2020

The Impact Of Opt-Out Legislation On Access And Delivery Of Anesthesia Services In California

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Abstract

ABSTRACT

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Anesthesia services provide the support and stability for patient safety during surgical procedures. The service delivery can come from a variety of providers trained in anesthesia, and the typical approach comes in a team model of physician anesthesiologist (MDA), supervising a certified registered nurse anesthetist (CRNA). Researchers examine the various anesthesia services consisting of MDA alone, CRNA only, and the anesthesia care team model (ACT) with focus on their safety and quality. Stakeholders debate which anesthesia method of delivery is best suited for the patient care. In recent literature, these methods were tested by focusing on variables, including the anesthesia practitioner type and their skill sets, patient complexity, and defined patient outcomes, such as pain management, postoperative nausea and vomiting, length of hospitalization, and death. In 2001, the Executive Branch of the United States (U.S.) Federal Government released a rule, Medicare and Medicaid Programs; Hospital Conditions of Participation: Anesthesia Services, allowing states to opt-out of the federal requirement stipulating that a physician must supervise the delivery of anesthesia care by a CRNA to provide greater access to services when shortages of providers exists (Centers for Medicare and Medicaid Services, 2001; Lewis, Nicholson, Smith, & Alderson, 2014; & Sun, Miller, & Halzack, 2016). President Clinton signed that conditions of participation enacting the rule nationwide. However, his successor President Bush, amended this ruling to become state specific. This requirement intended to support access to care in rural areas improve. Since 2001, nineteen states have passed opt-out legislation; for example, California was the 15th state to opt out in 2009 (Sun et al., 2016). However, few studies to date include investigation of how this legislation affected the access to quality anesthesia care. The purpose of this proposed study is to analyze how opt-out legislation in California has impacted the three types of anesthesia delivery methods with nurse anesthesia practice for surgical services and their subsequent outcomes.

Degree Type
Dissertation

Degree Name
Doctor of Philosophy (PhD)

Graduate Group
Nursing

First Advisor
Rosemary C. Polomano

Keywords
Access to Care, Anesthesia, Anesthesia Supervision, Nurse Anesthetists, Opt-out Medicare legislation, Supply and Distribution

Subject Categories
Nursing

THE IMPACT OF OPT-OUT LEGISLATION ON ACCESS AND DELIVERY OF ANESTHESIA SERVICES IN CALIFORNIA

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A DISSERTATION

in

Nursing

Presented to the Faculties of the University of Pennsylvania

in Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2020

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ABSTRACT

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Anesthesia services provide the support and stability for patient safety during surgical procedures. The service delivery can come from a variety of providers trained in anesthesia, and the typical approach comes in a team model of physician anesthesiologist (MDA), supervising a certified registered nurse anesthetist (CRNA). Researchers examine the various anesthesia services consisting of MDA alone, CRNA only, and the anesthesia care team model (ACT) with focus on their safety and quality. Stakeholders debate which anesthesia method of delivery is best suited for the patient care. In recent literature, these methods were tested by focusing on variables, including the anesthesia practitioner type and their skill sets, patient complexity, and defined patient outcomes, such as pain management, postoperative nausea and vomiting, length of hospitalization, and death. In 2001, the Executive Branch of the United States (U.S.) Federal Government released a rule, *Medicare and Medicaid Programs; Hospital Conditions of Participation: Anesthesia Services*, allowing states to opt-out of the federal requirement stipulating that a physician must supervise the delivery of anesthesia care by a CRNA to provide greater access to services when shortages of providers exists (Centers for Medicare and Medicaid Services, 2001; Lewis, Nicholson, Smith, & Alderson, 2014; & Sun, Miller, & Halzack, 2016). President Clinton signed that conditions of participation enacting the rule nationwide. However, his successor President Bush, amended this ruling to become state specific. This requirement intended to support access to care in rural areas improve. Since

