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Patient-Specific Factors Associated with Surgical Delay in a Large Academic Hospital

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PATIENT-SPECIFIC FACTORS ASSOCIATED WITH SURGICAL DELAY IN A LARGE ACADEMIC HOSPITAL

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Abstract

The high cost of healthcare is driving the search for more efficient practice, especially in high-stakes locations like the operating room. In addition to financial losses, patients suffer physical and emotional distress, including an increased risk of morbidity or mortality when surgical cases are delayed due to inefficiency. While patient-related causes of delay have been implicated, it is unclear which specific factors are most significant. This study aimed to identify specific patient factors correlated with surgical delay and develop a predictive risk algorithm that describes the relationship between patient-specific factors and surgical delay.

A retrospective review of 36,543 patients' charts who underwent surgery at a large academic hospital over a 5-year period was conducted. Patient-specific factors, including demographics, insurance type, proximity to the hospital, anesthesia type, American Society of Anesthesiologists (ASA) classification, system-specific comorbidities, and medication usage, were identified. Bivariate analysis using chi-square analysis was conducted to determine if any of these factors were significantly correlated with surgical delay. The significant patient-specific factors were entered into a logistic regression model.

Black race, ASA =>3, renal failure, insulin, steroid, and several surgical specialties (colorectal, gynecologic oncology, hepatobiliary, neurosurgery, ophthalmology, and plastic surgery) were associated with an increased odds of surgical delay in this sample. Obesity, general anesthesia, and cardiovascular anesthesia were associated with a decreased odds of surgical delay. The model explains approximately 3.8-5.3% of surgical delays in this sample. The overall predictive rate of the model was 57.1%. Despite previous studies attributing a significant amount of surgical delay to patient factors, reasons other than patient factors were responsible for 94-95% of surgical delay in this sample. Further research in

other populations or studies using different methods such as a prospective approach are necessary to fully understand the role of patient-specific factors in surgical delay. On the other hand, the power of this study permitted the discovery of seemingly small disparities that are nonetheless clinically significant. This study demonstrates that there are certain types of patients more at risk for surgical delay and therefore a diminished access to care.

Keywords: surgical delay, operating room, patient-specific, acuity, disparity

Dedication

Above all, I dedicate this dissertation to my family, specifically my husband, Mark, our son Jacob, and my parents for their support. Without them I never would have had the courage to start this journey and I certainly would not have had the strength to finish it.

And to Dr. Sarah Giron for rescuing me when I thought I could not go on. For helping me to see that even when all seems lost, there is always another way, a solution. For showing me how exciting research can really be!

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TABLE OF CONTENTS

Chapter I: PROBLEM

The Joint Commission (JC), an independent agency that grants accreditation to hospitals and other healthcare facilities, has identified a delay in treatment as one of the top sentinel events that can lead to patient death, harm, psychological impact or unanticipated additional care for the last few decades (2015). In this 2015 report, the JC has made rectifying treatment delay a priority, warning that the search for reasons should not be directed at practitioners, but rather a systems-approach should be adopted. When taking this approach, common causes of delay were listed as human factors, communication failures and poor planning. Much of the research to date on surgical delays has also identified systems issues as the primary causes of delay (Wong, Khu, Kaderali, & Bernstein, 2010; Garg et al., 2009; Wright et al., 2010). Understanding the causes of surgical delay is a necessary step in improving efficiency for surgical patients.

Significance

As healthcare undergoes a major transformation, experts are tasked with identifying areas of improvement, especially with regards to optimizing cost and decreasing complications. The operating room (OR) is one area where unexpected deviation can have a huge impact on the patient, the care team and the institution. Poor efficiency primarily affects the institution in the form of financial losses. In one analysis done in 2010, the author estimated OR costs to be between $20 and $62/min (Marcario, 2010). A more recent study that looked at actual costs in hospitals in California, from ambulatory centers to hospitals, the cost was found to be $36 to 37/min (Childers & Maggard-Gibbons, 2018).

The surgically delayed individual has more to lose than just money. The possible consequences to the patient include emotional or mental anguish, and even increased morbidity and mortality depending upon the urgency of the procedure and the patient's pre-existing health status. This has been especially noted in hip fracture patients, where a delay to surgery increases the likelihood of death or morbidity. In one study, delaying surgery more than 120 hours was the cutoff point for a statistically increased risk of mortality, with an odds ratio of 2.14 of death after this point (Vidan et al., 2011).

Eliminating, or even reducing delay is one step to improving OR efficiency, safety and patient outcomes. Quality improvement projects have focused heavily on first-case starts (Deldar et al., 2017; Mathews, Kla, Marolen, Sandberg, & Ehrenfeld, 2015; Wright, Roche, & Khoury, 2010). Focusing on first-case starts means ensuring that everything is done to ensure the first case in a room begins on time. Logically it makes sense that if the first case in a room is delayed, subsequent cases in the room will be delayed so by focusing efforts on the first case, the hope is that a downstream savings is achieved. In analysis of 13,547 cases in a German hospital, the average number of minutes a case was delayed increased from approximately 15 minutes for the first case to 25 minutes for the third case (Balzer, Raackow, Hahnenkamp, Flessa & Meissner, 2017).

In order to strategize how to improve scheduling, several studies have examined reasons for delays on the morning of surgery. The predominant findings are related to equipment issues or availability of staff, such as surgeons or anesthesia providers, although "medical" reasons are cited as a cause in some cases (Garg, Bhalotra, Bhadoria, Gupta, & Anand, 2009; Balzer et al., 2017; Wright et al., 2010). Unfortunately, no studies specifically delineate the different types of medical causes for surgical delay. Exploring these medical reasons and other patient-specific factors as a cause of surgical delay is an opportunity to identify trends or areas that are especially vulnerable to delay that have yet to be explained and may be entirely preventable. Additionally, there is a need for research to investigate the other side of surgical schedule deviation, which includes cases happening earlier than scheduled. Understanding the patient-specific factors that are correlated with surgical schedule deviation provides information for the creation and implementation of quality improvement projects that may be able to prevent delays, increase efficiency, save cost, increase staff satisfaction and improve outcomes for patients.

Purpose and Specific Aims

The purpose of this study was to review possible patient-specific factors that are correlated with surgical schedule deviation, including cases occurring earlier or later than scheduled, at a large academic hospital in Los Angeles for 5 years, from May 2012 through April 2017. Identifying trends in patient-specific factors can inspire more detailed research for specific vulnerable populations as well as provide evidence for quality improvement processes that target resources towards specific populations who are most at risk for schedule deviation from the surgical schedule. A retrospective analysis of all surgical cases with a schedule deviation for a five-year period will aid in answering the following research questions:

Research Questions

1. Does surgical schedule deviation happen more frequently in a particular population with particular characteristics such as age, gender, race/ethnicity, American Society of Anesthesiologists class, patient proximity to the hospital, insurance type, comorbidities, and medications?
2. Is there a difference in the patient-specific characteristics of age, gender, race/ethnicity, American Society of Anesthesiologists class, patient proximity to

the hospital, insurance type, comorbidities, and medications between cases that are early versus cases that are delayed?

3. Is there a predictive pattern that can explain surgical schedule deviation due to patient-specific factors?
4. Is there a predictive pattern of patient-specific factors in surgical cases that start earlier than the scheduled time?
5. Is there a predictive pattern of patient-specific factors in surgical cases that start later than the scheduled time?

Specific Aims

1. Identify any patient-specific factors that are significantly correlated with surgical schedule deviation using descriptive statistics.
    a. Identify any patient-specific factors that are significantly correlated with surgical cases that occur earlier than the scheduled start time using descriptive statistics.
    b. Identify any patient-specific factors that are significantly correlated with surgical cases that occur later than the scheduled start time using descriptive statistics.
2. Develop a predictive risk algorithm that describes the different patient-specific factors that are correlated with surgical schedule deviation using logistic regression.
    a. Develop a predictive risk algorithm that describes the different patient-specific factors that are correlated surgical cases that occur earlier than the scheduled start time using logistic regression.

b. Develop a predictive risk algorithm that describes the different patient-specific factors that are correlated with surgical cases that occur later than the scheduled start time using descriptive statistics using logistic regression.

Conceptual Framework

The National Academy of Engineering and the Institute of Medicine developed a model of healthcare that explains the role of the individual patient in a systems-based healthcare structure (Fangjiang, Grossman, Compton, & Reid, 2005). This model is particularly appropriate for explaining the influences of patient-specific factors to surgical delays within the context of the whole healthcare system. In this model there are four layers of healthcare: the individual Patient is in the center and operates within the Care Team, which operates within the Organization, which operates within the Environment. Because the Patient is at the center, the Patient is the defining factor in his or her healthcare experience. The Patient deals directly with the Care Team, which consists of the healthcare providers, and must come to congruence with them. But the Care Team must operate within the confines of the Organization, which would be the hospital or clinic. Furthermore, the Organization is limited by its Environment which includes insurance, funders and the public.

Within the context of the OR, the Patient is still at the center of care as in other healthcare settings. The Care Team consists of the nurses, anesthesia providers, surgeons, family and other healthcare providers or people who are caring for the patient for that particular surgery. The Organization would include the OR and hospital facilities. The Environment includes the patient's insurance, government or other agencies that regulate and fund the hospital or research at that hospital.

When analyzing delays in the OR it is prudent to identify deficiencies at all 4 levels of the healthcare model, because logically the response and interventions to correct or mitigate deficiencies will be different at each level. Issues with the Environment may require changes in policy and regulatory changes. An example would be health insurance regulations which require certain tests to be performed before a patient undergoes anesthesia or surgery. Another example would be policy that requires certain members of the surgical team all be present before surgery can begin. Issues with the Organization would often be labeled as systems issues and are what have commonly been identified in the literature as "causes of surgical delay." These could include availability of space in the hospital or necessary equipment to perform the case. Issues arising from the Care Team may include interpersonal or working relationships or staffing shortages. This includes availability of the surgeon, anesthesia provider, surgical technicians or nurses. At the center of the conceptual framework, patient-specific causes of schedule deviation should be identified before any of the other deficiency since all layers hinge upon this central component of the patient. Patient-specific factors that will be explored in this study and include patient demographics, insurance type, proximity to the hospital, comorbidities, and medications. If any of these factors are found to correlate with surgical schedule deviation, identifying them early in the patient surgical experience can inspire the Care Team, Organization and Environment to preemptively address additional issues with programs, policy and improvement projects. The authors of the original model explicitly state the importance of "synchronous communication" between the different levels to avoid delays and improve efficiency of the delivery of healthcare services (Fangjiang et al., 2005).

Chapter II: LITERATURE REVIEW

Background

Delay of care in the surgical environment has been highlighted as an area where improvements in scheduling and delays are needed. This is likely due to the high costs associated with surgery and operating rooms, however surgical delays can result in more than just increased cost. Wasted resources, a physical and emotional strain on the patient, and subsequent delays to cases later in the day are just a few of the processes affected. While the limited research on the topic has implicated systems deficiencies as the primary cause of surgical delays, unique patient-specific factors have not been thoroughly explored as correlates for delays. Furthermore, while delay has been studied, there is little research on cases that occur earlier than scheduled. Surgical schedule deviation can include cases occurring earlier and later than scheduled. It is important that all possible causes of surgical delay are elucidated to better direct resources for delay prevention, patient safety, medicoeconomic optimization, and improved access to care.

Definition of Delay

Surgical delay is defined differently depending upon the context in which it is used. For scheduled cases there is a set surgical start time. Surgical start time is commonly defined as the time the patient is in the room (Wright et al., 2010), however others may define the surgical start time as incision time, which is the time when the surgeon begins to "cut" (Gupta, Agrawal, D'zousa, &Dev Soni, 2011). Not all cases involve cutting; for example, many urology procedure involve placing a camera through the urerthra and using laser or vibration to break up stones and no "cut" is ever made. At the facility where data was collected for this dissertation, surgical start time is defined as the time the patient is in surgical suite.

Another area of discrepancy in defining delay is what amount of time after the scheduled surgical start time is considered a delay. Most studies do not define this time so it is assumed that any time after the schedule surgical start time is considered a delay. In the study by Wright et al. (2010), they defined delay as any case starting after 08:00 AM. They had a secondary metric of cases starting by 08:15 AM, which captured cases that were later than the 08:00 AM start time but not significantly late. When using delay to assess OR efficiency, it is appropriate to look at delay in terms of minutes. In Vidan et al.'s study on delay in hip fractures (2011), delay is used to assess patient mortality risk and so it is measured in terms of days. They had 4 levels of delay: > 48 hours, 48-72 hours, 73-96 hours, and >120 hours after the planned surgical time. It is also important to consider the context when defining delay. For this dissertation, surgical delay was defined as being in the room 1 minute or more after the scheduled time.

Delay as a Measure of OR Efficiency

The JC defines a delay in treatment as when a "patient does not get a treatment…that has been ordered for them in the time frame in which it was supposed to be delivered" (2015). In their analysis of delays as sentinel events, many events resulted in either patient death, permanent loss of function, or unexpected additional care. From the perspective of healthcare quality, these outcomes are all likely to place a huge burden on the healthcare system in terms of cost and resources. In the context of the Operating Room (OR) environment specifically, delay can be viewed as a measure of OR efficiency.

OR efficiency is defined by many metrics other than delay. Marcario (2006) identified 8 different factors when measuring OR efficiency in the creation of a scoring tool. Surgical delay was identified as one of the eight measures, as well as delay to admission to PACU. Other factors included cancellation rate, staffing costs, and prolonged turnovers. The purpose of this scoring tool was to improve efficiency to maximize usage of the OR for cost savings and growth. This suggests that efficiency is often tied to cost and improved productivity.

The incidence of delay is perhaps one of the most significant sources of inefficiency in the OR. A retrospective review of data from the National Anesthesia Clinical Outcomes Registry (NACOR), which is a large data warehouse that falls under the Anesthesia Quality Institute and gathers information from the Centers for Medicare and Medicaid Service, analyzed 1,777,051 anesthesia cases in a medium-sized hospital to identify predictors of OR inefficiencies (Gabriel, Wu, Huang, Dutton, & Urman, 2016). This study made important contributions to our understanding of surgical delay because it looked at hospitals all across the country and is one of only a few multi-site studies that examined surgical delay. The study limited the analysis to medium-sized hospitals to control confounding. By far, the most recognized inefficiency was delay at 14.43%, whereas cancellation was only 0.05% of cases analyzed, unplanned admission was 0.18%, and extended PACU stay was 1.12%. From this study one can glean that delay is a major source of inefficiency in the OR.

Other studies indicate even higher incidences of delay, demonstrating a wide variability secondary to the hospital setting. In a retrospective review of 2,123 cases in one urban hospital, 27.2% of all first cases were delayed (Van Winkle, Rachelle, Champagne, Gilman-Mays, & Aucoin, 2016). The small nature of this study combined with the inclusion of only one facility limits the generalizability of the study. Conversely, the authors were able to get a more in-depth understanding of the delays because of the small setting. While most delays were found to be caused by equipment or staff availability, they did have an "other" category for causes that could not be categorized otherwise. Within this category certain trends emerged that included many patient-specific factors such as need for medications, presence of preoperative history and physical, acuity and patient stability. This study demonstrates that there are still many unanswered questions with regard to the cause of the delays in the OR but that patient-specific factors, particularly with regard to health status, play a clinically significant role in delay.

Usually delays in the OR are attributed to equipment or facilities issues or failures. In a large, retrospective analysis of 1,531 elective neurosurgical cases at one facility in Canada, one surgeon examined all errors from 2000-2009 including delay, errors in surgical technique, contamination of sterility and communication among several other errors (Wong et al., 2010). The most common error reported was delay (33%) and more than half of all cases had at least one type of delay. While this study was limited in only including one surgeon's cases at one hospital, it demonstrates that delay is a significant issue when analyzing OR efficiency. This study also found that over half of the delays were due to equipment failures. The next biggest category, which accounted for approximately a third of the delay, was simply termed "getting into the OR," or whether the case started on time. Interestingly, there is no further breakdown of this category, but there are many possibilities for a cause of not "getting into the OR" on-time.

In addition to the lost time from first cases not starting on time, subsequent cases are impacted. A large retrospective study of 13,547 elective surgical cases in one facility demonstrated that 66% of first cases deviated from the schedule start time at least 10 minutes (Balzer et al., 2017). Deviations in timeliness were as follows: 15 +/- 72 (mean +/- SD) minutes for the first case, 21 +/- 84 minutes for the second case and 25 +/-93 minutes for all following cases. It appears that as the day progressed the degree of deviation increased, resulting in more delays for the later cases in the day. One key finding in this study was that as the amount of time between the day the surgery was planned to the actual of day of surgery (DOS) increased, the amount of variation from start time increased. Cases planned 2 days before the DOS deviated from start time by 13.5 minutes, whereas cases planned 20 days before the DOS had start times that deviated from the scheduled time by 27.6 minutes. Another interesting point about this study is that it analyzed cases going earlier than scheduled, not just later. While most studies look only at delays as a deviation from the scheduled start time, Balzer et al. found that while delays were responsible for 74% of schedule deviation, cases going early accounted for 26%. Though less detailed in their analysis of the delays, Van Winkle et al. (2016) also demonstrated an increase in delays with each subsequent case throughout the day. Whereas the first case delay rate was 27.2%, subsequent cases were delayed 72.8% of the time (Van Winkle et al., 2016). While some of the same factors that delay first cases may be present in subsequent cases, this wide variation demonstrates that there are probably more and possibly different causes for deviations in start times of subsequent cases are.

Delay can also describe late starts of subsequent cases when turnover time between cases is longer than what was originally scheduled. Turnover time is the time between two cases for cleaning the room and preparing the equipment for the following case. Cases after the first case may be delayed even if the first case starts on time because of delayed turnover times. Whether the factors that delay a first-case start are also possible causes of delay for subsequent cases is still to be determined. In a study of 685 hand surgery cases with 5 different surgeons done at one ambulatory surgery center (ASC) or affiliated hospital, several factors influenced turnover times (Gottschalk et al., 2016). Turnover times were significantly shorter if the surgeon was in the OR during turnover (27.5 vs 30.4 minutes), when surgeons gave incentives to the staff (24 vs 29 minutes), and when the case was done at the hospital instead of the ASC. Other factors that were correlated with shorter turnover times were lower ASA score, the types of procedures done before or after the turnover time and the order of cases. Thus, it is imaginable that most of these factors could be causes of delay for a first-case start. Turnover time is an area where cases going much earlier than scheduled would be a possible area of inefficiency. If several cases in a room go earlier than scheduled and the rooms ends earlier than planned, then the OR was blocked unnecessarily preventing additional cases from being scheduled and committing staffing for longer than necessary.

Delay as a Measure of Healthcare Costs

Evaluating the financial costs of OR delays is a challenge due to individual facility variability in things such as staffing costs (Marcario, 2010). Marcario does not break down the cost of delays, but rather uses estimates of the entire cost of an OR case and divides that monetary amount by the number of minutes the case would take. In this nebulous world of healthcare cost, it is very difficult to say truly how much each minute in the OR costs and how much a decrease in delays actually saves costs. The number of personnel, equipment, supplies, invasive monitors, implants etc. all factor into cost. The most commonly cited article on the topic estimated each OR minute to cost $62 (Marcario, 2010) however a 2018 article looking at actual costs in a wide variety of settings across California found the cost to be $36 to 37 per minute (Childers & Maggard-Gibbons). Not surprisingly, one can imagine how quickly this can add up with multiple rooms doing multiple procedures each day throughout the year.

