation used in this diagnostic group during 1999 as compared to 1998.

APPENDIX O

Summary Results of Statistical Analysis 1998 & 1999

Comparison of two proportions (z test)

Variable	2403-2405	2407-2408	2409-2412	2499
Complications				
Listing of types in order of frequency:	Venous Thrombosis Iatrogenic Hypothermia	Other Neuro (confusion)	Other Neuro (confusion) Swelling after extubation Other Hypothermia Multisystem failure (MODS) Other Respiratory Encephalopathy Cardiac Arrest with CPR Skin Breakdown	Swelling after extubation Other Neuro (confusion) Iatrogenic Hypothermia Other Hypothermia Delirium/Acute Psychosis Skin Breakdown
All complications, z test:	z= 0.919; p= 0.358	z= 0.183; p= 0.855	z= 1.324; p= 0.185	z= 2.32; p= 0.003

APPENDIX P

Summary Results of Statistical Analysis Control Group & Study Group 1999

Variable	Student two-tailed *t* and Chi Square Statistical Test Results $p < 0.05$			
	2403-2405	2407-2408	2409-2412	2499
Age	t= -0.447; p= 0.665	t= -0.39; p= 0.716	t= 0.910; p= 0.369	t= -0.843; p= 0.408
Origin	X2= 5.6; p= 0.061	N/A	X2= 6.76; p= 0.034	X2= 0.241; p= 0.886
Condition on Admit	X2= 0.148; 0.700	X2= 0.150; p= 0.699	X2= 0.065; p= 0.798	X2= 2.032; p= 0.154
ICU LOS	t= -0.189; p= 0.854	t= -0.989; p= 0.379	t= 0.759; p= 0.452	t= 0.180; p= 0.859
Hospital LOS	t= -0.321; p= 0.754	t= 1.74; p= 0.157	t= 1.002; p= 0.322	t= 0.545; p= 0.591
Functional Status on D/C	X2= 0.364; p= 0.546	N/A	X2= 2.612; p= 0.271	X2= 2.215; p= 0.330
Mean MPM0	t= 0.058; p= 0.955	t= 0.088; p= 0.934	t= -0.313; p= 0.757	t= 2.038; p= 0.054
Mean Apache II	t= 0.483; p= 0.677	t= 1.03; p= 0.412	t= -2.024; p= 0.051	t= 0.913; p= 0.372
ICU VDC	t= -0.672; p= 0.519	t= -0.498; p= 0.645	t= 0.636; p= 0.528	t= -0.917; p= 0.369
Pharmacy VDC	t= 0.447; p= 0.666	t= -2.95; p= 0.042	t= 0.901; p= 0.373	t= -1.329; p= 0.197
Respiratory Therapy VDC	t= 0.271; p= 0.792	t= -3.69; p= 0.021	t= 0.706; p= 0.484	t= -0.493; p= 0.626
Laboratory VDC	t= 0.994; p= 0.346	t= -0.41; p= 0.700	t= 0.320; p= 0.751	t= -0.928; p= 0.363
Radiology VDC	t= -0.142; p= 0.89	t= -2.09; p= 0.105	t= 0.651; p= 0.578	t= -1.437; p= 0.164
Total ICU VDC	t= 0.483; p= 0.640	t= -1.71; p= 0.162	t= 0.720; p= 0.476	t= -0.968; p= 0.343

APPENDIX Q

Summary Results of Statistical Analysis Control Group & Study Group 1999

Variable	Comparison of two proportions (z test)			
	2403-2405	2407-2408	2409-2412	2499
Medical Treatments				
Major/Heavy Sedation	z= -0.009; p= .993	z= -0.387; p= 0.699	z= 1.341; p= 0.18	z= 0.331; p= 0.741
Vaso-active Medications	None	N/A	z= 2.576; p= 0.010	z= 0.702; p= 0.483
NeuroMusc. Blockade	N/A	z= -0.306; p= 0.759	N/A	z= 0.415; p= 0.678
Specialty Bed	None	None	None	None
Antibiotic Use	z= 1.34; p= 0.179	z= 1.53; p= 0.126	z= -0.484; p= 0.628	z= 0.575; p= 0.565
Bronchodilator use	N/A	N/A	N/A	z= 0.241; p= 0.809
Steroid use	z= 0.023; p= 0.981	N/A	N/A	z= -0.445; p= 0.656
Procedures				
Ventilator use	z= -0.612; p= 0.541	z= 0.303; p= 0.759	z= 0.886; p= 0.375	z= 1.515; p= 0.130
Intubation	z= -0.612; p= 0.541	z= 0.866; p= 0.386	z= 0.167; p= 0.867	z= 0.318; p= 0.751
Echocardiogram	N/A	N/A	z= 0.635; p= 0.526	z= -0.264; p= 0.792
Oxygen >60%	N/A	N/A	N/A	N/A
BIPAP/CPAP use	N/A	N/A	z= 2.08; p= 0.037	N/A
Tracheostomy	z= -0.009; p= .993	N/A	z= 0.035; p= 0.972	z= 0.415; p= 0.678

APPENDIX R

Summary Results of Statistical Analysis Control Group & Study Group 1999

Comparison of two proportions (z test)

Variable	2403-2405	2407-2408	2409-2412	2499
Complications				
Listing of types in order of frequency:	Iatrogenic Hypothermia Other Neuro (confusion)	None	Other Neuro (confusion) Other Respiratory Other Hypothermia Multisystem failure (MODS) Variceal Bleed	Swelling after extubation Other Neuro (confusion) Other Hypothermia
All complications, z test:	z= 1.79; p= 0.072	N/A	z= 0.787; p= 0.431	z= 0.545; p= 0.585

APPENDIX S

Supplemental Information Survey Results
Clinician Survey 1999

Demographics:
Intensivist with greater than 15 years experience managing critically ill patients. Has not previously used severity of illness scores in the past to assist in the management of patients. Has familiarity with severity of illness scoring systems from literature review.

Findings:
Completed three surveys, with the first two in the first month of the supplemental information being provided prior to ICU rounds during his shifts in the ICU. The final survey was completed after the completion of the study period.

Responses to Questions:

	Survey #1	Survey #2	Survey #3	Averages:
1. The Supplemental information provided from Project Impact assisted in the management of patients	2	3	4	3
2. The Supplemental information was presented in a useful way.	4	4	5	4.3
3. The Supplemental information provides the right data to support patient care decisions.	3	3	3	3
4. The information Project Impact provides is useful to clinicians on a daily basis.	2	3	5	3.33
5. The severity of illness scores provided information that I had not considered previously.	3	4	5	4
Averages:	2.8	3.4	4.4	