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CHAPTER ONE: INTRODUCTION

Introduction

Anesthesia is designed to relieve pain and provide sedation to surgical patients throughout the perioperative continuum. Both Certified Registered Nurse Anesthetists (CRNA) and Anesthesiologists (MDA) deliver anesthesia in inpatient and ambulatory care settings. In a Cochrane's review, Lewis et al. (2014) reported that each year CRNAs provide approximately 90% or 34 million out of the 40 million anesthetic encounters in the U.S. Specifically, CRNAs are either independent providers or part of a team to make this majority of delivery methods. The remaining 10% of anesthesia delivered is with MDA only, or a team approach of MDA and CRNA (Lewis et. al, 2014). CRNAs and MDAs may work together within a collaborative model, referred to as an anesthesia care team (ACT). These teams currently administer the majority of the anesthesia in the U.S., but their services are 30% more expensive, compared to anesthesia delivery by CRNAs or MDAs practicing independently (Jordan, 2011).

In the U.S., there are three main anesthesia service methods, consisting of MDA and CRNA ACT, MDAs practicing independently, and CRNAs practicing independently. Facilities that use the ACT model require that a physician, usually an MDA, but sometimes an airway trained physician (proceduralist) performing the surgical intervention supervises CRNAs. This ACT model approach exists mainly in health service areas with a large distribution of CRNAs. Both teaching and public hospitals with greater surgical volumes and higher patient acuity levels are more likely to provide anesthesia through ACTs (Rosenbach & Cromwell, 1989).

The degree to which CRNAs require supervision through the ACT model is determined at the facility level, and is guided and/or regulated by federal, state, and insurer policy regulations. In 2001, the Executive Branch of the U.S. Federal Government, intending to increase access to anesthesia care, released *Conditions of Participation for the Medicare and Medicaid Programs; Hospital Conditions of Participation: Anesthesia Services, 42 CFR 482.52* allowing states to opt-out of the federal requirement that a physician supervise the administration of anesthesia given by a CRNA with its intended purpose of providing greater access to anesthesia services in a time of potential shortage of providers (Centers for Medicare and Medicaid Services, 2001; American Association of Nurse Anesthetists, 2001). Prior to this ruling, the U.S. Centers for Medicare and Medicaid Services (CMS) required CRNA supervision by a physician, either an anesthesiologist or proceduralist, as a condition for reimbursement for provider services and payments to healthcare facilities for the respective CRNAs' services (Centers for Medicare and Medicaid Services, 2001; American Association of Nurse Anesthetists, 2001; Sun, Dexter, & Miller, 2016; Sun, Miller, & Halzack, 2016). The 2001 Condition of Participation was significant in that it did not require physician supervision of CRNAs for payment for services. For opt-out of supervision to occur, the governor of each state must issue a letter attesting that consultation with the state medical and nursing boards about access to and quality of anesthesia services was completed, that citizens would benefit from removal of the supervisory requirement, and that opt-out is consistent with state law (Centers for Medicare and Medicaid Services, 2001; American Association of Nurse Anesthetists, 2001). Since the conditions of participation were announced, nineteen states have opted out, with ten of these states specifying that this decision was enacted to increase access to anesthesia care. States adopting the opt-out Medicare regulation allow CRNAs to practice to the fullest extent of their license and scope of authority promoting independent practice.

In the decade since this ruling, medical professional societies and state medical boards have continuously challenged CRNAs' ability to practice independently and have lobbied to prevent the expansion of opt-out states. The medical societies and boards have questioned CRNAs' education and training, skills, and level of quality care, despite compelling evidence of the safety and quality of CRNA practice (Neuman & Martinez, 2011). Dulisse & Cromwell (2010) examined opt-out states and non-opt-out states for inpatient mortality and anesthesia complications both before and after opting out. They found that there was an increase in the proportion of surgeries in which anesthesia was provided by a CRNA with no anesthesiologist involvement in both non-opt-out and opt-out states. Despite this shift, there was no increase in mortality or complications for either group (Dulisse & Cromwell, 2010). This body of research identifies the three practice models: CRNA only, MDA only, and ACT focusing on outcomes of cost, length of stay, and geography, using state specific data, as opposed to previous research combing all states data.