From the context of the conceptual framework that scaffolds this dissertation, the Patient is at center of several layers in the healthcare system (Fangjiang et al., 2005). The first layer, the Care Team, includes healthcare workers directly associated with that patient's care. In the OR this includes nurses, anesthesia providers, surgeons, surgical staff, administrative staff, and perhaps others. Delays may require these people to work longer than expected, sometimes with increasing costs after hours in the form of overtime pay. In the previously mentioned scoring tool for OR efficiency, staffing cost is one of the 8 metrics used (Marcario, 2006). When attempting to quantify how much can be saved in labor costs by increasing efficiency, the studies are not extremely favorable towards saving cost on staffing. For example, a computer simulated analysis of the effect of decreased turnover times on anesthesia cost demonstrated a decrease in labor cost by 0.8 to 1.8% if turnover time decreased 3 to 9 minutes and a decreased labor cost of 2.5 to 4% for a decrease of 10 to 19 minutes in turnover time (Dexter, Abouleish, Epsteib, Whitten, & Lubarsky, 2003). Instead of saving money by reducing staffing if time is saved on turnover time, the bulk of cost savings in this simulation study was seen by reducing allocated OR time, not through a reduction in actual cost paid to anesthesia providers for overtime. Allocated OR time would likely fall under the next layer of healthcare, the Organization. It is apparent that attempting to decipher exactly where the cost of delay lies is extremely challenging due to the interconnected nature of the complex factors.

Delay as a Measure of Patient Outcome

In addition to the price our healthcare system pays in terms of lost revenue and productivity, the conceptual framework guides the researcher to consider how delays have an impact on the central layer of the healthcare system: the Patient. The Patient stands to suffer physical and mental strife as well as their own personal financial loss depending on the severity of the surgical delay. Recent research on the impact on the patient has been done on emergency cases, particularly hip fracture patients.

In the hip fracture patient, a body of research has been devoted to the consequences of a delay on patient outcomes. In a meta-analysis of 16 observational studies on hip fracture delay, earlier surgery (within 24, 48 or 72 hours) was correlated with a significant mortality risk reduction (relative risk (RR) 0.81, 95%CI 0.68-0.96) (Simunovic et al., 2010). There was also a reduction in pneumonia (RR 0.59, 95% CI 0.37-0.93) and pressure ulcer development (RR 0.48, 95% CI 0.34-0.69.) Interestingly, one study even found that when a hip fracture was surgically corrected within the first 48 hours of injury, the increased upfront costs of gathering resources to expedite surgery, saved money in the long-run by decreasing costly, long-term outcomes (Shabat et al., 2003). In another retrospective study on over 2,000 hip fracture patients, mortality risk was only increased when the delay was more than 120 hours after adjusting for confounding factors with an odds ratio (OR) of 2.14 (95% confidence interval (CI) 1.25-3.63) (Vidan et al., 2011).

In addition to hip fractures, other emergent surgeries may have a higher risk of poor patient outcome when surgery is delayed. In a study at one tertiary hospital, 15,160 patients who underwent emergency non-cardiac surgery between January 2012 and October 2014 were analyzed for outcomes. The odds ratio for mortality was 1.59 (95% CI 1.30-1.93) in those with a delay versus those without a delay illustrating that delay may have an impact on long-term outcomes that extend beyond the OR (McIsaac et al., 2017). The authors further validated the association of the outcomes specifically with delay (as opposed to confounders) by using a propensity-matched cohort. Within this matched group, delay was still significantly associated with mortality with an odds ratio of 1.56 (95% CI 1.18-2.06) and was also associated with longer length of hospital stay (OR 1.07, 95% CI, 1.01-1.11) and higher total costs (OR 1.06, 95% CI 1.01-1.11). Interestingly, this study included an institution that stratified the allowable time of delay in to five categories. There were 5 classes of priority: (A: < 45 min; B: < 2 h; C: < 4 h; D: < 8 h; E: < 24 h). The surgeon who assessed the patient determined which priority level applied to the patient in their initial assessment and documented this. This adds further credibility to the delay standards in this sample since many hospitals and studies simply set an arbitrary number of minutes for all cases to be defined as delayed, regardless of the patient or surgical characteristics.

Not all studies find delay to be a cause of poor outcome. In a small study on 472 trauma patients undergoing exploratory laparotomy where 109 (23%) were delayed, a delay of more than 2 hours was not associated with any adverse outcome (Lewis, et al., 2017). Unlike the study by McIsaac et al. (2017) which did find delay associated with mortality and worse outcomes, the study by Lewis et al. (2017) was limited by a small sample size and lack of generalizability. This study only included trauma patients undergoing laparotomy. There was also no stratification for prioritizing the cases, as all cases had the same criteria for delay: 2 hours.

Regarding emergent surgeries such as hip fractures and traumas, literature supports that delays tend to lead to worse outcomes, although there is a lack of clear consensus. This is likely due to confounding factors such as the high pre-surgical morbidity of patients who would be undergoing such a procedure. In other words, these patients have a high risk for poor outcomes regardless of the surgery and while some studies do attempt to adjust for these confounding factors, most studies are large observational, retrospective studies that are therefore limited in their ability to control for confounding. To date, there is no research that investigates surgical delay and patient outcomes in elective cases. This is an area that deserves exploration because elective cases in healthier patients may have a very different trajectory than emergency cases due to the differences in types of patients and expected outcomes for the procedure.

A Novel Measure of OR Efficiency: Early Start Times

An area that has not been addressed in the literature is early surgical start times. In addition to cases being delayed, or even cancelled, some surgical cases could occur earlier than the scheduled time. Calling an early start time inefficient is counterintuitive as most would assume this increases efficiency. On the other hand, if a large number of cases are earlier, or cases are significantly earlier than scheduled, the OR schedule may be losing efficiency due to resources required to make changes. When cases do not go at the time planned, resources must be utilized to secure space, equipment and staff. Also, if all the saved time is added together it may be enough to add additional cases to the schedule. If a case needs to go earlier because of the patient's status, and this is accomplished by switching the order of cases, this results in another case being delayed. For example, some patients who are sick or frail may not tolerate waiting all day for surgery with nothing to eat or drink and so they may be moved to the beginning of the schedule. The case that was scheduled first now has to be delayed. Because it is not known whether these switches impact cost or patient outcome, any deviation in case start time from the scheduled time deserves exploration to determine whether early or delayed.

Causes of Delay

While the causes of delay have been explored in the literature, there are still many questions to be answered. Much of the research to date focuses on systems issues such as room availability, equipment and staffing. Additionally, most studies are observational and retrospective in design and utilize isolated facilities with a limited ability to control intrinsic and extrinsic factors. Furthermore, it is very difficult to assign causality to any delay factor because of the large number of variables and possibility for interaction, as well as the retrospective nature of the bulk of the studies on this topic. It is more accurate to define these factors as correlating factors.

While the specific correlating factors of surgical delay are variable among studies, they generally fall into several broad categories. The categories used in this dissertation are defined within the context of the conceptual framework. The conceptual framework defines 4 levels within the healthcare system: the Environment, the Organization, the Health Care Team and the Patient (Fangjiang et al., 2005). Precipitating factors within the Environment would be factors related to the way the healthcare environment is organized and would include aspects such as policies or regulations defined by the government. Currently, there are no studies that investigate causes in this category specifically. Precipitating factors within the Organization include OR availability, equipment, or logistical scheduling issue. Precipitating factors within the Health Care Team include availability of or issues related to any of the healthcare providers who care for the patient for the particular surgical event in question. Lastly, precipitating factors related to the Patient include patient-specific characteristics such as demographics, comorbidities, or acuity. This last category of patient-specific causes of delays are the primary subject of interest for this dissertation.

Availability of either the surgeon or anesthesia provider is one of the frequent causes of delay in research studies to date. In the retrospective review by McIsaac et al. (2017) a subset of 1109 cases were reviewed for the cause of delay. The largest source of delays was attributed to availability of personnel (31.7%), with the surgeon being overwhelmingly the most common cause of delay over other surgical healthcare providers. In the investigation by Deldar et al. (2017) 36.8% of the delays were attributed to surgeon readiness and 6.8% to anesthesia readiness in the pre-intervention group, which was only decreased to 36.1% and 6% post-intervention. Readiness of these two providers accounted for the largest cause of delay. The study metric utilized by Deldar et al. (2017) included the availability of the provider as well as factors such as extra time needed for an epidural (attributed to "anesthesia") or lack of consent (attributed to the "surgeon").

Performance improvement studies also demonstrate provider availability as a key factor in delay. One performance improvement evaluation that included 19,148 surgical cases uniquely employed the electronic health record (EHR) to examine the most prevalent causes of delay in a post-intervention analysis (Foglia, Alder, & Ruiz, 2013. The study attributed delay to be surgeon-related 33% of the time, followed by the anesthesiologist at 22% and nurse at 7%. Of interest, this study did not further explain whether the delay was attributed to availability of the provider, or if it could include factors such as lack of consent. Another performance improvement study by Wright at al. (2010) similarly found provider availability as a major cause of surgical delay. Before the performance improvement initiative, anesthesiologist availability accounted for 24% of delays whereas surgeon availability accounted for 21% over a 9-month period. This study's conclusions however are limited because they fail to mention the number of cases included in the evaluation. The authors simply mentioned that the study spanned 9 months in a facility that had 14 ORs that performed 11,000 cases per year.

Another commonly mentioned cause of delay is the availability of physical resources. This includes availability of operating rooms, equipment or other facility resources. In previously mentioned studies, physical resources as a source of delay accounted for 13% in the study by McIsaac et al. (2017). In the study by Deldar et al. (2017) physical resources fell under other generalized, non-standardized terms. For example, equipment related to anesthesia fell under the "anesthesia" cause of delay. Equipment for the surgeon fell under "surgeon." "OR Factors" accounted for 11.4% to 12.3% of delays and included set-up and failure of equipment or surgical instruments. Unfortunately, each study uses different definitions to categorize delay. This is noted by Van Winkle et al. (2016) in their study of 2123 OR cases using the EHR. Van Winkle cites equipment issues under the "uncategorized" category rather than under "facility." These issues highlight the challenges of studying delay without specific and standardized definitions.

Other studies which describe equipment or facility issues are limited in their scope and therefore difficult to generalize. A small study that evaluated causes of delay by one neurosurgeon over 9 years found equipment failure to be the most common cause of surgical delay in in 1,531 cranial cases (Wong et al., 2010). This study only included one facility, and one specialized surgeon, and therefore is extremely limited in generalizability. However, it does illustrate that from a surgeon's perspective, equipment is an important source of delay. Another limitation of the aforementioned studies that identify physical resources as a source of delay, is the lack of separate evaluation for elective and emergent cases. In a retrospective study of 2,250 hip fracture cases, which are inherently emergent cases, the primary cause of delay was lack of an available operating room (60.7%) (Vidan et al., 2011). Again, it is difficult to compare and contrast conclusions of studies because what is relevant for elective cases, may not be as relevant in emergent cases. In emergent cases people may be willing to move forward with less in place, such as equipment, all necessary staff or optimization of the patient, because of the critical nature of the situation. Conversely, because emergent cases are not scheduled, it is not surprising that finding an available room to perform the procedure may be a more common issue than in an elective case where rooms are allocated well in advance.

The last major area for potential surgical delays includes patient-specific issues. Patient-specific issues have been mentioned in the literature as a cause of delay, but they are rarely broken down to explain exactly what they are. Notably, patient-specific causes are perhaps the vaguest and least-defined in the literature. McIsaac et al. (2017) found patient-specific causes of delay to accounted for 13.6% of all delays. Patient-specific causes in this study were primarily attributed to a patient being medically complex or decompensated, but there is no further breakdown to explain exactly what this means. Deldar et al. (2017) had a similar incidence for patient-specific causes of delay (22.3% pre-intervention and 16.5% post-intervention) however the patient-specific causes cited in their study included factors such as arriving late to the hospital, the family being late or the patient having additional questions. There was another separate category entitled "preoperative assessment" which accounted for 14.9% pre-intervention and 9.9% post-intervention of delays and included medications, IV access and further work-up needed. This is similar to the study by Van Winkle et al. (2016) which included arrival to the hospital, waiting for the family, violating NPO status, and positioning issues as patient-specific causes of delay. In contrast, preoperative preparation issues such as IV access and preoperative assessments in the Van Winkle (2016) study fell under the "anesthesia" category. This is an excellent example of of the difficulty in comparing studies when there is a lack of consistency with regard to defining causes of delay.

While it is clear that there are issues specific to the patient that lead to delays, the literature is not very clear on the specific causes. A previously mentioned large study using NACOR data evaluated all cases that occurred in medium-sized hospitals between January 2010 and June 2015 (Gabriel et al., 2016). After excluding cases with missing data this included 986,902 cases, and 14.43% of these cases were delayed. Rather than using the EHR to look for specific causes of delay that would have been manually entered by a nurse or other staff member as in previous studies, this study looked for patient-specific factors that correlate with delay using CMS entered data. The authors found that patients undergoing gastroenterology procedures (primarily endoscopy cases performed in an outpatient setting) were delayed most frequently at 22.8%. Additionally, pediatric patients had a 2.83 odds ratio (95% CI 2.75-2.91) of being delayed compared to people aged 19 to 49, demonstrating that younger patients had a much higher risk of delay than adults. Higher ASA status, which equates with more comorbidities, had a slightly lower odds ratio for delay versus healthier patients (OR, 0.88; 95% CI 0.86-0.89) which is surprising since most of the other studies found patient medical status, or decompensation, as a source of delay (Deldar et al., 2017;

McIsaac et al., 2017). This is counter to the assumption sicker patients more likely to be delayed due to medical optimization. This result could be confounded by the fact that the sicker patients in this sample were less likely to get the procedures that are delayed such as gastroenterology-endoscopy procedures, or procedures under monitored anesthesia care (MAC), also known as sedation. Regional anesthesia had a decreased odds for delay versus general anesthesia (OR, 0.47; 95% CI, 0.45-0.48). MAC cases had a noticeable increased odds for delay (OR, 3.79; 95% CI, 3.73-3.86.) This is especially interesting as gastroenterology procedures also had a higher odds for delay and these cases are primarily performed under MAC.

It should be noted that there is a difference between causes of delay and predictors of delay. It is very difficult to establish causality in the studies that have been done in patient-specific delays because of the lack of control. A predictor could be a characteristic that is associated with delay, but itself does not necessarily cause the delay. For example, if a case is documented as delayed because of lack of availability of a room, it is easy to see the direct causal relationship. On the other hand, when the delay is related to a characteristic in a patient such as their health status, the relationship is more indirect rather than directly causal. It is these characteristics that could possibly be used to estimate delay risk through correlation. This means the chance of delay could be predicted based on the contributing patient characteristics, however correlation does not equal causality.

Intervention to Reduce Delay from Patient-specific Causes

In attempts to decrease delays, certain interventions have been implemented and evaluated in the literature. Some interventions such as scheduling improvements and maximizing OR efficiency can help reduce delays due to facility or systems issues (May, Spangler, Strume, & Vargas, 2011). The preoperative clinic is used for assessment and evaluation of patients before the day of surgery and is a common intervention that is specific to patient-specific delay causes (Correll, Bader, Hull, Hsu, & Tsen, 2006; Ferschl, Tung, Sweitzer, Huo, & Glick, 2005).

Clinics run by anesthesia providers to ensure a patient has been adequately optimized before surgery is an idea that has been gaining attention in the last few decades. The clinics have been shown to reduce delays and cancellations on the day of surgery (Correll et al., 2006; Ferschl et al., 2005). In a retrospective review of 63,941 ambulatory surgical patients during the implementation of an internal medicine clinic meant not only to assess, but to properly optimize patients for surgery, the delay rate decreased by 49% for the 50,967 patients who utilized the preoperative clinic (Parker, Tetzlaff, Litaker, & Maurer, 2000). In a retrospective study of 6,524 cases in one academic hospital, 8.4% of the patients in the group who were seen in the preoperative clinic were cancelled whereas 16.2% of patients in the group who did not attend the clinic were cancelled (Ferschl et al., 2005). There was a negligible, although statistically significant, difference in start times for patients seen in the clinic before surgery versus those not seen, with patients seen in the preoperative clinic starting 1 minute earlier. The benefit of the preoperative clinic when it is run by anesthesia providers is the unique ability to identify medical issues that would be likely to result in a delay well before the day of surgery. This is because anesthesia providers are familiar with the medical issues that preclude undergoing the stress of surgery and anesthesia. In a prospective study of over 5,000 patients seen in the preoperative clinic over a 3-month period, 565 patients had medical problems warranting further workup and 115 had new medical problems that were diagnosed in the preoperative clinic (Correll et al., 2006). These are issues that would have either delayed or cancelled over 13% of surgical procedures on the DOS but were caught ahead of time allowing for optimization.

The value of nurse-led preoperative clinics has also been evaluated as a cost-effective way to prepare patients for surgery and decrease delay rates. In a literature review of studies that evaluated nurse-led preoperative clinics for orthopedic surgeries, cancellation rates were all reduced as well as mortality and length of hospital stay (Sau-Man & Wan-Him, 2016). Another study found that when nurse practitioners were utilized in the preoperative clinic for orthopedic surgeries at one facility, the cancellation rate was decreased from 7.7% when primary care providers were used to 0.8% with a decrease in lost revenue from $386,033 to $184,480 (Sebach, Rockelli, Reddish, Jaronsinski, & Dolan, 2015).

The value of these preoperative clinic studies is that they provide a deeper understanding of the types of patient-specific factors that could potentially delay a case on the DOS. They also demonstrate the important role of the anesthesia provider or nurse in preventing these OR inefficiencies. While these practices can aid in preventing delays, it should be noted that some scenarios are unavoidable. In a secondary analysis of data collected for a study on communication in the OR, researchers found that there are many things happening in the OR that contribute to delay that are hidden and not easily rectified (Higgins, Bryant, Villanueva, & Kitto, 2013). For example, the authors explain how persons with differing levels of authority within the OR have more power than others to avert delays, however they may not have all the knowledge to anticipate these delays and therefore rely on communication with other staff to prevent the delays.

Challenges in the Literature

The emergence of the EHR in recent years has had a significant impact on healthcare operations, particularly in the surgical environment. In some instances, it improves operations with data collection, scheduling and organization but it is not without pitfalls. A performance improvement project evaluation by Foglia, Adler and Ruiz (2013) demonstrated how implementing the EHR in combination with other performance improvement initiatives such as staff education and preoperative clinics can actually increase OR efficiency. The number of cases increased 35% and the revenue increased 53%. The authors attributed the success to the ability of the EHR to streamline scheduling, precisely identify problem areas and have more fluidity between multiple geographic sites.

While the EHR does provide convenience and can improve performance, one of its drawbacks is the difficulty in dealing with such a large amount of data. Most of the studies which have been done on the topic of OR delay utilize the EHR to collect large databases of information. Many of these studies are retrospective and so there is a lack of control over variable and data quality. Van Winkle et al. (2016) specifically examine this issue as they explore the use of the EHR in evaluating OR delays. They found that the data fields that required subjective decision making were left blank 24% of the time. These data fields were the delay type and the delay reason. They also found that the complexity of the OR environment was difficult to capture in the EHR, describing 490 permutations possible when explaining the cause of delay using the data fields. While the EHR affords researchers access to large amount of data, the quality of the data is not always optimal and must be regarded cautiously.