In January 2017, the Veterans Health Administration (VA) granted full practice authority to APRNs, except CRNAs. This ruling was designed to increase veterans' access to VA health care by expanding the pool of qualified health care professionals authorized to provide primary health care and other related health care services to the full extent of their education, training, and certification. This decision is not considered a part of the opt-out legislation, as it was VA system-wide decision to allow full practice authority for advanced practice nurses providing care to veterans unfortunately. CRNAs were the only APRN group to whom this ruling was not applied (Lansford, 2011).

The opt-out policy is not the only regulation that affects independent practice for CRNAs. Other advanced practice nurses (APRNs) face barriers from both local hospital policies and state scope of practice (SOP) regulations. In addition to the opt-out policy, these occupational restrictions such as the ability to evaluate patients, diagnose, order and interpret diagnostic tests, initiate and manage treatments—including prescribe medications—under the exclusive licensure authority of the state board of nursing are reduced or restricted and play a crucial role in access to care. The prevailing opinion is that broadening scope of practice is both necessary and inevitable. Given the direction the healthcare system is moving with more people insured and an aging population increasing the number of patients and their need for services, there is a greater emphasis on team-based care and allowing providers to practice to the fullest extent of their training which can ultimately increase accessibility to services.

Lobbying efforts are underway by the American Association of Nurse Anesthetists (AANA) to convince governors and state legislators to sign opt-out legislation in states that currently do not have this legislation passed. However, these activities may be futile if there are insufficient data, aside from what was examined by Dulisse & Cromwell (2010) to demonstrate the benefits of this opt-out legislation that permits anesthesia care delivery from independent CRNAs. The sustainability of the opt-out ruling in states that have already enacted this regulation could be jeopardized if further research is not available to demonstrate the impact of the legislation. States such as Colorado have changed their ruling twice, and currently have the opt-out legislation enacted in only rural areas of the state.

Currently forty states, with nineteen of those being opt-out states, do not require physician supervision of CRNAs via their nursing statutes or licensing requirements. Letting states decide this issue for CRNA practice will ultimately align itself with Medicare's policy for reimbursing CRNA services according to their state scope of practice (42 CFR 410.69(b), CMS-1590-FC) (Centers for Medicare and Medicaid Services, 2001). The removal of the physician supervision requirement of CRNAs by CMS would be consistent with the promotion of patient access to quality, cost-effective healthcare. By adopting such a regulatory change, CMS would permit states and local healthcare facilities the opportunity to decide the best anesthesia-staffing model for safe patient care and allow optimal use of the available anesthesia workforce.

At this time, there is a lack of scientific evidence to support CRNA independent practice and refute the belief that CRNAs must be supervised. The purpose of this dissertation research is to evaluate the impact of opt-out policy in the state of California through the outcomes of surgical services, patient complexity, and geographic variation with anesthesia delivery methods. Before deciding to adopt opt-out, California had to state that the governor had consulted with the California Boards of Medicine and Nursing to determine that this exemption was consistent with state law, and in the interests of the people of California (American Association of Nurse Anesthetists, 2010). Because

California was an early adopter of the opt-out model of medical supervision per the 2001 Conditions of Participation, this study used data from that state to examine patterns of access to and delivery of anesthesia care. The focus on California is largely due to the ability to capture a large percentage of the population requiring anesthesia services through both CMS and other publicly available data.

Debates over the merits of opt-out have focused largely on whether this exemption has affected the safety and quality of anesthesia care. Less work has addressed whether it has increased access to care or the value of that care, the normative intent of the administrative rule (Centers for Medicare and Medicaid Services, 2001). The degree to which opt-out has increased access to anesthesia care still needs to be determined. There are important health policy implications not just for surgical care, but also for healthcare more broadly. A more balanced approach to the delivery of healthcare, with services provided by well-trained, highly qualified professionals, both physicians and advanced practice nurses, may increase accessibility to affordable care for all populations. Although prior literature discusses CRNA independent practice from the perspective of safety and quality, there are a limited number of studies examining CRNA independent practice after opt-out legislation enactment and subsequently improved access to care (Sun et al., 2016; Sun et al., 2016; & Sun, Miller, & Halzack, 2017). This body of research measures the effects of opt-out legislation in California on the access to and delivery of anesthesia through outcomes of cost, length of stay, and geographic balance of anesthesia providers.