Another example of the limitation of the EHR is the way data is categorized. In their pre/post-intervention study for improvement of delays, Deldar et al. (2017) defined "readiness" of a healthcare provider not just by availability of the provider. For example, a delay due to anesthesia could be anesthesia staff availability or also delay for placement of epidural or availability of anesthesia equipment. Similarly delays due to surgeon readiness could be surgeon availability but also could be logistic issues such as consent. Issues with consent or marking the operative site could be categorized under preoperative assessment or preparation, which could also be considered patient-specific issues. Comparing studies must be done cautiously as each research study categorizes causes differently. There are myriad causes of surgical delays, thus it is difficult to find a standard method of comparison.

Another concern when assimilating surgical delay studies is the type of facility in which the studies were done. A large study of NACOR data limited the cases to medium-sized community hospitals, however many of the studies on delay are done in large, academic facilities which could have different contributing factors to delay. In a prospective study of 25 different facilities (varying from small to large community hospitals, to university hospitals) and 6,009 procedures requiring anesthesia, university hospitals were shown to have 2.23 times (95% CI, 1.49-3.34) higher cancellation rates than small and mid-sized community hospitals (Schuster et al., 2011). Institution size and type must be considered in data interpretation.

While access to large electronic databases has allowed researchers to gain some insight into the causes of delay in the OR, there are still many unanswered questions. Studies have consistently shown several major categories of delay including physical resources like the facility or equipment, availability of providers such as the surgeon, anesthesiologist or nursing staff, and multiple factors related to the patient such as medical status and availability. Patient-specific factors represent an especially novel area of delay-focused research since the data to date is very limited in identifying the specific type of patient most at risk for a surgical delay.

Conclusion

To date the bulk of research on surgical delays are single-site, retrospective studies that utilize the EHR as the primary source of data. Because of the challenges with using EHR data and the variability in definitions and dynamics among individual sites, comparing studies and attempting to understand the subtleties of surgical delay are challenging at best. What is known is that surgical delays are a consistent problem with a complex web of contributing factors including issues related to the facility, providers and the patient. There are certainly many opportunities for research to better understand this phenomenon and identify interventions that can improve OR efficiency, specifically with respect to the role of patient-specific factors.

Chapter III: Methods

Design

This was a retrospective, descriptive study using existing data from 55,245 individual surgical cases within the electronic health record (EHR). The patients studied underwent a scheduled surgical procedure between May 2012 and April 2017 at a large, academic surgical hospital in Los Angeles, California. Data was collected from the EHR and analyzed to explore the first aim of the study: the identification of any patient-specific factors correlated with surgical schedule deviation. Next, to address the second aim of the study, any correlated factors were used to build a predictive model of surgical schedule deviation in this sample of patients.

Sample

Study Participants

A database of 55,232 surgical cases between May 2012 and April 2017 was utilized as the sample for the study after Institutional Review Board (IRB) approval was obtained. Inclusion criteria for the study encompassed all patients who had elective surgery with anesthesia. Exclusion criteria includes any participants requiring emergent surgery or younger than 18 years of age. Additionally, some patients underwent multiple surgical procedures within the study timeframe. Only the first surgical case for any patient was included. All subsequent surgical cases after the first case for any individual patient were excluded to improve accuracy of the data. After applying exclusion criteria, 36,543 cases remained for analysis.

Sample Size Calculation

Due to the correlational nature of the first aim of the study, the response, or dependent, variable was a categorical variable termed surgical delay. Fifty independent variables were selected to explore and assist in addressing the second aim: to build a predictive risk algorithm that identifies patient-specific factors associated with surgical delay. According to Polit's *Statistic and Data Analysis for Nursing Research* (2010), power analysis for logistic regression is very complex due to the lack of a straightforward analog equivalent of R^2 for effect size estimation. Another way to estimate sample size is to estimate the number of cases for each predictor. A strong model will have at least 20 cases per predictor. Using 50 predictors necessitates a sample size of 860 cases. All EHRs of patients who underwent scheduled surgery between May 2012 and April 2017 were available and were included in analysis. There were 36, 543 total cases within this timeframe after exclusion criteria were applied.

Setting

All study participants underwent surgery at a large, tertiary-care, academic hospital where every major surgical service is present.

Dependent Variables

The dependent variable was surgical delay. Surgical delay was the primary dependent variable and was defined as any start time that is more than 1 minuts from the scheduled time on the date of surgery (DOS). These values were recorded in minutes. This was a binary, categorical variable. The two categories were (1) on-time or early or (2) delayed.

Independent Variables

The independent variables were all patient-specific factors related to the surgical patient population. They were chosen based on previous research, an extensive literature review and the primary author's experience with the surgical patient population as factors that could possibly increase the time needed to prepare a patient for surgery. Patients are identified in the dataset by their medical record number (MRN) which is specific to their care in the healthcare setting.

Gender. Gender was defined as male (M) or female (F).

Age. Age was in years.

Race. Race was defined according to the templated choices set by the EHR and included White, Black, Asian and Other.

Ethnicity. Ethnicity was defined according to the templated choices set by the EHR and include Hispanic or non-Hispanic.

Proximity to hospital. Proximity was defined as the number of miles the patients' zip code on file is from the hospital zip code. Previous studies identified arriving late to the hospital as a cause of delay to surgery (Deldar, et al., 2017; Van Winkle et al, 2016). It is presumed that if patients live further away from the hospital, they may be more at risk for a delay due to tardiness on the DOS or missing preoperative appointments aimed at optimizing the patient's health status before the DOS.

Insurance type. Insurance type was defined as Managed Care or Exchange, Medicare, Medicaid, Uninsured/self-pay or Charity. This was retrieved from the financial file associated with each patient. Health insurance has been linked causally to health care utilization and outcomes (Freeman, Srikanth, Bell, & Martin, 2008). It is logical to consider it in the context of surgery as different types of insurance may have different effects on a patient preparation for surgery and therefore readiness for the procedure.

Acuity. Acuity was defined using the American Society of Anesthesiologists (ASA) classification. ASA classification is a graduated measure of physical status that is based on chronic illness and is being used in this study as a measure of patient health (ASA House of Delegates, 2014). It is assigned by the anesthesia provider based on the definitions provided by the American Society of Anesthesiologists (See Table 1). Because of the subjective nature of the assignment, bias does exist. A recent cohort study to assess ASA found moderate interrater reliability, $\chi = 0.61$ (95% CI, 0.60-0.65. In terms of validity, it was moderately valid in predicting mortality (AUC 0.74; CI, 0.68–0.80) and myocardial injury (AUC 0.75; CI, 0.71–0.79) (Sankar et al., 2016). Previous studies have shown that patients who are medically decompensated are more likely to be delayed (McIsaac et al., 2017). There has even been a link specifically between ASA status and delay in the large study using NACOR data (Gabriel et al., 2016).

Classification	**Definition**	**Examples**
ASA I	A normal healthy patient	Healthy, non-smoking, no or minimal alcohol use
ASA II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity ($30 < BMI < 40$), well-controlled DM/HTN, mild lung disease
ASA III	A patient with severe systemic disease	Substantive functional limitations; One or more moderate to severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents.
ASA IV	A patient with severe systemic disease that is a constant threat to life	Examples include (but not limited to): recent (< 3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
ASA V	A moribund patient who is not expected to survive without the operation	Examples include (but not limited to): ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
ASA VI	A declared brain-dead patient whose organs are	

	being removed for donor purposes	

Table 1. ASA Classifications (ASA House of Delegates, 2014)

Physiologic system-specific comorbidities. Major system-specific comorbidities included neurological, cardiac, renal, hepatic, gastro-intestinal, endocrine, hematological, musculoskeletal, and genitourinary disease processes as well as psychiatric and pain disorders. Comorbidity variables are defined with commonly-used terms. (See Table 2)

Comorbidity Variable	**Search Term**
Neuro: Stroke	Stroke, Cerebral Vascular Accident, Transient Ischemic Attack, TIA, Cerebral Infarction
Neuro: Movement disorder	Parkinson's Disease, Multiple Sclerosis, Myasthenia Gravis, Muscular dystrophy, Huntington's disease, Tremor
Neuro: Epilepsy	Seizure, Epilepsy
Neuro: Dementia	Alzheimer's, Dementia
Cardiac: Hypertension	Hypertension, High Blood Pressure
Cardiac: Heart Failure	CHF, Heart Failure, Cardiomyopathy
Cardiac: CAD	Coronary Artery Disease, Myocardial Infarction, Chest Pain, Angina, Heart Attack
Cardiac: Arrhythmia	Atrial Fibrillation, Ventricular Fibrillation, Ventricular Tachycardia, Heart Block
Cardiac: Pacemaker	Pacemaker, Implantable Cardioverter Defibrillator, ICD
Cardiac: Hyperlipidemia	Hyperlipidemia
Pulmonary: Chronic infection	Chronic sinusitis, tonsillitis, allergic rhinitis
Pulmonary: Reactive airway	Asthma, Emphysema, COPD, reactive airway disease
Pulmonary: Smoker	Tobacco, smokes, smoker, nicotine
Pulmonary: OSA	Obstructive sleep apnea
Vascular Disease	Peripheral vascular disease, AAA, Abdominal Aortic Aneurysm
Obesity	Obesity
Renal Failure	Kidney Failure, Renal Failure, Dialysis, Chronic Kidney Disease, Renal Insufficiency, ESRD
Liver Failure	Liver Failure, Hepatic Failure, Cirrhosis
GI: Reflux	GERD, reflux, Heartburn, Hiatal Hernia
Endocrine: Diabetes	Diabetes
Endocrine: Hypothyroidism	Hypothyroidism
Hematology	Anemia, thrombocytopenia, coagulation disorders, other blood disorders
Musculoskeletal	Arthritis
Chronic Pain	Fibromyalgia, Chronic Pain, Neuropathy, Migraine, CRPS
Psychiatric disease	Depression, Anxiety, Bipolar, Schizophrenia, Psychosis
Substance Use	Alcoholism, Drug use, Drug abuse, Opioid abuse, Drug Addiction, EtOH, Alcohol Abuse
Cancer	Tumor, Leukemia, Lymphoma, Malignant Neoplasm, Melanoma, Cancer

Table 2: Comorbidity Variables

While medical status has been shown to be correlated with delay, specific types of medical issues have not been delineated (Deldar et al., 2017; McIsaac et al., 2017). This exploratory study built upon prior research by specifically exploring the major physiologic systems in search of specific areas or disease processes that are higher risk for surgical delay.

Medication Usage. Both the number and types of prescriptions medications was used as another measure of chronic illness. Common medications utilized by the participants in the study were identified and categorized into the following groups. (See Table 3.)

Medication Variable	Search Term
Medication: Insulin	Insulin
Medication: Hypoglycemic	Glipizide, Glyburide, Metformin, Actos, Pioglitazone, Acarbose, Nateglinide
Medication: Anti-hypertensive	Atenolol, Labetalol, Metoprolol, Propranolol, Carvedilol, Lisinopril, Enalapril, Captopril, Hydrochlorothiazide, Losartan, Valsartan, Amlodipine, Nimodipine, Nifedipine, Clonidine
Medication: Anti-arrhythmic	Diltiazem, Verapamil, Amiodarone, Sotalol
Medication: Steroid	Prednisone, Prednisolone, Methylprednisolone, Hydrocortisone, Dexamethasone, Triamcinolone
Medication: Anticoagulant	Warfarin, Heparin, Rivaroxaban, Dabigatran, Apixaban, Edoxaban, Enoxaparin, Fondaparinux, Clopidogrel, Ticagrelor, Dipyridamole, Aspirin, Ticlopidine, Eptifibatide
Medication: Opioid	Codeine, Fentanyl, Hydrocodone, Oxycodone, Meperidine, Hydromorphone, Methadone, Morphine
Medication: Antidepressant	Fluoxetine, Duloxetine, Amitryptiline, Desipramine, Nortriptyline, Imipramine
Medication: Antipsychotic	Clozapine, Olanzapine, Quetiapine, Risperidone
Medication: Anxiolytic	Alprazolam, Clonazepam, Diazepam, Lorazepam

Table 3: Medication Variables

Anesthetic Type. Anesthetic type was defined as Major, Major Cardiovascular (CVS) or Minor. Major anesthesia included general anesthesia or regional anesthesia where regional is the primary anesthetic. For example, a patient receiving an epidural as the source of surgical anesthesia would be considered "Major." This variable could not be further broken down into regional versus general categories due to limitations in available data. Major CVS included anesthesia cases, primarily cardiac procedures, where cardiac bypass was utilized. Minor anesthesia included cases where sedation was the primary anesthetic provided by the anesthesia team.

Study Procedure and Timeline

After obtaining IRB approval for the use of patient data, data collection commenced. A sample of patients who received surgery between May 2012 and April 2017 in the main operating room (OR) was utilized and each patient was identified by their unique MRN. This sample was derived from a hospital main OR dataset which was used for case tracking and scheduling purposes. After accounting for inclusion and exclusion criteria, a final sample of 36,543 cases was created. The data collected on this sample included the following independent variables: age, ASA status, surgical service, delay reason, and number of minutes the case varied from scheduled time. The de-identified list of MRNs was provided to the study site Information Technology department to collect additional independent variables. The IT department initially pulled data using ICD-9 codes (Medicode, 1996) and ICD-10 codes (World Health Organization, 2004) that matched the independent variables. The data returned had a large amount of missing data. The IT department then pulled the data using the generic search times (see Table 2 and 3). This information was returned in a list format and then was organized into a database by the researchers.

Initial IRB approval was attained in October 2017 and the list of patients with some of the variables was received in November 2017. Data collection from the EHR to gather remaining data began March 2018 and was completed in January 2019. Data analysis began in January 2019 and was completed in August 2019. Manuscript development is currently ongoing and anticipated to be complete in June 2020. (See Figure 1).

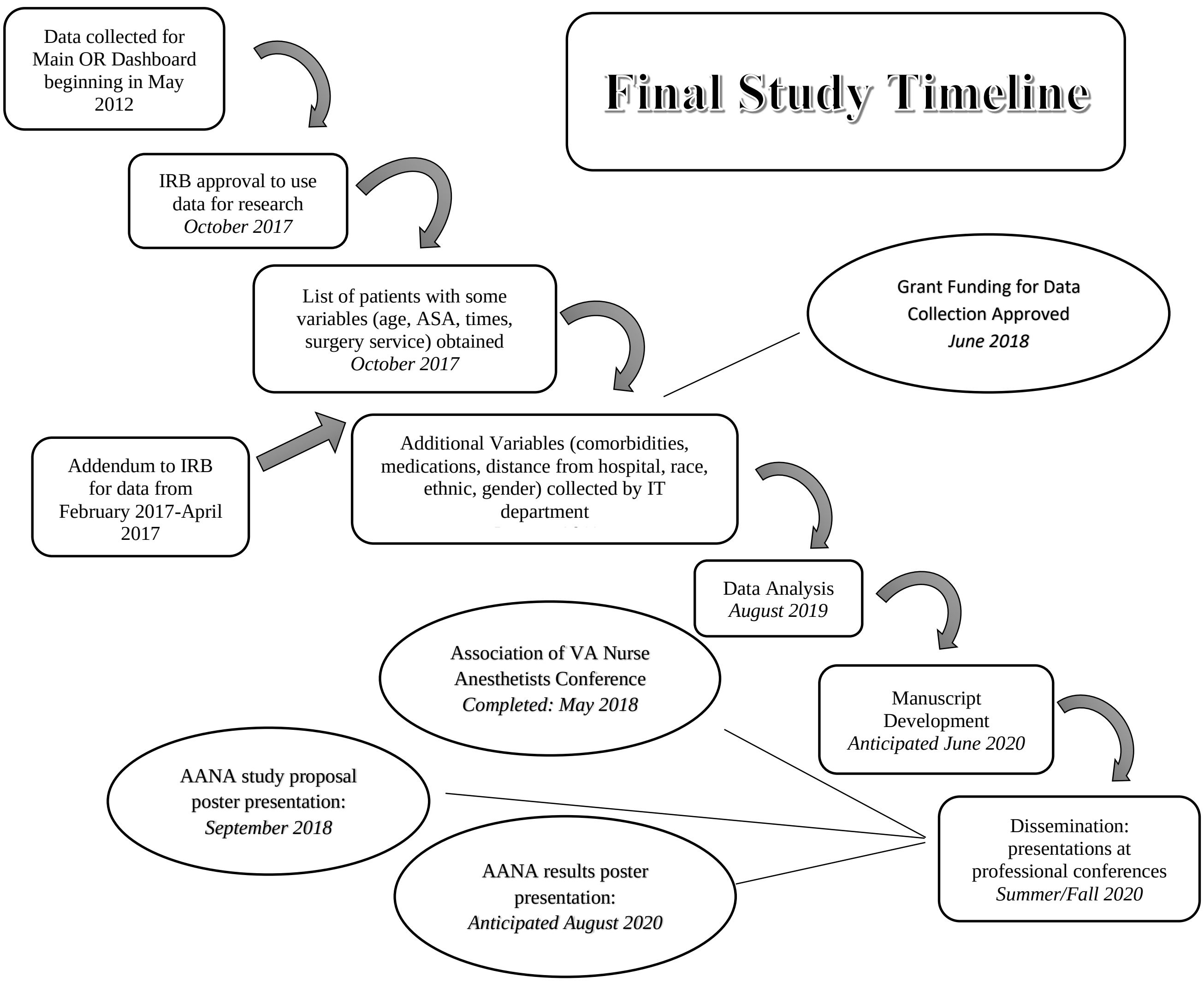

Figure 1. Study Timeline

Data Analysis

An abbreviated description of data analysis is described here. The final results are reported in the third manuscript of the dissertation. Descriptive statistics was used on all variables and examined for responses. Descriptive statistics was used to compare all cases that were delayed versus on-time/early. Normality of data was determined on all independent variables' data to allow for categorizing the variable as either categorical or continuous. Only one independent variable, age was maintained as a continuous variable. All other variables were transformed into categorical variables due to non-normality. Chi-square analysis was used to compare all categorical independent variables to the dependent variable of surgical delay. A T-test was used to compare age to surgical delay. Significance was set at $p < 0.05$. All variables with statistically significant relationships to surgical delay were entered into a logistic regression model. Calculations were completed using SPSS v25 (IBM Corp, 2017).

Compliance Plan

Data and Safety Monitoring Plan

Information including patient medical record number (MRN), age, date and time of surgery, ASA classification, and surgery type were derived from the Hospital Main OR Block Dashboard which is maintained by Surgery Department for performance improvement purposes. This information was provided to the study personnel on a password protected thumb drive. This information was stored in a password-protected excel spreadsheet on a password-protected laptop utilized by the primary investigator (PI). This spreadsheet was uploaded to the HIPAA-compliant Microsoft OneDrive (version 19) system maintained by the University of Southern California. Only Sarah Giron, Natalie Meyers and the IT staff assigned to this study by the IRB had access to this OneDrive account. The IT staff assigned to the case used this patient list to acquire the rest of study variables using patient MRN's for identification. All study variables were added to the original spreadsheet which was password-protected. This spreadsheet was returned to the study personnel through OneDrive. The study personnel immediately coded the final spreadsheet for confidentiality and removed personally identifiable information (PII) such as MRNs. Each patient was assigned a number beginning with 1 and ending with 36,543. This coded spreadsheet was utilized for data analysis. Only aggregate data that had been analyzed was shared outside of these platforms with people approved by the IRB.

Statement of Assumptions and Protection of Human Subjects

Due to the retrospective nature of this study using already collected data, informed consent was necessary. All patient information was maintained with strict confidentiality among the members of the research team. All data was stored on a password-protected computer and all data files were password-protected. Only the PI had access to the passwords. Only members of the research team approved by the IRB had access to the raw data. Only de-identified aggregate data was shared with other entities for manuscript development.

Risks of Study Participants

There was no physical risk to the study participants since the data had already been collected and did not affect treatment. There was a risk of breach in confidentiality and exposure of patient information. For this reason, all data was password-protected and data for analysis was coded to removed PII. No breaches occurred.

Confidentiality

As this study involves retrospective chart review and harvesting previous collected clinical data, there was no potential direct or clinical risk to the participants of this study. There was a potential risk to patient confidentiality and privacy since patient-specific information was utilized to identify patients for data collection. All patient information was be maintained with the strictest confidentiality and all data were protected on password-protected computers. No patient names or social security numbers were utilized for identification. Only hospital-assigned medical record numbers were used to identify subjects for initial data collection. Subsequently, a coded data sheet that eliminates MRNs was utilized for analysis.

Potential Benefits

There were no direct potential benefits to the participants in this study. All information was collected retrospectively and did not influence the direct care of any patient whose information was used in the study. There was a potential benefit to future patients, society and hospital systems with the information generated in this study. Additional resources may be channeled to patients found to be at a higher risk for surgical delay as a result of this study. Policy changes may be made at the government level or within insurance systems to optimize care for at-risk populations.

Inclusion of Women

The study hospital services all genders without discrimination. In addition, they have extensive gynecological and gynecological-oncology surgical services which cater specifically to women and their specific concerns.

Inclusion of Minorities

The study hospital services a diverse population of patients that include every major racial and ethnic group without discrimination. Analysis of these demographics was performed to assess the makeup of the sample and compare it to the population at large to determine its generalizability.

Inclusion of Children

The study hospital had a very minimal pediatric population and therefore children were not included in this study. All patients were 18 years or older.

Description of the System for Maintenance of Records

After the appropriate mandated time after the conclusion of the study, all personally-identifiable information will be destroyed. This includes all data sheets that have patient names and MRNs.

Limitations

Due to the lack of control of intrinsic and extrinsic factors, as well as the retrospective nature of the study, causality could not be determined. While the study revealed factors that are correlate with a surgical schedule delay at this facility, it is impossible to eliminate all confounding factors. Sources of confounding are facility or staff causes of aberration in start time rather than patient status. In other studies, things such as equipment issues, availability of personnel or operating room space were causes of delay. Since we did not have this information, it is impossible to know the extent that these issues contributed to changes in the surgical start time.

While the number of independent variables was limited to the most common comorbidities and medication types as well as demographic data, there are 50 different variables. With this number of variables, the risk of collinearity is increased. Some possibilities for collinearity included hypertension and antihypertensive medications, or chronic pain and pain medications.

This study was performed on a cohort of patients who received surgery in the main OR (as opposed to ambulatory centers) from one, large, academic, tertiary care hospital where the acuity of patients was known to be higher than the average surgical patient. The generalizability of the results beyond this setting are extremely limited.

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Chapter 4: MANUSCRIPT I

American Association of Nurse Anesthetist Foundation Doctoral Fellowship Grant

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I. Title

The Relationship Between Patient-Specific Factors and Surgical Schedule Deviation

II. Specific Aims

The surgical setting is a high-paced environment where time is money. It is estimated each minute in the operating room (OR) costs $62 (Marcario, 2010). In facilities with multiple ORs and numerous cases, delayed surgical procedures result in significant financial losses. In addition to financial loss and wasted resources, individual patients may suffer from emotional and financial consequences (Ivarsson, Kimblad, Sjoberg & Larsson, 2002) as well as increased risk of morbidity (Vidan et al., 2011.

The frequency of delay to surgery varies from 14.43% (Gabriel, Wu, Huang, Dutton, & Urman, 2016) to as high as 67% (Balzer, Raackow, Hahnenkamp, Flessa, & Meissner, 2017). Just a few of the possible reasons for surgical delay are equipment, OR space, staff availability and patient health status (Deldar et al., 2017; Higgins, Bryant, Villanueva, & Simon, 2011; McIsaac et al., 2017; Van Winkle, Rachelle, Champagne, Gilman-Mays, & Aucoin, 2016). While poor health status for patients has been implicated as one possible cause of delay, specific conditions correlated with delay are still not known. Furthermore, to date, studies are not congruent; in a large retrospective study of medium-sized community hospitals, a higher acuity was actually negatively correlated with a delay (Gabriel, Wu, Huang, Dutton, & Urman, 2016).

In addition to gaps in research to explain the role of patient-specific factors in delay, the preponderance of OR scheduling research examines delayed cases and not cases that start earlier than the scheduled time. One study examined surgical schedule deviation, whether earlier or later than scheduled, and found that any variation in start time can impact OR utilization (Balzer et al., 2017). Examining deviation that is earlier than scheduled in addition to later than scheduled may be especially relevant when considering patient-specific factors as a cause of schedule changes. Changes in patient health status could be an impetus for delaying a case to improve patient optimization, or it could potentially force a case to go earlier than scheduled if the surgical procedure is needed to improve the patient's condition.

In order to explore patient-specific factors that are correlated with surgical schedule deviation, a study is proposed that retrospectively examines all cases that occurred either earlier or later than scheduled in the main operating room at large academic hospital in Los Angeles for a five-year period, from May 2012 through April 2017. Identifying trends in patient-specific factors can inspire more detailed research for specific vulnerable populations as well as provide evidence for quality improvement processes by anesthesia providers and other clinicians that target resources towards specific populations most at risk for surgical schedule deviation. In order to understand the relationship between patient health status and surgical schedule deviation, the proposed study will address the following aims:

1. Identify any patient-specific factors that are significantly correlated with surgical schedule deviation including late or early deviation
2. Develop a predictive risk algorithm that describes the different patient-specific factors that are correlated with surgical schedule deviation

III. Research Strategy

A. Significance

As healthcare undergoes a major transformation, experts are tasked with identifying areas of improvement, especially with regards to optimizing cost and decreasing complications. The operating room (OR) is one area where unexpected deviation in scheduled start times can have a huge impact on the patient, the care team and the institution. Poor efficiency primarily affects the institution in the form of financial losses. In one analysis done in 2010, the author estimated OR costs to be between $20 and $62/min (Macario, 2010). This is commensurate with a British study that found an approximate loss of £24/min for delays in the trauma OR (Ang, Sabharwal, Johannsson, Bhattacharya, & Gupte, 2016).

The surgically delayed individual patient is impacted with financial losses as well as other repercussions. The possible consequences include emotional or mental anguish as was shown in a sample of heart surgery patients whose cases were cancelled or postponed (Ivarsson, Kimblad, Sjoberg & Larsson, 2002).

Additionally, a patient may suffer an increased morbidity and mortality depending upon the urgency of the procedure and the patient's pre-existing health status. This has been especially noted in hip fracture patients, where a delay to surgery increases the likelihood of death or morbidity. In one study, delaying surgery more than 120 hours was the cutoff point for a statistically increased risk of mortality, with an odds ratio of 2.14 of death after this point (Vidan et al., 2011). When looking at a sample of 15,160 patients who underwent any type of emergent surgery other than cardiac surgery, there was an increased odds for mortality in those with a delay to surgery (OR 1.59, 95%; CI,1.30-1.93) (McIsaac et al., 2017).

How often delay occurs in the OR depends on the population and the setting. In a study of over 1.7 million cases in medium-sized community hospitals the rate was 14.43% (Gabriel et al., 2016). In academic settings the rate is higher and can range between 24 and 67% (Van Winkle et al., 2016; Balzer et al., 2017). This may be due to the fact there are more trainees in these settings who have less experience or more complex cases. Although this has not been studied to date in the OR, there is evidence to support the effect of trainees on mortality and efficiency in the hospital in general (Young, Rangi, Wachter, Lee, Neihaus & Auerback, 2011).

Eliminating, or even reducing delay is one step to improving OR efficiency, safety and patient outcomes. Quality improvement projects have focused heavily on first-case starts, which refers to the first case of the day in a particular room starting on-time (Deldar et al., 2017; Mathews, Kla, Marolen, Sandberg, & Ehrenfeld, 2015; Wright, Roche, & Khoury, 2010). Focusing on first-case starts means ensuring that everything is done to ensure the first case in a room begins on time. Logically if the first case in a room is delayed, subsequent cases in the room will be delayed. In an analysis of 13,547 cases in a German hospital, the average number of minutes a case was delayed increased from approximately 15 minutes for the first case to 25 minutes for the third case (Balzer et al., 2017). By focusing efforts on the first case, quality improvement is aimed at achieving a downstream savings.

To better understand surgical delays, several studies have looked at the common causes of delay. It is nearly impossible say definitively that certain factors cause a delay, especially when looking retrospectively, because there are so many factors and they are interrelated. Studies that utilize the electronic health record (EHR) as a source of data can be particularly useful when analyzing delay because often the EHR has embedded data fields where a staff member had to manually input a reason for the delay on the day of surgery (McIsaac et al., 2017; Van Winkle et al., 2016; Vidan et al, 2011). These reasons can be regarded with somewhat more confidence as actual cause of delay, as opposed to retrospectively looking at factors that correlate with delayed cases, since a person was able to see exactly what transpired to lead to the delay before inputting the reason into the chart at the time of the event. Despite the fact that this data exists, it is still not failsafe. Van Winkle et al. (2016) looked at 2,123 EHR's in an exploration of the ability of the chart to demonstrate the reasons for delay. The researchers found that deficiencies in the chart setup, the subjectivity of decision making, and the large amount of missing data made it difficult to truly understand the cause of delays in their sample.

While staff, equipment and room availability are commonly cited as reasons for delay, health status of the patient has also been documented as a cause of delay (Garg, Bhalotra, Bhadoria, Gupta, & Anand, 2009; Balzer et al., 2017; Wright et al., 2010). Unfortunately, no studies specifically delineate the different types of medical causes for surgical delay. A retrospective review of over 1.7 million surgical cases done in medium community hospitals from the National Anesthesia Clinical Outcomes Registry (NACOR), a data warehouse used for quality improvement, found conflicting results for acuity as a predictor of delay (Gabriel, Wu, Huang, Dutton & Urman, 2016). In this study, patients with a higher acuity as measured by the American Society of Anesthesiologists (ASA) classification had a decreased odds (OR 0.88; 95% CI, 0.86-0.89) of being delayed versus patients with a lower ASA classification. This is in direct conflict to other studies where patients with a higher ASA classification were more often delayed (Ferschl, Tung, Sweitzer, Huo, & Glick, 2005). Exploring these medical reasons and other patient-specific factors as a cause of surgical delay is an opportunity to identify trends or areas that are especially vulnerable to delay that have yet to be explained and may be entirely preventable. Furthermore, it will be important in future studies to pay particular attention to the type of sample being studied as there may be vast differences between community versus academic settings, rural versus urban, small versus large, etc.

In terms of studies on interventions, there has already been work done to demonstrate that anesthesia-led and nurse-led preoperative clinics can help decrease delays on the day of surgery (Correll, Bader, Hull, Hsu, & Tseng, 2006; Ferschl et al., 2005). By identifying medical issues in patients before the day of surgery, there is time to correct these issues or optimize the patient's health status before surgery. Neither the research on correlating factors with delay, nor these studies on how the preoperative clinic can reduce delays explain the specific medical issues that likely cause delays. By having a clearer understanding of what the specific medical conditions are, protocols and pathways can be developed that specifically target the most at-risk patients.

B. Innovation

Current research indicates that patient health status plays some role in whether the case is started on time or not, however the current knowledge is limited in explaining why this occurs. Some of the patient-specific factors that are highlighted include patient availability or patient status and acuity (Deldar et al., 2016; Gabriel et al., 2016; Van Winkle et al., 2016). The proposed study will deepen our understanding of what specific types of medical issues impacting patient status are correlated with deviations from the scheduled start time. This will not only inform further studies into interventions aimed at these populations but help clinicians to know what patients are most at risk for missing their scheduled procedure time. Anesthesia providers in particular can use this information to improve the preparation process for patients beginning in the preoperative clinic and extending to the day of surgery with streamlined protocols.

While recent studies have identified delay as type of OR inefficiency, there is virtually no research on the role of cases that start earlier than scheduled. There is one study to date that explored the impact of a deviation in surgical start time on OR utilization, including early and late starts for cases (Balzer et al., 2017). In this study, 87% of cases deviated from the scheduled start time by more than 10 minutes, with 74% being delayed and 26% being early. This study will explore a novel variable in OR efficiency: early cases as well as delayed cases and therefore add to the knowledge base for clinicians in the OR as well as administrative staff responsible for scheduling and budgeting.

The design of the study supports collaboratives relationships between the different clinical specialties within the surgical area. The study is being done in concert with the departments of surgery, information technology and biostatistics, and encompasses multiple disciplines including nursing, anesthesia and surgery. The results could be utilized by all disciplines in the study and implementation of interventions to improve OR scheduling and fosters a multi-disciplinary effort within this institution. It also enhances the role of nurse anesthetists in the overall planning and management of OR procedures.

C. Approach

1. Design and Methods

This study will be a retrospective, descriptive study using the existing data patients' her from those who underwent a scheduled surgical procedure. Data will be collected from the EHR and descriptive analysis used to explore the first aim of the study: the identification of any patient-specific factors correlated with surgical schedule deviation. Much of the gathered data will be categorical and/or non-normally distributed. Summary statistics such as means, medians, standard deviations, and ranges will be produced for continuous variables. Frequencies will be tabulated for categorical and ordinal variables. Next, to address the second aim of the study, any correlated factors will be used to build a predictive model of surgical schedule deviation in this sample of patients. Graphical methods will be used to examine distributions and guide data transformations if warranted. For continuous variables with markedly non-normal or skewed distributions, appropriate transformations, such as natural logarithms, and will be applied as necessary and appropriate or non-parametric methodology may be employed.

2. Sample and Setting

A database of 55,232 patients who underwent a scheduled surgery between May 2012 and April 2017 at a large, academic surgical hospital in Los Angeles, California will be utilized as the sample for the study. Inclusion criteria for the study encompasses all patients who had surgery. Exclusion criteria includes any participants requiring emergent surgery or younger than 18 years of age.

3. Variables

Dependent Variables

The primary dependent variable for the correlational component of the study is surgical schedule deviation, which is continuous and will be defined as any start time that is more than 15 minutes earlier or later from the scheduled time on the date of surgery (DOS) recorded in minutes. Fifteen minutes was chosen based on previous studies that allowed for a grace period when defining deviation (Balzer el al., 2017; Wright et al., 2010) and the fact that the Center for Medicare Services defines one base unit for billing in anesthesia as 15 minutes of time (2017).

A secondary analysis will be done comparing factors associated with either being early or delayed, using deviation as a categorical variable of either early or delayed. Early cases are any that occurred more than 15 minutes before the scheduled time. Delayed cases are cases that occurred more than 15 minutes after the scheduled time. Those patients who did not experience a delay will be used as a comparison group in statistical analysis.

Independent Variables

The independent variables are all patient-specific factors related to the surgical patient population. They have been chosen based on previous research, an extensive literature review and the author's experience with the surgical patient population as factors that could possibly increase the time needed to prepare a patient for surgery. Patients are identified in the dataset by their medical record number (MRN) which is specific to their care in the healthcare setting.

Gender. Gender will be defined as male (M) or female (F).

Age. Age will be in years.

Race. Race will be defined according to the templated choices set by the EHR and will include the following choices: American Indian or Alaskan Native; Asian; Black or African-American; Native Hawaiian or other Pacific Islander; other; unknown; White; Multiple; patient refuses or does not know; no response.

Ethnicity. Race will be defined according to the templated choices set by the EHR and include the following options: Hispanic or Latino; Non-Hispanic or Latino; patient refuses or does not know; unknown.

Proximity to hospital. Proximity will be defined as the number of miles the patients' zip code on file is from the hospital zip code. Previous studies identified arriving late to the hospital as a cause of delay to surgery (Deldar, et al., 2017; Van Winkle et al, 2016). It is presumed that if patients live further away from the hospital, they may be more at risk for a delay due to tardiness on the DOS or missing preoperative appointments aimed at optimizing the patient's health status before the DOS.

Insurance type. Insurance type will be defined as either private preferred provider (PPO), private health-management organization (HMO), government insurance (such as Medical or Medicare), or none. This will be retrieved from the financial file associated with each patient. Health insurance has been linked causally to health care utilization and outcomes (Freeman, Srikanth, Bell, & Martin, 2008). It is logical to consider it in the context of surgery as different types of insurance may have different effects on a patient preparation for surgery and therefore readiness for the procedure.

Acuity. Acuity will be defined using the American Society of Anesthesiologists (ASA) classification. ASA classification is a graduated measure of physical status that is based on chronic illness and is being used in this study as a measure of patient health. It is assigned by the anesthesia provider based on the definitions provided by the American Society of Anesthesiologists (See Table 1 in Appendices). Because of the subjective nature of the assignment, bias does exist. A recent cohort study to assess ASA found moderate interrater reliability, $\chi = 0.61$ (95% CI, 0.60-0.65. In terms of validity, it was moderately valid in predicting mortality (AUC 0.74; CI, 0.68–0.80) and myocardial injury (AUC 0.75; CI, 0.71–0.79) (Sankar et al., 2016). Previous studies have shown that patients who are medically decompensated are more likely to be delayed (McIsaac et al., 2017). Interestingly in a large study using National Anesthesia Outcomes Clinical Registry data, ASA was negatively correlated with delay to surgery, however this was only demonstrated in medium-sized community hospitals (Gabriel et al., 2016).

Physiologic system-specific comorbidities. Major system-specific comorbidities will include neurological, cardiac, renal, hepatic, gastro-intestinal, endocrine, hematological, musculoskeletal, and genitourinary disease processes as well as pain disorders. Comorbidity variables are defined with ICD-9 and ICD-10 diagnosis codes that correlate with commonly used terms (Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, 2011; Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics 2018). (See Table 2 in Appendices)

While patient status has been shown to be correlated with delay, specific types of medical issues have not been delineated (Deldar et al., 2017; McIsaac et al., 2017). This exploratory study will build upon prior research and further our understanding by specifically exploring the major physiologic systems to find out whether any specific area or disease process is a risk factor for surgical delay.

Medication Usage. Both the number and types of prescriptions medications will be used as another measure of illness chronicity. Common medications utilized by the participants in the study will be identified and categorized into groups. (See Table 3 in Appendices)

Preoperative Clinic Clearance. Preoperative clinic clearance will be defined as having or not having a preoperative evaluation note at least one year before the DOS. Preoperative clinic clearance has been shown to be negatively correlated with surgical delay in previous studies (Van Winkle et al. 2016).