One industry concern is the impact of an aging workforce across all types of anesthesia healthcare providers. Studies predict that physician retirement decisions will have a considerable impact on the supply of physician anesthesia providers (Association of American Medical Colleges, 2017). A report by the American Society of Anesthesiologists (ASA) notes that the average anesthesiologist's age is 46.5 years, while the average for CRNAs is 38.6 years (Somnia Anesthesia, 2017). Anesthesiologists also have the highest attrition rates compared to CRNA colleagues (Somnia Anesthesia, 2017). Increased age and high rates of attrition lead to the expectation that there will be fewer anesthesiologists in the future than the number practicing today. The Association of American Medical Colleges has identified the need for additional MDA in the field by providing additional funding for medical education, however, the demand outweighs the supply of providers (Association of American Medical Colleges, 2017). Projected staffing models with moderate to high use of advanced practice registered nurses, such as CRNAs, could help ease between 30% and 60% of the demand for physicians in the specialty (Association of American Medical Colleges, 2017). The supervision and medical direction methods requires the redundant care of two providers caring for the same patient. With opt-out legislation this will be lessened, and ultimately lead to a greater expansion of anesthesia providers available to assist with surgical services.

In addition to using anesthesia workforce shortage as a proxy for measuring access to anesthesia care, Epstein et al. (2012) examined the medical direction model and how it would impact surgical start times and anesthesia reimbursement due to lack of availability of MDAs to supervise CRNAs for the induction of anesthesia. Epstein et al.

(2012) explored predictions using real data captured from an anesthesia information management system to determine the incidence and timing of simultaneous critical portions of cases in which MDAs were reimbursed under a medical direction model (Epstein, & Dexter 2012). This simulated model estimated risk of a supervision lapse to surgical suites with various numbers of operating rooms. This model identified a supervision ratio of 1:2, lapses occurring on 35% of days, with a peak incidence occurring before 8:00 a.m. ($p = 0.0001$) (Epstein, & Dexter 2012). The average time from operating room entry until anesthesia release time (post-induction to hand over to surgeon) during the first case of the day was 22.2 minutes (95% C.I.:21.8–22.8) (Epstein, & Dexter 2012). This number could potentially increase throughout the day depending on the length of time for the surgical procedures. Overall, these delays could directly affect access and patient satisfaction due to an unexpected delay in wait time. Furthermore, there could be additional costs to the health system related to the need to hire more MDAs to maintain more conservative ratios and the need to potentially reschedule or cancel procedures. To date several studies have focused on factors influencing access to care. While work in this area has just begun, predictions of lower numbers of practicing MDAs and Epstein et al.'s work estimating risks related to supervision lapse at critical periods in surgical cases suggest the need for further development and use of CRNA independent practice (Epstein, & Dexter 2012). With the implementation of opt-out legislation and the removal of CRNA supervision, the process of two providers caring for the same patient will be reduced and ultimately lead to more availability of anesthesia providers.

Background and Significance

Anesthesia is described as a component of both the nursing and medical disciplines. CRNAs deliver the larger majority of anesthesia care for surgical and pain management services in the U.S., and as of 2016, anesthesia was provided in the amounts by CRNAs and MDAs, (49.6% (50,580) and 48.3% (49,201), respectively (*HIPAA administrative simplification: National plan and provider enumeration system data dissemination,* 2007; Quraishi, Jordan, & Hoyem, 2017; & Lewis et al., 2014). Specifically, CRNAs are independent providers in nearly 18.5% of all healthcare facilities across the country and in two-thirds of all rural hospitals (Wilson, 2012).

These numbers represent a shift from past anesthesia practice. Since 1886 beginning with Alice Magaw at the Mayo Clinic, nurses were the dominant providers of anesthesia services (Neuman & Martinez, 2011). An influx of physicians into anesthesia practice resulted in a greater number of anesthesiologists who practiced alone or in team arrangements with CRNAs (Dulisse & Cromwell, 2010). These arrangements represent a confusing array of methods used to deliver this care that are driven more by context, payment, or workforce numbers than by quality benchmarks.