Anesthetic Type. Anesthetic type will be defined as Major, Major Cardiovascular (CVS) or Minor. Major anesthesia includes general anesthesia or regional anesthesia where regional is the primary anesthetic. For example, a patient receiving an epidural as the source of surgical anesthesia would be considered "Major." Major CVS includes anesthesia cases, primarily cardiac procedures, where cardiac bypass is utilized. Minor anesthesia includes cases where sedation is the primary anesthetic provided by the anesthesia team. Regional anesthetic blocks such as epidural anesthetics or peripheral nerve blocks will also be tracked. All cases will either be classified as Major, Major CVS or Minor and then may include a sub-classification to include regional anesthesia. While regional anesthesia is often chosen as a way to improve outcomes for patients, it can be associated with delays due to the technical nature of the procedures required (Liu, Strodtbeck, Richman, & Wu, 2015).

4. Procedures

Preliminary IRB approval for the use of patient data was obtained in October 2017, with an addendum in February 2018 to extend collected data from February 2017 through April 2017. A sample of patients who received surgery between May 2012 and April 2017 in the main operating room (OR) will be utilized and will only be identified by their unique MRN. This sample is derived from a dataset which is used for case tracking and scheduling purposes by the main OR at the study site. After accounting for inclusion and exclusion criteria, a final sample of patient cases will be created. The data that is collected from this pre-existing dataset will includes the following independent variables: age, ASA class, surgical service, delay reason, and number of minutes the case varied from scheduled time. The list of MRNs will be provided to the hospital Information Technology (IT) department to collect additional independent variables using a data collection tool (see appendix A). Total time for the study will be 10 months after funding is received to complete data collection. The list of patients in the already collected dataset is already in-hand. The data collection from the EHR by IT for additional variables will begin once funding is secured and will take approximately 2 months for IT to extract all remaining independent variables. Data analysis will begin immediately upon reception of the data and will take 2 months to complete. Manuscript development will follow and is projected to take 6 months to include collaboration among authors and revisions. (Appendix B). All data files will be maintained by the PI in password-protected file, on a password-protected computer.

5. Protection of Human Subjects including Data Monitoring Program

Due to the retrospective nature of this study using already collected data, informed consent is not necessary. There is an inherent risk of breach in confidentiality which is why strict measures to protect patient information will be employed. All patient information will be maintained with strict confidentiality among the members of the research team. All data will be stored on a password-protected computer and all data files will be password-protected. When sharing information, such as MRNs with the IT department, the hospital's HIPAA compliant One-Drive system will be used exclusively. Only members of the research team will have access to the raw data. Only de-identified aggregate data will be shared with non-USC entities for manuscript development.

6. Analysis Plan

First, descriptive statistics will be use to compare all patients with a surgical case that deviates from the scheduled time to patients who started on time. Secondary analysis will be done to compare patients whose cases were early versus those who were delayed. Assuming the dependent variable, surgical schedule deviation (measured in minutes), is normally distributed, parametric testing including T-test and ANOVA will be utilized to compare the groups (on-time, early and delayed) for each of the independent variables. Significant relationships will be included in the final model. Linear regression will be utilized to create a predictive model of surgical schedule deviation. Logistic regression will be utilized to create a predictive model of cases that go early and cases that go late. Significance will be set at $p < 0.05$. Calculations will be completed using SPSS v25 (IBM Corp. Released 2017. IBM SPSS Statistics for MAC, Version 25.0. Armonk, NY: IBM Corp.)

7.Potential Challenges or Limitations

Due to the lack of control of intrinsic and extrinsic factors, as well as the retrospective nature of the study, causality will not be determined. While the study may reveal factors that correlate with a surgical schedule deviation at this facility, it is impossible to eliminate all confounding factors such as other causes of delay like staff, equipment or room availability. While the number of independent variables was limited to the most common comorbidities and medication types, there are 43 different variables. With this number of variables, the risk of collinearity is increased. This study will also be performed on a cohort of patients who received surgery in the main OR from one, large, academic, tertiary care hospital where the acuity of patients is likely higher than the average surgical patient. Results cannot be generalized to other settings such as ambulatory surgery centers, rural hospitals or hospitals of different sizes or in different regions, however the results may inform researchers who wish to perform studies in these settings.

D. Investigators

The principal investigator Natalie Meyers, MS, CRNA is a doctoral candidate at the University of San Diego (USD) Hahn School of Nursing and Health Science in the Doctorate of Philosophy program. Her research experience includes work as an ungraduated research assistant to Dr. June Horowitz at Boston College's Connell School of Nursing. Ms. Meyers will coordinate all research operations and manuscript development among members of the research team. The co-investigator, Sarah Giron, PhD, CRNA is an Associate Professor of Clinical Anesthesiology at the University of Southern California Keck School of Medicine. She has participated in Phase Three clinical trials of Sugammadex at UCLA's Jules Stein Eye Institute and was awarded the 2012 American Association of Nurse Anesthetists (AANA) Baxter Research Doctoral Fellowship. Dr. Giron will be manage operations at the study site including IRB issues and communicating with the IT department for data collection; she will also provide creative input for manuscript development. Co-Investigator Joseph Burkard, DNSc, CRNA is an Associate Professor at the USD Hahn School of Nursing and Health Science and is an expert in the field of nurse anesthesia education and research. He has received several research grants from USD and the Tri-Service Nursing Grants for work in Simulation and Emergence Delirium. Dr. Burkard will be the primary faculty support person for USD and provide creative input for manuscript development. Co-Investigator Ruth A. Bush, PhD, MPH is an Associate Professor at the USD Hahn School of Nursing and Health Science and is a prolific researcher with extensive experience in epidemiology and biostatistics. She began her research career with dissertation funding from an NIH National Center for Research Resources M01 grant (5M01RR000827-25) later followed by an Agency for Healthcare Research and Quality K99/R00 grant in Patient Centered Outcomes in which she has used the Electronic Health Record (EHR) to retrospectively capture and to measure medical treatment utilization patterns. Her expertise will support the study design, outcomes measurement, and analysis/integration of the data.

E. Environment

The use of data that is pre-collected in the EHR is an efficient and convenient way to a study a large sample of patients in this academic, tertiary care hospital that has a diverse patient population and wide variation of surgical services and procedures represented. The hospital uses the Cerner software systems for its EHR (Cerner, North Kansas City, MO). Data is easily extracted from this system by the IT department within the medical center. Because the design of the study is retrospective and uses pre-existing data, the members of the research team are able to perform the study in a flexible manner and across geographic distances, allowing for experts from multiple institutions and disciplines to easily collaborate. The anesthesia department at the site is extremely supportive of this study as a way to improve processes within the clinical setting and provide patients the very best care possible as evidenced by the letters of support provided below.

IV. Biographical Sketch of Key Researchers

Natalie Meyers, MS, CRNA: Ms. Meyers's experience as a CRNA, Air Force officer and university faculty member prepared her to lead the proposed research project studying surgical scheduling. Ms. Meyers has participated in several evidence-based practice improvement projects in the perioperative area including a pressure ulcer task force, enhanced recovery after surgery (ERAS) multidisciplinary team and postoperative delirium project.

Sarah Giron, PhD, CRNA: Having a bachelor's degree in Biochemistry & Cellular Biology and experience with several undergraduate and graduate research projects, science has prepared Dr. Giron to contribute her expertise with the research process include methodology.

Ruth A. Bush, PhD, MPH: Dr. Bush brings her experience conducting secondary analysis of large data sets. Dr. Bush has a broad scientific background, with specific training and expertise in key research areas: examining secondary data; analyzing large data sets; and translating statistical findings into clinically relevant modifications to enhance patient care.

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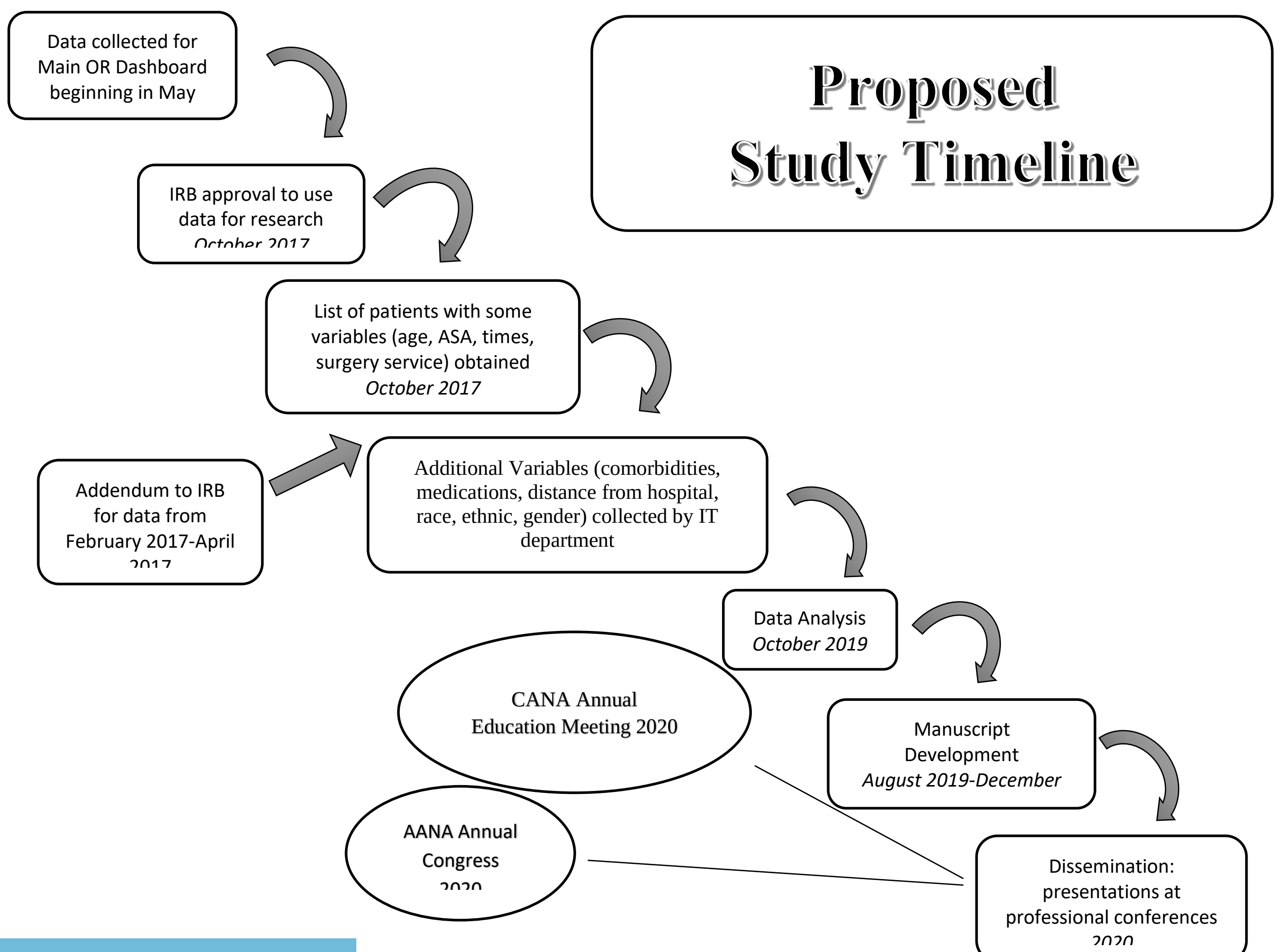
VI. Timeline



VII. Budget

AANAF Reference #	2018-FS-2	**AANA Foundation Fellowship Budget**		
PI: Natalie Meyers				
Detailed Budget	**Title**: The Relationship Between Patient-Specific Factors and Surgical Delay			
	Date: 11/19/19			

PERSONNEL	Project Role	% Effort	Salary Requested	
Natalie Meyers	Principal Investigator	50	0	
Sarah Giron	Co-Investigator	30	0	
Joseph Burkard	Co-Investigator	10	0	
Ruth Bush	Co-Investigator	10	0	
			Subtotal:	0

CONSULTANT COSTS					
Name	Role	Rate	Amount		
USC Information Technology	Data Extraction and Cleaning	125/hr	1125		(see attached invoices)
Sarah Giron	Data Analysis	150/hr	3600		
			Subtotal:	4725	

EQUIPMENT				
Item	Vendor	Quoted Cost		
			Subtotal:	0

SUPPLIES				
Item	Amount			
			Subtotal	0

OTHER				
Item	Amount			
			Subtotal:	0
			Total Directed Costs:	4725
			Total Awarded Amount:	5000
			Refund due to AANA Foundation:	275

This is my best estimate of expenditures:

Approved by AANA Foundation:

Natalie Meyers Digitally signed by Natalie Meyers
Date: 2019.11.19 16:29:57 -08'00'

VIII. Appendices

Appendix A. Data Collection Tool

	Patient 1	Patient 2	Etc.	Search Terms	ICD9	ICD10
Medical Record Number						
Age						
ASA						
Surgical Service						
Marital Status						
Employment Status						
Race						
Ethnicity						
Religion						
Proximity to Hospital						
Health Plan				HMO, PPO, Medicare, MediCal		
Neuro: Stroke				Stroke, Cerebral Vascular Accident	432.9, 434.9	I60, I61, I62, I63
Neuro: Parkinson's Disease				Parkinson's Disease	332	G20
Neuro: Epilepsy				Seizure, Epilepsy	345	G40
Neuro: Dementia				Alzheimer's, Dementia	290, 331	F03.90, G30
Cardiac: Hypertension				Hypertension, High Blood Pressure	401, 405	I10, I15
Cardiac: Heart Failure				CHF, Heart Failure, Cardiomyopathy	425, 428	I42, I50
Cardiac: Coronary Artery Disease				Coronary Artery Disease, Myocardial Infarction, Chest Pain, Angina	410, 411, 412, 413, 414	I20, I21, I22, I23, I24, I25
Cardiac: Arrhythmia				Atrial Fibrillation, Ventricular Fibrillation, Ventricular Tachycardia, Heart Block	427	I49
Cardiac: Pacemaker or ICD				Pacemaker, Implantable Cardioverter Defibrillator, ICD	V45.01	Z95
Vascular Disease				Peripheral vascular disease	443	I73
Renal: Renal Failure				Kidney Failure, Renal Failure, Dialysis, Chronic Kidney	584, 585, 586	N17, N18, N19

				Disease, Renal Insufficiency		
Hepatic: Liver Failure				Liver Failure, Hepatic Failure, Cirrhosis	570, 571	K70, K71, K72, K73, K74
GI: Reflux				GERD, reflux, Heartburn, Hiatal Hernia	530.81, 551.3, 552.3, 553.3	K21, K44
Endocrine: Diabetes				Diabetes	250	E10, E11, E13
Endocrine: Hypothyroidism				Hypothyroidism	243, 244	E00, E01, E02, E03, E89
Hematology: Anemia				Anemia	280-289	D50 -D89
Musculoskeletal				Arthritis	714, 715	M06, M15, M16, M17, M18, M19
Chronic Pain				Fibromyalgia, Chronic Pain, Neuropathy, Migraine	338, 346, 356, 729.1, 729.2	G43, G60, G89, M79.1, M79.2, M79.6, M79.7
Psych				Depression, Anxiety, Bipolar, Schizophrenia, Psychosis	295, 296, 297, 298, 300	F20, F21, F22, F23, F24, F25, F26, F27, F28, F29, F30, F31, F32, F33, F34, F39, F40, F41, F42, F43, F44, F45, F46, F47, F48
Cancer				Tumor, Leukemia, Lymphoma	140-149, 150-159, 160-165, 170-176, 179-189, 190-199, 200-209, 210-229, 230-239	all C and D codes
Number of Medications						
Medication: Insulin				Insulin		
Medication: Hypoglycemic				Glipizide, Glyburide, Metformin, Actos, Pioglitazone, Acarbose, Nateglinide		
Medication: Anti-hypertensive				Atenolol, Labetalol, Metoprolol, Propranolol, Carvedilol, Lisinopril, Enalapril, Captopril, Hydrochlorothiazide, Losartan, Valsartan, Amlodipine, Nimodipine, Nifedipine, Clonidine		

Medication: Anti-arrhythmic				Diltiazem, Verapamil, Amiodarone, Sotalol		
Medication: Steroid				Prednisone, Prednisolone, Methylprednisolone, Hydrocortisone, Dexamethasone, Triamcinolone		
Medication: Anticoagulant				Warfarin, Heparin, Rivaroxaban, Dabigatran, Apixaban, Edoxaban, Enoxaparin, Fondaparinux, Clopidogrel, Ticagrelor, Dipyridamole, Aspirin, Ticlopidine, Eptifibatide		
Medication: Opioid				Codeine, Fentanyl, Hydrocodone, Oxycodone, Meperidine, Hydromorphone, Methadone, Morphine		
Medication: Antidepressant				Fluoxetine, Duloxetine, Amitryptiline, Desipramine, Nortriptyline, Imipramine		
Medication: Antipsychotic				Clozapine, Olanzapine, Quetiapine, Risperidone		
Medication: Antianxiety				Alprazolam, Clonazepam, Diazepam, Lorazepam		
PreOp Clinic				Within one year of surgery date		

Appendix B. ASA Classifications

Classification	**Definition**	**Examples**
ASA I	A normal healthy patient	Healthy, non-smoking, no or minimal alcohol use
ASA II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity (30 < BMI < 40), well-controlled DM/HTN, mild lung disease

ASA III	A patient with severe systemic disease	Substantive functional limitations; One or more moderate to severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents.
ASA IV	A patient with severe systemic disease that is a constant threat to life	Examples include (but not limited to): recent (< 3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
ASA V	A moribund patient who is not expected to survive without the operation	Examples include (but not limited to): ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes	

(ASA House of Delegates, 2014)

Appendix C. Comorbidity Variables

Variable	**Defining Terms**
Neuro: Stroke	Stroke, Cerebral Vascular Accident, CVA
Neuro: Parkinson’s Disease	Parkinson's Disease
Neuro: Epilepsy	Seizure, Epilepsy
Neuro: Dementia	Alzheimer's, Dementia
Cardiac: Hypertension	Hypertension, High Blood Pressure
Cardiac: Heart Failure	CHF, Heart Failure, Cardiomyopathy, LVAD
Cardiac: Coronary Artery Disease	Coronary Artery Disease, Myocardial Infarction, Chest Pain, Angina
Cardiac: Arrhythmia	Atrial Fibrillation, Ventricular Fibrillation, Ventricular Tachycardia, Heart Block
Cardiac: Pacemaker or ICD	Pacemaker, Implantable Cardioverter Defibrillator, ICD, AICD
Vascular Disease	Peripheral vascular disease, venous insufficiency
Renal: Renal Failure	Kidney Failure, Renal Failure, Dialysis, Chronic Kidney Disease, Renal Insufficiency
Hepatic: Liver Failure	Liver Failure, Hepatic Failure, Cirrhosis
GI: Reflux	GERD, reflux, Heartburn, Hiatal Hernia
Endocrine: Diabetes	Diabetes
Endocrine: Hypothyroidism	Hypothyroidism
Hematology: Anemia	Anemia
Musculoskeletal	Arthritis, gout, degenerative joint disease, osteoarthritis
Chronic Pain	Fibromyalgia, Chronic Pain, Neuropathy, Migraine
Psych	Depression, Anxiety, Bipolar, Schizophrenia, Psychosis
Cancer	Tumor, Leukemia, Lymphoma

Appendix D. Medication Variables

Medication Variable	**Defining Terms**
Number of Medications	Number of medications prescribed at the time of surgery
Medication: Insulin	Insulin
Medication: Hypoglycemic	Glipizide, Glyburide, Metformin, Actos, Pioglitazone, Acarbose, Nateglinide
Medication: Anti-hypertensive	Atenolol, Labetalol, Metoprolol, Propranolol, Carvedilol, Lisinopril, Enalapril, Captopril, Hydrochlorothiazide, Losartan, Valsartan, Amlodipine, Nimodipine, Nifedipine, Clonidine
Medication: Anti-arrhythmic	Diltiazem, Verapamil, Amiodarone, Sotalol

Medication: Steroid	Prednisone, Prednisolone, Methylprednisolone, Hydrocortisone, Dexamethasone, Triamcinolone
Medication: Anticoagulant	Warfarin, Heparin, Rivaroxaban, Dabigatran, Apixaban, Edoxaban, Enoxaparin, Fondaparinux, Clopidogrel, Ticagrelor, Dipyridamole, Aspirin, Ticlopidine, Eptifibatide
Medication: Opioid	Codeine, Fentanyl, Hydrocodone, Oxycodone, Meperidine, Hydromorphone, Methadone, Morphine
Medication: Antidepressant	Fluoxetine, Duloxetine, Amitryptiline, Desipramine, Nortriptyline, Imipramine
Medication: Antipsychotic	Clozapine, Olanzapine, Quetiapine, Risperidone
Medication: Antianxiety	Alprazolam, Clonazepam, Diazepam, Lorazepam

Chapter 5: MANUSCRIPT II

Preventing Surgical Delays and Cancellations with Patient-Specific Interventions

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Background

With the increasing costs of healthcare, healthcare providers are under pressure to become more efficient in their performance. With operating room (OR) costs accounting for 48% of the $387 billion that is spent in hospitals annually in the United States, it is an area where maximum efficiency is imperative (Weiss, Elixhauser & Andrews, 2011). Patient outcomes must be optimized while spending less by reducing inefficiencies such as delays and cancellations of surgical procedures.

Within the OR, efficiency is primarily measured by time. Cost and patient outcome are secondary measures but they are ultimately dependent on time as well. Measures of timeliness in the OR that are especially relevant and measurable are the number of day-of-surgery (DOS) delays and cancellations. Staff, equipment and room availability are commonly cited as reasons for DOS delays or cancellations (Garg, Bhalotra, Bhadoria, Gupta, & Anand, 2009; Balzer, Raackow, Hahnenkamp, Flessa, & Meissner, 2017; Wright, Roche, & Khoury, 2010). There have been many studies demonstrating the effectiveness of proper scheduling, flow and identification of facility or equipment-related causes of delay in order to improve timeliness (Balzer et al., 2017; Cima et al., 2011; Foglia, Alder, & Ruiz, 2013).

To date there is a lack of research explaining the patient-related causes of DOS delay and cancellation while systems issues have been heavily studied. Despite lacking knowledge of the role of the patient in DOS delay and cancellation, there have been several studies evaluating interventions to prevent patient-related causes of DOS delay and cancellation. Some areas include preoperative clinics, routine screening, and focused education before surgery. In order to better understand the current understanding of patient-related causes and how best to manage them, the following paper will review patient-centered interventions to prevent DOS delays and cancellations. The bulk of the patient-centered intervention research is concentrated in preoperative clinic assessment however there are other interventions such as education and screening for high-risk conditions.

Review of Patient Causes

While systems issues account for the bulk of inefficiency in the OR, patient-related factors are responsible for a significant number of DOS delays and cancellations. This may be related to the patient's health status or it may be due to patient not arriving for their surgery, being late, having questions, or not being ready for surgery due to not following preoperative instructions (Deldar et al., 2017). In one study of hip fracture patients, patient-related causes that were specifically associated with health status accounted for 13.6% of delays (Vidan et al., 2017). In another study evaluating interventions to improve efficiency, patient-related causes accounted for 16.5% of delays but this primarily explained delays due to the patient being late (Deldar et al., 2017). In this study, patient health status as a cause of delay was attributed to preoperative preparation which accounted for 14.6% of delays.

The exact role of patient health status in DOS delays and cancellation is not well-understood. The assumption is that sicker patients are more often delayed or cancelled, and that preoperative clinics are helpful in preemptively managing these patients' issues. A large retrospective study of medium community hospitals found conflicting results for acuity as a predictor of delay (Gabriel, Wu, Huang, Dutton & Urman, 2016). Patients with a higher acuity as measured by the American Society of Anesthesiologists (ASA) classification had a decreased odds (OR 0.88; 95% CI, 0.86-0.89) of being delayed versus patients with a lower ASA classification. This is in direct conflict to other studies where patients with a higher acuity measured by ASA were more often delayed (Ferschl, Tung, Sweitzer, Huo, & Glick, 2005) which further confounds the issue of patient-specific causes of delay and cancellation. Furthermore, there is no research to explain the specific medical issues. In other words, it is unknown whether particular chronic conditions or medications are responsible, or if it is the combination of issues that increase acuity overall makes a patient more prone to being delayed or cancelled.

The Preoperative Clinic

While preoperative evaluation has existed for some time, anesthesia providers recently recognized that preoperative evaluation practices needed improvement to prevent DOS delays and cancellation. Historically surgeons, not anesthesia providers, would order preoperative labs and tests, and there was a lack of standardization or evidence to drive practice. Anesthesiologists began implementing anesthesia-run preoperative clinics to focus on patient optimization rather than blanket testing all surgical patients with the same labs and tests. Initially the focus was cost-savings by eliminating unnecessary laboratory testing (Starznic, Guarnieri, & Norris, 1997).

Eventually, researchers found that preoperative clinics run by anesthesia providers were effective in preventing DOS delays and cancellations. In one retrospective comparison of patients who attended an anesthesiologist-run preoperative clinic, there were half as many cancellations in the group who went to preoperative clinic (8.4%) versus those who did not go to the clinic (16.2%, $p<0.001$), despite the fact that the patients in the clinic group tended to be older and have a higher acuity score by ASA classification (Ferschl et al., 2005). The value of preoperative clinics in preventing DOS delays or cancellations has been confirmed in several subsequent studies (Knox, Myers, Wilson & Hurley, 2009; McKendrick, Cumming, & Lee, 2014). Another study demonstrated the value of preoperative clinics in not only addressing known conditions that could potentially delay or cancel a procedure, but also the ability of clinics to identify new medical problems that had not yet been diagnosed or treated (Correll et al., 2006). Identification of new onset healthcare concerns improved DOS efficiency by eliminating delays that would have resulted with discovering the new conditions on the DOS. Accordingly, new problems had a higher probability of resulting in a delay (10.7%) or cancellation (6.8%) versus known, preexisting problems resulting in a delay (0.6%) or cancellation (1.8%). Of known, pre-existing problems, 15.8% required management or changes to their healthcare regimen, whereas 27.2% of those with newly diagnosed issues required new management requirements.

In addition to anesthesia providers, other providers have been shown to effectively run preoperative clinics. In one Veterans Health Administration (VHA) hospital, the preoperative clinic transferred oversight from anesthesia providers to hospitalists who supervised physician assistants and nurse practitioners with a general medical background (Vazirani, Lankarani-Fard, Liang, Stelzner, & Asch 2012). This study found some improvements including a decreased length of stay for inpatient surgical patients with ASA classifications of 3 or more ($p<0.0001$), however no statistically significant changes in the number of DOS delays or cancellations; this illustrates that preoperative clinics run by hospitalists can be as effective as those run by anesthesia providers. An additional benefit of hospitalist-run preoperative clinics is that the hospitalist's scope of practice allows them to change long-term patient medications in order to improve chronic illness management, whereas anesthesia providers' scope is focused more on management in the immediate perioperative period. An anesthesia provider may have to refer a patient back to the primary care provider whereas the hospitalist can make changes at the preoperative appointment, effectively eliminating the need for an additional doctor's appointment.

Preoperative clinics run by nurses and nurse practitioners (NP) have also been shown to improve efficiency by preventing DOS cancellations, however delay rate has not been evaluated. NP-run preoperative clinics have been found to be especially useful in the orthopedic populations, reducing not just cancellations but also lost revenue Conny & Wan-Lim, 2016; Sebach, Rockelli, Reddish, Jarosinski, & Dolan, 2015). When cases are delayed or cancelled, resources allocated for those cases are lost. These resources could include unused staff, equipment, or facility time. Additional benefits of nurse and NP-run preoperative clinics are the consistently high-level of patient satisfaction and potential cost-savings over physicians without compromising patient safety or outcomes (Nicholson, Coldwell, Lewis, & Smith 2013).

For non-anesthesia providers performing preoperative evaluations (that do not have a background or the proper training necessary to focus on anesthetic and surgical considerations) additional interventions may be necessary to ensure adequate assessments and follow-ups are performed on preoperative patients. Focused training of non-anesthesia providers is one method cited in the literature that has been shown to be effective in improving the quality of preoperative evaluations. In a study of non-anesthesia nurse-led preoperative clinics, structured training that focused on anesthetic and surgical considerations actually did improve DOS delay and cancellation rates (Muckler, Vacchiano, Sanders, Wilson, & Champagne 2012).

Because some conditions may be unknown when a patient is going to surgery, certain screening protocols for especially high-risk conditions may identify conditions that can result in DOS delays or cancellations. One benefit of preoperative clinics is the identification of new problems (Correll et al, 2006). To standardize practice and capture the most applicable conditions, screening protocols can be implemented. Obstructive sleep apnea (OSA) is one condition noted to be increasing with growing obesity rates, and can be extremely dangerous in combination with anesthesia and postoperative pain medications. One preoperative clinic in an ambulatory surgical center implemented routine OSA screening and found 10% of their patients possibly had undiagnosed OSA (Tabet & Lopez-Bushnell, 2018). Furthermore, the identification of patients with likely OSA resulted in case cancellation of 16% of surgeries at the preoperative clinic appointment because the risk of performing surgery on a patient with possible OSA in an ambulatory setting. This prevented surgeries from being cancelled on the day of surgery and allowed them to be rescheduled in a safer environment capable of managing potential complications for these patients.

Over the last several decades preoperative patient preparation has transformed from surgeon-directed lab screening to patient-focused evaluation and optimization directed by healthcare providers who are trained in anesthesia- and surgery-specific clinical considerations. This is the primary focus of research in reducing DOS delays and cancellations that are associated with patient-related causes, however there are other interventions that may also be useful.

Other Interventions

Preoperative clinic appointments are not always necessary for healthy patients undergoing routine procedures. Phone-based evaluations may serve to screen patients going to surgery and identify those who truly need to come to the healthcare facility for a face-to-face evaluation or diagnostic. In one large acute care facility that utilized nurse-led phone-based preoperative screenings in a rural setting, an algorithm was used to ensure proper and standardized oversight by anesthesia providers working with the screening nurses (Yen, Tsai, & Macario, 2010). Using the study's algorithm, healthy patients undergoing routine procedures would have nurses perform the evaluation without anesthesiologist input; for moderately sick patients, based on ASA classification and moderately complex procedures, it was up to the discretion of the nurse to involve the anesthesiologist; for very sick patients and complex procedures, the anesthesiologist would review the record. As a result of the study's algorithm utilization, this multidisciplinary and collaborative approach resulted in an extremely low DOS cancellation rate of 0.07% at this facility.

In addition to completing a preoperative evaluation by telephone, technology such as phone calls or email reminders can be used to reiterate or follow-up with patients in the days prior to surgery. In a study of nurse-led phone follow-up 3 days prior to surgery, cancellation rate was reduced by 53% in one academic setting (Haufler & Harrington, 2011). The setting previously had a unit secretary phone patients the day before surgery. The success of the intervention was attributed to the utilization of a clinician with the appropriate training and education to identify clinical issues that could have resulted in a DOS delay or cancellation if not addressed.

Another way to prevent DOS delays and cancellations is centralization of preoperative preparation, especially with regard to patient education. In one hospital that introduced a standardized preoperative pathway that focused on patient-centered interventions and standardization, cancellations decreased from 8.5% to 4.9% (95% CI for mean reduction 2.6-4.5, $p < 0.001$) and the number of surgeries increased by 17% ($p=0.004$) (Hovlid, Bukve, Haug, Aslaksen, & von Plessen, 2012). In another study, implementation of a preoperative protocol decreased DOS delay and cancellation by having a centralized point, the preoperative nurse, disseminate education to patients rather than having information come from multiple different members of the surgical team (Turunen, Miettinen, Setälä, & Vehviläinen-Julkunen, 2018).

Certain problems cannot be addressed until the day of surgery, such as toxicology screenings. Cocaine must be screened for on the DOS because acute cocaine intoxication can increase the risk of poor outcomes when combined with general anesthesia (Luft & Mendes, 2007). Certain patient populations may have a high incidence of substance abuse. In a survey of VHA anesthesia providers there was a wide variability in the standard practice for substance abuse screening for routine surgical procedures (Elkassabany et al. 2013). Additionally, only about 10% of the respondents reported that their facility had a formal policy on how to deal with a positive drug screen on the day of surgery. Lack of a protocol, itself, can lead to delays and cancellations as each provider has to take the time to go through a decision tree every time a patient has a positive drug screen. Having a standardized practice not only improves patient care, but can improve efficiency, especially in a setting where there is a high incidence of a particular condition.

There are many different ways to reduce DOS delays and cancellations by focusing on patient screening and education. Addressing issues ahead of time avoids having to deal with those issues on the DOS. Furthermore, having standardized processes streamlines processes and speeds up decision-making.

The Future for Patient-Centered Interventions

DOS delays and cancellation rates are being reduced as healthcare researchers and providers gain a better understanding of the role of the patient in OR efficiency. A common theme among the interventions mentioned in this paper is a focus on patient-centered care. A study of patient-centered interventions prior to surgery demonstrated high patient satisfaction and a patient desire to be actively involved in their plan of care (Hovlid, von Plessen, Haug, Aslaksen, & Bukve, 2013). When a patient is actively engaged, they may be more likely to be compliant with the plan of care which further eliminates problems that may causes a delay or cancellation.

In addition to patient-centered care, standardized practices such as preoperative clinics and screening for high-risk conditions allows providers to capture all patients and potential problems ahead of time. Having a routine practice for preoperative preparation captures all patients to identify any areas that need attention prior to the day of surgery. The concepts of patient-centered care and standardized practices are coincidentally the focus of a new concept that is being embraced by healthcare providers called the perioperative surgical home (PSH). The American Society of Anesthesiologists defines a key element in the PSH as being an opportunity for anesthesiologists to improve healthcare operations by reducing delays and cancellations (Dexter, & Wachtel, 2014). In the PSH, the anesthesia provider manages the patient throughout the perioperative period, from the preoperative clinic, through surgery and in the postoperative period. By having one point of contact for a patient, many inefficiencies that occur by passing care from one service to another could be eliminated. Furthermore, because anesthesia providers are well-educated in specific considerations for undergoing anesthesia and surgery they are well-suited to managing a patient in the perioperative period. With further study, the PSH may be something that can not only improve efficiency in the OR, but also patient outcomes through focused, patient-centered care.

Conclusion

The OR is a fast-paced arena with many areas vulnerable to inefficiency, thereby putting patients at risk for delay or cancellation of their surgical procedure. In addition to eliminating systems-related causes of delay and cancellation, patient-related causes should also be considered. To date, the specific patient-related causes are still not entirely understood, but research has demonstrated value in adequate preoperative preparation of patient in the form of preoperative clinics, education and follow-up to proactively address patient-related issues. Further study is needed to identify which patient conditions are most linked to delay and cancellation so that resources and interventions can be focused on these areas. Additionally, concepts such as the PSH may be the answer for surgical patients with a patient-centered focus and increased continuity of care.

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Chapter 6: MANUSCRIPT III

Patient-Specific Factors Associated with Surgical Delay in a Large Academic Hospital

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Introduction

The operating room places an enormous burden on the cost of healthcare, accounting for 48% of the $387 billion that is spent in hospitals annually in the United States (Weiss, Elixhauser, & Andrews, 2011). In addition to providing surgical services to patients, a significant portion of the cost is attributed to inefficiencies such as delays, cancellations, unplanned admissions, and poor scheduling (Marcario, 2006). Understanding the causes is essential to identifying methods of improving surgical efficiency and saving healthcare dollars.

Delay and cancellation of surgical cases, the most studied surgical inefficiencies, are often attributed to facility-specific factors such as staff, equipment and room availability; patient-specific factors such as availability and medical reasons; or other reasons such as administrative factors (Al Talalwah & McIltrot, 2014; Deldar et al., 2017; Garg, Bhalotra, Bhadoria, Gupta, & Anand, 2009; Wright, Roche, & Khoury, 2010). Unfortunately, studies explaining the patient-specific causes of surgical delay and cancellation are lacking.

One of the primary challenges to researching this topic involves the management of big data. Many studies on this topic rely on harvesting data from the electronic health record (EHR), where researchers are limited to defining variables by what is already available. The method in which causes of delay are broken down and defined are not consistent from one study to the next, thus making it difficult to compare studies and truly understand the problem. In one study evaluating interventions to improve efficiency, patient-specific causes accounted for 16.5% of delays but this primarily explained delays due to the patient being late, whereas health status of patient, which accounted for 14.6% of delays, was defined under a separate umbrella called "patient preparation" (Deldar et al., 2017). In another study, patient-specific causes of delay were included together with hospital-specific causes (Foglia, Alder , & Ruiz, 2013). The idiosyncrasies of each dataset mandate that caution is used when generalizing the findings to populations. Nonetheless, the trends from each study demonstrate that factors unique to the patient have a significant contribution to surgical delay. A gap in knowledge lies with what the specific patient-related factors are that cause delays. Patient-related factors could include demographics or markers of health such as certain diseases but research in this area is lacking.

When trying to understand the patient-specific causes of delay, the assumption is that sicker patients are more often delayed, and that preoperative clinics are helpful in preemptively managing these patients' issues. A large retrospective study of medium community hospitals found conflicting results for acuity as a predictor of delay (Gabriel, Wu, Huang, Dutton & Urman, 2016). Patients with a higher acuity, as measured by the American Society of Anesthesiologists (ASA) classification, had a decreased odds (OR 0.88; 95% CI, 0.86-0.89) of being delayed versus patients with a lower ASA classification. This is in direct conflict to other studies where patients with a higher acuity measured by ASA were more often delayed (Ferschl, Tung, Sweitzer, Huo, & Glick, 2005). It also conflicts with studies that show preoperative clinics decrease delays in patients with particular comorbidities (Correll et al., 2006; Ferschl et al., 2005; Vazarani, Lankarani-Fard, Stelzner & Asch, 2012). As mentioned earlier, comparison of studies is limited because samples are often taken from one facility and therefore factors specific to that institution may be contributing to delays and improvements.

A study was designed to better understand the role of patient-specific factors in surgical delay. The primary aim of this study was to better understand patient-specific causes of delay by comparing patients at a large academic hospital who experienced a surgical delay to those who were not delayed over a 5-year period. The secondary aim was to develop a predictive model of patients at risk for surgical delay.