No uniform pattern of labor exists across anesthesia teams. The term ACT does not represent one standard model. At times, CRNAs and MDAs work independently of each other, assuming total responsibility for care. In some health systems, all three practice methods (MDA independently, CRNA independently, and MDA/CRNA team) are used concurrently. In fact, there are varieties of anesthesia methods with differing ratios of MDAs or proceduralists acting as the supervisors of CRNAs.

Several factors do characterize ACT models such as their presence in medical teaching institutions, location, and the scope of practice of the state or specific hospital institution. One example of this is found in Colorado, a state that's had op-out legislation since 2010. Shifts in CRNA independent practice in Colorado have occurred only in rural, critical access hospitals. All urban facilities in that state still require that CRNA practice be supervised, thus over-riding the federal ruling (Colorado Health Institute, 2010).

CRNAs' scope of practice working in a team setting varies between hospitals within the same state, and in a small percentage of hospitals, privileges vary within the hospital itself. There are many types of ACTs that can be used by hospitals. In one hospital, anesthesiologists may direct care based on a more restricted scope of practice for CRNAs, reflecting a specific set of Tax Equity and Fiscal Responsibility Act (TEFRA) of 1982 Medicare documentation rules (Silberman, Odom, Smith, Dubay, Thompson, Task Force on the North Carolina Healthcare Safety Net 2005). For others, a ratio may be used to provide anesthesia supervision. Settings that use MDA to CRNA supervision ratios can range from 1:2 to 1:8. Anesthesia care teams are typically composed of CRNAs with supervision provided by an MDA or airway trained physicians, (such as oral surgeons or gastroenterologists). Personnel in these settings who are supervised include anesthesia residents, nurse anesthesia doctoral degree students (SRNA), or anesthesia assistants (AA) **(Table A.1-1)** (Matsusaki & Sakai, 2011).

In 2009, 27% of CRNAs practiced nationally in non-medically directed or unsupervised settings, and 73% of CRNAs practiced in medically directed environments

(Jones & Fitzpatrick, 2009). Medical direction is different from medical supervision and was put in place for Medicare reimbursement (Silberman et al., 2005). Although the term "medical direction" implies a consultation between two providers, the MDA acts more collaboratively with the CRNA to plan care. In this instance, the seven TEFRA conditions must be met in order to bill for medical direction (Centers for Medicare and Medicaid Services , 2001; Sun et al., 2016; & Sun et al., 2016). They consist of the presence of a physician directing at least two CRNAs during the following activities:

- pre-anesthetic examination and evaluation;
- prescribing the anesthesia plan;
- personally participating in the most demanding procedures in the anesthesia plan; including, if applicable, induction and emergence;
- ensuring that any procedures in the anesthesia plan, not performed by the physician, be performed by a qualified individual;
- monitoring the course of anesthesia administration at frequent intervals;
- remaining physically present and available for immediate diagnosis and treatment of emergencies; and provides indicated post-anesthesia care.(Silberman et al., 2005)

There are significant economic implications for patients and payers if the criteria for medical directions eligibility are not documented for every anesthesia procedure. This is important, as Medicare payment is higher with physician reimbursement. When the conditions are not appropriately documented, the MDA is reimbursed at a lower rate.

There are several issues surrounding the TEFRA requirements by those who determine billing and payment structures. Many healthcare executives, administrators, and finance personnel incorrectly presume that TEFRA requirements and the use of the medical direction anesthesia are necessary to meet physician supervision conditions under state scope of practice regulations. Some also believe that state and federal regulatory language explicitly dictates that the supervising physician be an anesthesiologist (Quraishi et al., 2017). These beliefs are unfounded as there are clear functional variations in the roles of MDAs and CRNAs within the ACT, according to TEFRA and CMS reimbursement guidelines. In addition, Fassett and Calmes (1995) found that anesthesia administered using the ACT model was more costly than those administered by CRNAs or anesthesiologists practicing alone. They studied 385 anesthetic administrations over a four-week period and found that MDAs did most of the pre- and-postoperative care, while CRNAs administered the majority of the anesthetics. Both anesthesia professionals agreed that more than 70% of these cases did not need medical direction (Fassett & Calmes, 1995). These findings reflect the different perceptions about the need for both political and healthcare leadership to determine the best cost-effective, quality care.