Methods

Data Source

Data was retrospectively collected from the EHR of all surgical patients who underwent surgery in a large, acute care, academic hospital in Los Angeles, California from May 2012 through April 2017. The sample was taken from the facility's surgical quality improvement database which collects the name, medical record number, age, date and time of service, case duration, whether the case was emergent or not, ASA classification, surgical service, anesthesia type, and patient type (e.g., outpatient versus inpatient) of each patient who undergoes surgery in the main operating suite. Because the data was retrospective, the study was exempted from informed consent requirements and qualified for expedited review through the Institutional Review Board.

Independent variables collected on each patient are listed in Tables 1a-d and are broadly defined as demographics, comorbidities, medications, outpatient medication count, ASA classification, surgical service, and anesthesia type. Variables not initially collected on the date of service were retrospectively extracted from the EHR for each patient in the sample. Distance of residence to the hospital, race, ethnic group, employment status and health plan were collected through the patient's financial record. Comorbidities and medications were collected by using keyword search terms in the EHR for each patient.

Demographics included age (in years), gender (male or female), ethnicity (Hispanic/Latino or not), and race (White (reference category), Black, Asian, Other). Employment status was defined as full-time (reference category), part-time, retired, self-employed, or not employed. Health plan was defined as managed care or exchange (reference category), Medicare, Medicaid, Uninsured/self-pay, or Charity. Surgical specialty included the following options: Urology (reference category), Cardiovascular, Colorectal, General Surgery, Gynecologic Oncology, Gynecology, Hepatobiliary, Neurological Surgery, Obstetrics, Ophthalmology, Oral & Maxillofacial, Orthopedics, Otorhinolaryngology, Pain Management, Plastics, Thoracic, Vascular, and Cardiology. Patient type was defined as observation (reference category), inpatient, outpatient, extended recovery or other. ASA classification was defined based on the American Society of Anesthesiologists classification (American Society of Anesthesiologist, 2014). There are six categories broadly defined as:

- ASA I: a normal healthy patient (reference category)
- ASA II: a patient with mild systemic disease
- ASA III: a patient with severe systemic disease
- ASA IV: a patient with severe systemic disease that is a constant threat to life
- ASA V: a moribund patient who is not expected to survive without the operation
- ASA VI: a declared brain-dead patient whose organs are being removed for donor purposes

Anesthesia type was defined as:

- Minor: monitored anesthesia care/sedation (reference category)
- Major: general anesthesia, regional anesthesia

- Cardiovascular: cardiovascular anesthesia with cardiopulmonary bypass

Distance from the hospital was calculated using Google Maps (Google, n.d.) to determine the number of miles between the home zip code and zip code of the hospital. The categories for the categorical transformation of distance were:

- 0-5 miles: walking distance the day of surgery
- 6-10 miles: accessible by public transit the day of surgery
- 11-20 miles: accessible by car on the day surgery
- 21-50 miles: accessible by car the same day or day before surgery
- 51-100 miles: accessible by car the day before surgery
- 101-300 miles: accessible by plane the day before surgery
- 301+miles: accessible by plane more than one day before surgery

The following comorbidity variables with search terms to define them were used:

Comorbidity Variable	**Search Term**
Neuro: Stroke	Stroke, Cerebral Vascular Accident, Transient Ischemic Attack, TIA, Cerebral Infarction
Neuro: Movement disorder	Parkinson's Disease, Multiple Sclerosis, Myasthenia Gravis, Muscular dystrophy, Huntington's disease, Tremor
Neuro: Epilepsy	Seizure, Epilepsy
Neuro: Dementia	Alzheimer's, Dementia
Cardiac: Hypertension	Hypertension, High Blood Pressure
Cardiac: Heart Failure	CHF, Heart Failure, Cardiomyopathy
Cardiac: CAD	Coronary Artery Disease, Myocardial Infarction, Chest Pain, Angina, Heart Attack
Cardiac: Arrhythmia	Atrial Fibrillation, Ventricular Fibrillation, Ventricular Tachycardia, Heart Block
Cardiac: Pacemaker	Pacemaker, Implantable Cardioverter Defibrillator, ICD
Cardiac: Hyperlipidemia	Hyperlipidemia
Pulmonary: Chronic infection	Chronic sinusitis, tonsillitis, allergic rhinitis

Pulmonary: Reactive airway	Asthma, Emphysema, COPD, reactive airway disease
Pulmonary: Smoker	Tobacco, smokes, smoker, nicotine
Pulmonary: OSA	Obstructive sleep apnea
Vascular Disease	Peripheral vascular disease, AAA, Abdominal Aortic Aneurysm
Obesity	Obesity
Renal Failure	Kidney Failure, Renal Failure, Dialysis, Chronic Kidney Disease, Renal Insufficiency, ESRD
Liver Failure	Liver Failure, Hepatic Failure, Cirrhosis
GI: Reflux	GERD, reflux, Heartburn, Hiatal Hernia
Endocrine: Diabetes	Diabetes
Endocrine: Hypothyroidism	Hypothyroidism
Hematology	Anemia, thrombocytopenia, coagulation disorders, other blood disorders
Musculoskeletal	Arthritis
Chronic Pain	Fibromyalgia, Chronic Pain, Neuropathy, Migraine, CRPS
Psychiatric disease	Depression, Anxiety, Bipolar, Schizophrenia, Psychosis
Substance Use	Alcoholism, Drug use, Drug abuse, Opioid abuse, Drug Addiction, EtOH, Alcohol Abuse
Cancer	Tumor, Leukemia, Lymphoma, Malignant Neoplasm, Melanoma, Cancer

The following medication variables with search terms to define them were used:

Medication Variable	**Search Term**
Medication: Insulin	Insulin
Medication: Hypoglycemic	Glipizide, Glyburide, Metformin, Actos, Pioglitazone, Acarbose, Nateglinide
Medication: Anti-hypertensive	Atenolol, Labetalol, Metoprolol, Propranolol, Carvedilol, Lisinopril, Enalapril, Captopril, Hydrochlorothiazide, Losartan, Valsartan, Amlodipine, Nimodipine, Nifedipine, Clonidine
Medication: Anti-arrhythmic	Diltiazem, Verapamil, Amiodarone, Sotalol
Medication: Steroid	Prednisone, Prednisolone, Methylprednisolone, Hydrocortisone, Dexamethasone, Triamcinolone

Medication: Anticoagulant	Warfarin, Heparin, Rivaroxaban, Dabigatran, Apixaban, Edoxaban, Enoxaparin, Fondaparinux, Clopidogrel, Ticagrelor, Dipyridamole, Aspirin, Ticlopidine, Eptifibatide
Medication: Opioid	Codeine, Fentanyl, Hydrocodone, Oxycodone, Meperidine, Hydromorphone, Methadone, Morphine
Medication: Antidepressant	Fluoxetine, Duloxetine, Amitryptiline, Desipramine, Nortriptyline, Imipramine
Medication: Antipsychotic	Clozapine, Olanzapine, Quetiapine, Risperidone
Medication: Anxiolytic	Alprazolam, Clonazepam, Diazepam, Lorazepam

Medication count was defined as the number of home medications prescribed to the patient on an outpatient basis at the time of surgery. The categories for the transformed categorical medication variable are as follows:

- 1 to 5 medications
- 6 to 10 medications
- 11 to 15 medications
- 16 to 20 medications
- 21 to 111 medications

The dependent variable, surgical delay, was defined as any delay in the start of surgery of 1 minute or greater from the scheduled time. This is the definition used by this facility to define surgical delays. Cases that started at the schedule time or earlier than the scheduled time were defined as the reference category.

The original dataset contained duplicate patients due to the same patient having multiple surgeries within the 5-year study timeline. Only the first surgery for each patient was included in the final dataset. There were two months missing the data needed to determine whether the case was delayed or not (i.e. the dependent variable), so these cases were excluded. Any case that was classified as an emergency was excluded because these cases would not be subject to the same rules as routine cases. There is a generally accepted notion that emergency cases must proceed even if there are missing prerequisites.

Statistical Analysis

SPSS 25 (IBM, 2017) was used for statistical analysis of the data. Initially, the sample was divided into two groups: cases that had a surgical delay and those that did not. Descriptive statistics were used to compare the two groups. Continuous variables were analyzed for normality. The only continuous variable that was normally distributed was age. A T-test examined the relationship between age and surgical delay. Medication count and distance from the hospital, being relevant non-normally distributed variables, were transformed into categorical variables. Chi-square analysis was used to analyze the relationship between all categorical variables and surgical delay. Significance was set at 0.05. If the relationship between the independent and dependent variable was significant, that variable was selected to be entered into a logistical regression model.

Results

There was a total of 55,233 cases in the original dataset. After application of exclusion criteria, 36,543 cases remained. There were 18,504 (50.6%) delayed cases, and 18,039 (49.4%) cases that were on-time or early. Descriptive analysis and bivariate analysis of the sample is demonstrated in Tables 1a-1d. The p-value is reported to describe significance of bivariate analysis. Table 1a. describes patient demographics. The average age of the sample is 58.2 years. There are 8053 (22%) cases who identified as Hispanic or Latino. The sample is primarily composed of patients who identify as White. There were 3070 (8.4%) who identified as Asian, 1754 (4.8%) who identified as Black, and 5520

(15.1%) who identified as Other race. Most patients were either not employed (n=8748, 23.6) or retired (n=10208, 27.6%). There were 3824 (10.3%) working full-time, 1070 (2.9%) self-employed and 228 (0.6%) working part-time. More than half of the sample lived less than 50 miles from the hospital with 2875 (7.9%) 0-5 miles away, 5827 (15.9%) 6-10 miles away, 9052 (24.8%) 11-20 miles away, 9718 (26.6%) 21-50 miles away, 3456 (9.5%) 51-100 miles away, 4187 (11.5%) 101-300 miles away and 1428 (3.9%) more than 300 miles away. Table 1b. describes patient type including ASA classification, anesthesia type, patient type, and surgical specialty. More than half of the sample (n=18703, 51.2%) had an ASA classification of 3 or greater, indicating that most of the patients had chronic systemic illnesses. Table 1c. describes patient comorbidities. Patient table 1d. describes medication use by patients.

Table 1a. Demographics

	Total	% Total	On-time	% On-time	Delayed	% Delayed	P-Value
N	36543		18,039	49.4	18,504	50.6	
Mean age (years)	58.2		58.1		58.3		<0.0001
Gender (Male)	19516	53.6	9716	53.9	9800	53	0.089
Ethnic group (Hispanic)	8053	22	3836	21.3	4217	22.9	<0.0001
Race (compared to White)							<0.0001
Asian	3070	8.4	1527	8.5	1543	8.4	
Black	1754	4.8	765	4.2	989	5.3	
Other Race	5520	15.1	2603	14.4	2917	15.8	
Employment							<0.0001
Full-time	3824	10.3	1942	10.8	1882	10.2	
Self-employed	1079	2.9	580	3.2	499	2.7	
Part-time	228	.6	119	0.7	109	0.6	
Retired	10208	27.6	4884	27.1	5324	28.8	
Not employed	8748	23.6	4191	23.2	4557	24.6	
Health Plan/Insurance							<0.0001
Managed Care/Exchange	16648	45.6	8615	47.8	8033	43.4	
Medicare	15233	41.7	7246	40.2	7987	43.2	
Medicaid	2906	8	1303	7.2	1603	8.7	
Other	769	2.1	399	2.2	370	2	
Self-pay/uninsured	243	.7	109	0.6	134	0.7	
Charity	14	0	5	0	9	0	
Distance from Hospital							0.177
0-5 Miles	2875	7.9	1415	7.8	1460	7.9	
6-10 Miles	5827	15.9	2814	15.6	3013	16.3	
11-20 Miles	9052	24.8	4445	24.6	4607	24.9	
21-50 Miles	9718	26.6	4848	26.9	4870	26.3	
51-100 Miles	3456	9.5	1715	9.5	1741	9.4	
101-300 Miles	4187	11.5	2056	11.4	2131	11.5	
300+Miles	1428	3.9	746	4.1	682	3.7	

Table 1b. Patient Type

	Total	% Total	On-time	% On-time	Delayed	% Delayed	P-Value
ASA							<0.0001
ASA I	2650	7.3	1422	7.9	1228	6.6	
ASA II	15134	41.4	7641	42.4	7493	40.5	
ASA III	15414	42.2	7120	39.5	8294	44.8	
ASA IV	3243	8.9	1820	10.1	1423	7.7	
ASA V	24	.1	12	0.1	12	0.1	
ASA VI	22	.1	3	0	19	0.1	
ASA 3 or more	18703	51.2	8955	49.6	9748	52.7	<0.0001
Anesthesia Type							<0.0001
Minor/MAC			3986	22.1	4962	26.9	
Major/General/Regional			12235	67.9	12831	69.5	
CVS (cardiac)			1795	10	616	3.3	
Surgical Specialty							<0.0001
Cardiovascular			1877	10.4	690	3.7	
Colorectal			554	3.1	964	5.2	
General surgery			2020	11.2	1879	10.2	
Gynecologic oncology			283	1.6	352	1.9	
Gynecology			442	2.5	387	2.1	
Hepatobiliary			924	5.1	1224	6.6	
Neurological surgery			1744	9.7	1937	10.5	
Oral and Maxillofacial			17	0.1	24	0.1	
Orthopedics			3006	16.7	3291	17.8	
Otorhinolaryngology			1905	10.6	1998	10.8	
Pain management			9	0	20	0.1	
Plastic/reconstructive			262	1.5	277	1.5	
Thoracic			828	4.6	940	5.1	
Urology			3682	20.4	3693	20	
Vascular			470	2.6	795	4.3	
Patient Type							0.019
Observation			1315	7.3	1413	7.6	
Inpatient			12560	69.6	12770	69	
Outpatient			1979	11	2032	11	
Extended Recovery			498	2.8	532	2.9	
Other			3	0	17	0.1	

Table 1c. Comorbidities

	On-time	% On-time	Delayed	% Delayed	
Neuro: Stroke	339	1.9	395	2.1	0.113
Neuro: Movement disorder	408	2.3	474	2.6	0.089
Neuro: Epilepsy	281	16	66	0.4	0.001
Neuro: Dementia	66	0.4	90	0.5	0.090
Pulmonary: Smoker	140	0.8	125	0.7	0.220
Pulmonary: Chronic infection	636	3.5	583	3.2	0.280
Pulmonary: OSA	692	3.8	729	3.9	0.768
Pulmonary: Reactive airway	919	5.1	1010	5.5	0.193
Cardiac: Hypertension	4867	27	5251	28.4	0.018
Cardiac: Heart Failure	544	3	504	2.7	0.063
Cardiac: CAD	1347	7.5	1285	6.9	0.025
Cardiac: Arrhythmia	923	5.1	856	4.6	0.015
Cardiac: Pacemaker	219	1.2	185	1	0.038
Cardiac: Hyperlipidemia	1398	7.7	1432	7.7	0.724
Vascular Disease	335	1.9	382	2.1	0.202
Renal Failure	1002	5.6	1407	7.6	<0.0001
Liver Failure	169	0.9	244	1.3	0.001
GI: Reflux	1451	8	1522	8.2	0.753
Endocrine: Diabetes	2031	11.3	2403	13	<0.0001
Endocrine: Hypothyroidism	1049	5.8	1171	6.3	0.074
Hematology	2234	12.4	2613	14.1	<0.0001
Musculoskeletal	1899	10.5	1949	10.5	0.723
Chronic Pain	1058	5.9	1174	6.3	0.100
Psychiatric disease	1114	6.2	1267	6.8	0.020
Substance abuse	190	1.1	201	1.1	0.846
Cancer	5368	29.8	5844	31.6	0.002
Obesity	726	4	578	3.1	<0.0001

Table 1d. Medications

	On-time	% On-time	Delayed	% Delayed	P-Value
Medication Count					<0.0001
1-5 Meds	5776	32	5791	31.3	
6-10 Meds	5018	27.8	4903	26.5	
11-15 Meds	2472	13.7	2678	14.5	
16-20 Meds	1137	6.3	1344	7.3	
21-111 Meds	1017	5.6	1217	6.6	
Insulin	927	5.1	1219	6.6	<0.0001
Hypoglycemic	1595	8.8	1736	9.4	0.071
Anti-hypertensive	7132	39.7	7286	39.4	0.776
Anti-arrhythmic	893	5	772	4.2	<0.0001
Steroid	1228	6.8	1574	8.5	<0.0001
Anticoagulant	5406	30	5363	29	0.041
Opioid	4483	24.9	4925	26.6	<0.0001
Antidepressant	784	4.3	853	4.6	0.22
Antipsychotic	272	1.5	346	1.9	0.007
Anxiolytic	1809	10	2039	11	0.002

After entering those variables with a statistically significant relationship to surgical delay into a logistic regression model, a predictive algorithm was created. Black race, ASA =>3, renal failure, insulin, steroid, and several surgical specialties (Colorectal, Gynecologic oncology, Hepatobiliary, Neurosurgery, Ophthalmology, and Plastic surgery) were associated with an increased odds of surgical delay. Obesity, general anesthesia, and cardiovascular anesthesia were associated with a decreased odds of surgical delay (see Table 2). The overall model accounts for approximately 3.8% to 5.3% of surgical delays in this sample by Cox/Snell and Nagelkerke R-squared analysis. The model had a 47.8% predictive rate for early or on-time, 65.9% predictive rate for delay and an overall predictive rate of 57.1%. Hosmer-Lemeshow test demonstrated a significance of 27%, indicating goodness of fit for the model in predicting surgical delays.

Table 2.

	Standard Error	Significance	Odds Ratio	95% C.I. for EXP(B)	
				Lower	Upper
Age	0.001	0.332	1.00	1.00	1.00
Hispanic/Latino	0.038	0.638	1.02	0.94	1.10
Race (Ref: White)		*0.005*			
Asian	0.051	0.599	0.97	0.88	1.08
Black	**0.066**	**0.001**	**1.25**	**1.09**	**1.42**
Other	0.04	0.076	1.07	0.99	1.16
Unknown	0.111	0.559	0.94	0.75	1.17
Employment (Ref: Full-time)		*0.213*			
Self-employed	0.074	0.494	0.95	0.82	1.10
Part-time	0.145	0.304	0.86	0.65	1.145
Retired	0.057	0.670	0.98	0.87	1.092
Not employed	0.044	0.261	1.05	0.96	1.144
Health Plan (Ref: Charity)		0.007			
Managed Care	1.415	0.941	0.90	0.06	14.423
Medicare	1.416	0.998	1.00	0.06	16.087
Medicaid	1.416	0.987	1.02	0.06	16.404
Other	1.418	0.918	0.86	0.05	13.93
Self-pay/uninsured	1.428	0.764	1.54	0.09	25.251
ASA =>3	0.033	<0.0001	1.26	1.18	1.342
Anesthesia Type (Ref: Minor Anesthesia)		<0.0001			
Major Anesthesia	**0.034**	**<0.0001**	**0.82**	**0.77**	**0.88**
Cardiovascular Anesthesia	**0.199**	**<0.0001**	**0.32**	**0.22**	**0.48**
Surgical Specialty (Ref: Urology)		<0.0001			
Cardiovascular	0.193	0.065	0.70	0.48	1.02
Colorectal	**0.075**	**<0.0001**	**1.73**	**1.49**	**2.00**
General surgery	0.054	0.191	0.93	0.84	1.04
Gynecologic oncology	**0.102**	**<0.0001**	**1.48**	**1.21**	**1.81**
Gynecology	0.099	0.811	0.98	0.81	1.19
Hepatobiliary	**0.067**	**<0.0001**	**1.32**	**1.16**	**1.51**

Neurosurgery	**0.054**	**0.024**	**1.13**	**1.02**	**1.26**
Obstetrics	0.544	0.129	2.29	0.79	6.65
Ophthalmology	**0.048**	**0.008**	**1.14**	**1.03**	**1.25**
Oral/maxillofacial	0.057	0.706	1.02	0.91	1.14
Orthopedics	0.442	0.418	1.43	0.60	3.40
Otorhinolaryngology	0.118	0.672	1.05	0.83	1.33
Pain Management	0.071	0.256	1.08	0.94	1.25
Plastic surgery	**0.082**	**0.017**	**1.22**	**1.04**	**1.43**
Medication Count (Ref: 0-5 Medications)		0.127			
6-10 Medications	0.036	0.038	0.93	0.86	1.00
11-15 Medications	0.046	0.766	1.01	0.93	1.11
16-20 Medications	0.06	0.815	0.99	0.88	1.11
More than 21 Medications	0.064	0.334	0.94	0.83	1.07
Obesity	**0.072**	**<0.0001**	**0.70**	**0.61**	**0.81**
Renal Failure	**0.056**	**0.005**	**1.17**	**1.05**	**1.30**
Endocrine: Diabetes	0.046	0.138	1.07	0.98	1.17
Neuro: Epilepsy	0.097	0.186	1.14	0.94	1.38
Endocrine: Hypothyroid	0.054	0.263	1.06	0.96	1.18
Psychiatric Disease	0.053	0.300	1.06	0.95	1.17
Hematology	0.04	0.304	1.04	0.96	1.13
Cancer	0.031	0.328	0.97	0.91	1.03
Cardiac: Coronary Artery Disease	0.053	0.570	1.03	0.93	1.14
Cardiac: Arrhythmia	0.065	0.692	1.03	0.91	1.17
Cardiac: Pacemaker/ICD	0.124	0.705	1.05	0.82	1.34
Cardiac: Hypertension	0.033	0.819	0.99	0.93	1.06
Liver Failure	0.121	0.959	0.99	0.78	1.26
Steroid	**0.051**	**0.015**	**1.13**	**1.02**	**1.25**
Insulin	**0.063**	**0.041**	**1.14**	**1.01**	**1.29**
Anxiolytic	0.044	0.114	1.07	0.98	1.17
Antiarrhythmic	0.067	0.251	1.08	0.95	1.23
Antipsychotic	0.099	0.355	1.10	0.90	1.33
Anticoagulant	0.034	0.428	1.03	0.96	1.10
Opioid	0.032	0.946	1.00	0.94	1.07
Constant	1.418	0.934	1.12		

Table 3a displays odds ratios for surgical delay. Black race has a 1.25 odds (95% CI 1.09,1.42) of being delayed. ASA Classification =>3 has a 1.26 odds (95% CI 1.18,1.34) of being delayed. Renal failure has a 1.17 odds (95% CI 1.05, 1.30) of being delayed. Insulin has a 1.14 odds (95% CI 1.01, 1.29) of being delayed and steroid has a 1.13 odds (95% CI 1.02, 1.25) of being delayed. Obesity is associated with a 1.42 odds (95% CI 1.23,1.64) of being on-time or early. The surgical specialties with an increased odds of surgical delay were: Colorectal 1.73 odds (95% CI 1.50, 2,00), Gynecologic oncology 1.5 odds (95% CI1.21, 1.81), Hepatobiliary 1.31 odds (95% CI 1.16, 1.51), Neurosurgery 1.13 odds (95% CI 1.02, 1.23), Ophthalmology 1.14 odds (95% CI 1.03, 1.25), and Plastic surgery odds 1.21 (95% CI 1.04, 1.43). Table 3b displays odds ratios for being on-time or early. Major anesthesia versus minor anesthesia was associated with a 1.22 odds (95% CI 1.14,1.23) of being on-time or early. Cardiovascular anesthesia was associated with a 3.13 odds (95% CI 2,4.55) of being on-time or early.

Table 3a.

Surgical Delay Variables	**Odds Ratio**	**95% C.I.**	
Black race	1.25	1.1	1.42
ASA =>3	1.23	1.2	1.34
Colorectal	1.73	1.5	2
Gynecologic oncology	1.5	1.21	1.81
Hepatobiliary	1.32	1.16	1.51
Neurosurgery	1.13	1.02	1.23
Ophthalmology	1.14	1.03	1.25
Plastic surgery	1.21	1.04	1.43
Renal Failure	1.17	1.05	1.3
Steroid	1.13	1.02	1.25
Insulin	1.14	1.01	1.29

Table 3b.

On-time/Early Variables	Odds Ratio	95% C.I.	
Obesity	1.42	1.23	1.64
Major Anesthesia	1.22	1.14	1.23
Cardiovascular Anesthesia	3.13	2	4.55

Discussion

Surgical delay is a complex issue that has many different contributing factors. While it is already known that patient-related factors play a role in surgical delay based on previous studies (Al Talalwah & McIltrot, 2014; Deldar et al., 2017; Garg et al., 2009; Wright et al., 2010), this study examined specific patient-related factors that could possibly be correlated with delay.

A commonly accepted definition of surgical delay does not exist. In this study, a surgical delay was defined as 1 minute or greater delay from the scheduled time. This was based on this facility's definition of delay, since it is assumed that providers within the facility would be operating with that assumption when they were preparing for the case. Other facilities may have a more lenient definition of delay, or allow for a grace period, which could change the dynamic and therefore predictors of delay. In addition, this study looked at all cases throughout the course of the day. It has been shown that second, third and subsequent cases are more likely to be delayed than the first case of the day due to the domino effect when a prior case is delayed or takes longer than scheduled (Balzer et al., 2017). This would be especially relevant when considering predictors that might vary throughout the day, such as provider availability due to shift changes, or equipment availability due to it being cleaned and processed after use in a prior case. Because this study was interested in patient-specific factors of surgical delay, which should not vary greatly throughout the course of the day, all cases throughout the day were included.

It is commonly assumed that being sicker and having a greater acuity or having more severe chronic illnesses would be correlated with a surgical delay. This is because of the additional work-up and preparation the patient may require prior to surgery (such as medication administration, laboratory draws or medical optimization). In fact, several studies have looked at the effect of improved patient preparation through preoperative surgical clinics as a way to improve surgical delays (Correll et al., 2006; Ferschl et al., 2005; Vazirani et al., 2012). The current study demonstrated that patients with an ASA classification of 3 or greater were more likely to have a surgical delay, but this finding is not consistent in the literature. In the study by Gabriel et al. (2016) that looked at a very large sample of patients in community hospitals, higher ASA classification was inversely related to surgical delay. That study looked at a different population (medium-sized community hospitals) in contrast to this study (large academic hospital), however it is still surprising to find such a disparity among studies.

Many of the demographic variables had a very significant relationship with surgical delay in bivariate analysis but not within the logistic regression model. Other than Black race, other demographic characteristics such as ethnicity, employment status, and health insurance type did not have an increased odds for surgical delay within the logistic regression model. While no study has demonstrated demographic characteristics causing a delay to surgery, there are many healthcare studies outside of the operating room, particularly among patients with cancer, demonstrating treatment delay among certain minority groups (Gorin, Heck, Cheng, & Smith, 2006; Fedewa, Ward, Stewart, & Edge, 2010). A possible explanation for the lack of increased odds of delay among certain demographics, is that while the sample's racial makeup is grossly consistent with that of the population overall in the county in which this study takes place, the sample has less than half the proportion of Hispanics compared with the population in the county (U.S. Census Bureau, 2010). Furthermore, a very large percentage of the sample has either private insurance (managed care or exchange) or Medicare. Disparities that would normally appear among racial and ethnic groups may not have been apparent in this sample due to the sample being largely well-insured. Future analyses that look at minority subgroups may help to explain this issue better.

A very interesting finding in this study were the variables that had a decreased odds of being delayed. General and cardiovascular anesthesia were more likely to be on-time or early than minor anesthesia cases and this is consistent with the findings in the study by Gabriel et al. (2016). This may be due to the fact that minor anesthesia cases are usually shorter cases with more scheduled in a day and therefore more opportunities for delay. Perhaps it is because cardiovascular surgery has designated teams of personnel that are familiar with working with one another, are proficient with the equipment and have designated operating rooms. Dedicated surgical teams have been shown in other surgical populations to improve efficiency including on-time start time and turnover times (Doll, Kauf, Wieferich, Schiffer, & Luedi, 2017). Obesity also had a decreased odds for delay. This is surprising since obesity is often comorbid with many other chronic illnesses (Must et al., 1999) and would therefore lead one to believe that obesity should increase the chances of delay.

Due to the retrospective nature of this study, it is impossible to control for the other factors that contribute to surgical delay, as well as understand their contribution to surgical delays in this sample. In fact, Cox & Snell and Nagelkerke values lead us to believe that the patient-specific factors in this study make a rather small contribution to surgical delays. On the other hand, the very large sample size gave this study the power to detect small positive differences that are statistically, and more importantly, clinically significant.

Surgical specialty contributed significantly to surgical delay, with 6 specialties having a highly statistically significant relationship with surgical delay ($p<0.0001$). In other studies, the sample was limited to a specific population, such as hip fracture patients in an attempt to eliminate the bias introduced by specific surgical specialties (Vidan et al., 2011). In this study, surgical specialty was controlled for in the logistical model, but it may be helpful to study less heterogenous samples (i.e., samples in only one surgical specialty) to avoid bias.

This sample represented an older, acute population with a large portion retired and using Medicare. More than half had an ASA classification of 3 or greater, which means the sample had a high acuity overall. The results of the study cannot be generalized to the surgical population in general, especially when considering ambulatory surgery centers which primarily service outpatient settings and have a large proportion of young, healthy patients. The results are applicable in acute care settings with older, sicker populations, especially since these comorbidities are some of the contributing factors to surgical delay.

The clinical implications of this study include appraising providers of patients with particular risk factors for surgical delay. Many surgical patients receive a preoperative evaluation and workup at a preoperative clinic prior to presentation in the operating room. It is beneficial for providers to not only identify patient-related issues that may cause a delay, but also attempt to mitigate these risk factors by ensuring the patient is properly optimized before the day of surgery. On the day of surgery, patients with a risk for delay may require extra care including labs or medications that can delay their start time. The preoperative scheduler can take this into consideration when deciding whom to bring to the preoperative area for preparation, ensuring those that are at risk for delay are brought up first.

There are many opportunities for future research to better explain the complex phenomenon of patient-related surgical delays. For example, patients who take insulin had an increased odds of surgical delay in this sample. This is not surprising since these patients need frequent blood sugar checks and may experience adverse effects as a result of their disease process that require intervention. Studies that look at the specific populations of patients at risk may help to discover the cause of their delays and detect patterns that may be amenable to intervention. Prospective studies that control for various confounding factors are also suggested.

Minimizing surgical delays can improve patient and provider satisfaction, save resources and lower costs, and prevent downstream delays. The causes of surgical delay are complex and difficult to study, but well-planned studies can utilize the EHR to gather a wealth of information that may be helpful in understanding and mitigating this very common inefficiency within the operating room.

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Chapter 7: CONCLUSION

A review of the literature demonstrates a lack of knowledge explaining the role of the patient is surgical delays. While the patient has been shown to be a cause of delays (Deldar et al., 2017; Foglia, Alder , & Ruiz, 2013), it is unclear how much a patient's health status contributes to these delays and whether patients with certain comorbidities are more likely to be delayed than others. The studies can also be contradictory; in one study, patients with a higher acuity classification were more likely to be delayed especially before the implementation of a preoperative clinic (Ferschl, Tung, Sweitzer, Huo, & Glick, 2005), whereas in another more recent study sicker patients were less likely to be delayed (Gabriel, Huang, Dutton, & Urman, 2016). While many questions are still unanswered concerning the link between the patient and surgical delays, there is a wealth of research on patient-centered interventions to prevent delays. This includes studies on the value of preoperative clinics, standardized preoperative processes and patient education (Ferschl et al., 2005; Hovlid, Bukve, Haug, Aslaksen, & von Plessen, 2012).

In order to better understand patient-specific factors associated with surgical delay, this dissertation was designed to retrospectively analyze surgical cases in one large, academic acute care setting over a 5-year period. Initially, the analysis sought to compare cases that were on-time, cases that were delayed and cases that were started earlier than scheduled to fully understand the contributing to factors to patients' timeliness in the operating room. After application of exclusion criteria (which included emergency case), the original design was modified due to many of the early cases being eliminated. The modified analysis looked at patient-specific predictors of surgical delay by comparing delayed cases to cases that were early or on-time and a predictive model was created.

Several patient-specific factors were found to be associated with surgical delay in the study sample. The model contributed a relatively small fraction to the overall explanation of surgical delays in this sample which is contrary to previous studies which demonstrated a more sizable contribution to delays from patient causes (Deldar et al., 2017). Research using alternative study designs and different study populations may help explain this phenomenon. On the other hand, the significant power of this dissertation allowed for the detection of relationships, which may still be clinically significant despite their small size. The dissertation has started to answer some of the questions about the role of the patient in surgical delays, however they are still much work to be done to bridge the knowledge gap.

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Appendix A: University of Southern California Institutional Review Board Approval

USC Children's Hospital LOS ANGELES LAC+USC HEALTHCARE NETWORK iStar

Proposal #HS-17-00752

University of Southern California Health Sciences Campus
Institutional Review Board
LAC+USC Medical Center, General Hospital Suite 4700
1200 North State Street, Los Angeles, CA 90033
(323) 223-2340 phone
(323) 224-8389 fax
irb@usc.edu

Date: Oct 02, 2017, 08:35am

To: Sarah Giron, CRNA
Clinical Instructor of Anesthesiology
ANESTHESIOLOGY

From: Health Sciences Institutional Review Board
General Hospital, Suite 4700
1200 North State Street
Los Angeles, CA 90033
(323) 223-2340

TITLE OF PROPOSAL:
Predictive Risk Algorithm to Identify Patient-Related Characteristics Associated with Surgical Case Delay or Cancellation (Patient-Related Characteristics Associated with Surgical Case Delay)

Action Date: **10/1/2017** Action Taken: **Approve**

Committee: Institutional Review Board Chairman

Note: Your iStar application and attachments were reviewed by the expedited mechanism by Dr. Darcy Spicer on October 1, 2017.

The project was APPROVED

The materials submitted and considered for review of this project included:
1. iStar application, dated 09/23/2017
2. Study Protocol, undated (uploaded 09/20/2017)
3. Data Collection Form, undated (uploaded 09/23/2017)

This study was submitted for expedited review according to 45 CFR 46.110(b) (5).

The IRB reviewed this study and determined that it qualifies as exempt 8 under the USC Human Research Protection Program Flexibility Policy. You are authorized to conduct this research as approved. This project is not subject to requirements for continuing review.

Appendix B: University of Southern California IRB Amendment

USC Children's Hospital LOS ANGELES LAC+USC iStar

Proposal #HS-17-00752

University of Southern California Health Sciences Campus
Institutional Review Board
LAC+USC Medical Center, General Hospital Suite 4700
1200 North State Street, Los Angeles, CA 90033
(323) 223-2340 phone
(323) 224-8389 fax
irb@usc.edu

Date: Feb 05, 2018, 11:03am

To: Sarah Giron, PhD, CRNA
Clinical Assistant Professor of Anesthesiology
ANESTHESIOLOGY
1520 San Pablo Street, #3451
Los Angeles, CA 90033 USA

From: Health Sciences Institutional Review Board
General Hospital Suite 4700
1200 North State Street
Los Angeles, CA 90033
(323) 223-2340

TITLE OF PROPOSAL:
Predictive Risk Algorithm to Identify Patient-Related Characteristics Associated with Surgical Case Delay or Cancellation
Amendment: HS-17-00752-AM001 (Change in Dates for Data Collection)

Action Date: **2/5/2018** Action Taken: **Approve**

Committee: Institutional Review Board Chairman

Note: Your IRB submission received on 02/05/2018 was reviewed by Dr. Linda Sher on 02/05/2018.

The proposed changes qualify for expedited review according to 45CFR46.110(b)(2) minor changes in previously approved research during the period (of one year or less) for which approval is authorized.

The proposed changes were APPROVED.

The revised iStar Application dated 02/05/2018 was APPROVED.

Appendix C: University of San Diego Institutional Review Board Approval and Amendment

From: irb@sandiego.edu
Subject: IRB-2018-377 - Initial: Initial - Expedited
Date: March 22, 2018 at 9:53 AM
To: jburkard@sandiego.edu, nmeyers@sandiego.edu, rbush@sandiego.edu

University of San Diego®

Mar 22, 2018 9:53 AM PDT

Natalie Meyers
Hahn School of Nursing & Health Science

Re: Expedited - Initial - IRB-2018-377, Relationship Between Patient-Specific Factors and Surgical Schedule Deviation

Dear Natalie Meyers:

The Institutional Review Board has rendered the decision below for IRB-2018-377, Relationship Between Patient-Specific Factors and Surgical Schedule Deviation.

Decision: Exempt

Selected Category: Category 4. Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

Findings: None

Research Notes:

Internal Notes:

Note: We send IRB correspondence regarding student research to the faculty advisor, who bears the ultimate responsibility for the conduct of the research. We request that the faculty advisor share this correspondence with the student researcher.

The next deadline for submitting project proposals to the Provost's Office for full review is N/A. You may submit a project proposal for expedited or exempt review at any time.

Sincerely,

Dr. Thomas R. Herrinton
Administrator, Institutional Review Board

Office of the Vice President and Provost
Hughes Administration Center, Room 214
5998 Alcalá Park, San Diego, CA 92110-2492
Phone (619) 260-4553 · Fax (619) 260-2210 · www.sandiego.edu

From: irb@sandiego.edu
Subject: IRB-2018-377 - Renewal: Renewal
Date: March 11, 2019 at 1:58 PM
To: jburkard@sandiego.edu, nmeyers@sandiego.edu, rbush@sandiego.edu

I

Mar 11, 2019 1:58 PM PDT

Natalie Meyers
Hahn School of Nursing & Health Science

Re: Renewal - IRB-2018-377 Relationship Between Patient-Specific Factors and Surgical Schedule Deviation

Dear Dr. Natalie Meyers:
The Institutional Review Board has rendered the decision below forIRB-2018-377, Relationship Between Patient-Specific Factors and Surgical Schedule Deviation.

Decision: Exempt

Findings: None

Research Notes:

Internal Notes:

Note: We send IRB correspondence regarding student research to the faculty advisor, who bears the ultimate responsibility for the conduct of the research. We request that the faculty advisor share this correspondence with the student researcher.

The next deadline for submitting project proposals to the Provost's Office for full review is N/A. You may submit a project proposal for expedited or exempt review at any time.

Sincerely,

Dr. Thomas R. Herrinton
Administrator, Institutional Review Board

Office of the Vice President and Provost
Hughes Administration Center, Room 214