The factors of safety, quality, and cost have shaped the delivery of anesthesia services across the U.S. More importantly, as states opt-out of the team approach to anesthesia delivery services, there may be significant effects on payment and public access to these services. The concept of enabling all health professionals to practice at their full level of competence is vital to the success of care innovations identified by the Institute of Medicine (IOM) *Future of Nursing Report.* This report recognizes that there are barriers to APRN scope of practice and calls for APRNs to assume increased responsibilities for patient care in this complex healthcare system (Institute of Medicine, 2010; Dower, Moore, & Langelier, 2013). The opportunity to identify the best model for the patient at the point of care, which would complement the intentions of the IOM report, would appeal to policymakers, hospital administrators, and the public's interest. The IOM contends that to transform the system, APRNs such as CRNAs must be allowed to practice fully and independently, utilizing their education and training. The IOM recommends removing regulatory and policy barriers, such as supervision requirements, that limit nurses' ability to care for patients independently without the requirement of supervision of a physician to be physically present (Institute of Medicine, 2010). The healthcare system must use anesthesia professionals as efficiently as possible. Research has fallen short in providing an understanding of the impact on CRNA practice and anesthesia workforce arrangements following opt-out designations.

The various types of anesthesia care for surgical services are important for understanding the advantages and disadvantages of using alternate anesthesia delivery methods, specifically CRNA only delivery, to provide these required services. Anesthesia includes components of surgical, medical, and diagnostic procedures as well as pain management. The information gained from this research, analyzing the impact of this opt-out legislation on CRNA independent practice, can help inform employers (e.g., hospitals, anesthesia provider groups) about the quality and access implications of alternate delivery methods, other than the MDA only, or supervision of a CRNA as part of an ACT model. Findings from such research could provide an evidence base to inform federal and state regulators and legislators who are formulating rules and regulations for the delivery of anesthesia.

Approach/Innovation

This dissertation includes three manuscripts for publication. It begins with an integrative literature review of factors associated with opt-out designation and the influence on access to anesthesia services (Publication one). The search period of 2001 through 2017 provides a sixteen-year span of literature prior to and after the opt-out legislation of California in 2009 (Sun et al., 2016; Sun et al., 2016). Access to care is assessed and categorized by the various definitions in the model of Penchansky and Thomas' *Five Dimensions of Access* that include affordability, acceptability, accessibility, availability, and accommodation (Penchansky & Thomas, 1981).

The remaining two manuscripts for publication consist of separate secondary analyses using data from the Centers for Medicare and Medicaid (CMS). The American Association of Nurse Anesthetists Research Foundation funded the parent study, An Econometric Analysis of the Impact of Anesthesia Delivery Models in California, informing this research (Wiltse, Nicely, Fairman, & Harrington unpublished data, November 2017). The second and third manuscripts focus on the impact of opt-out designation using a comparative pre/post-secondary analysis from the years 2008 and 2013. The second manuscript is a secondary analysis examining the effects of anesthesia care delivery methods on access to care (patient volume), length of stay (LOS), and anesthesia service charges using data from patients receiving anesthesia for surgical services in California hospitals and outpatient facilities in 2008 (prior to opt-out) and 2013 (after opt-out legislation). This comparative design is used to examine the change in outcomes, anesthesia procedure charges and LOS, while adjusting for changes in patient factors over time (e.g., surgical volume, surgical complexity, and patient acuity) in the three anesthesia delivery methods before and after opt-out legislation implementation. Lastly, paper three observes the effect of opt-out designation on access to care from patients who used the anesthesia services in 2008 and 2013 in California. Patient characteristics from the perspective of geographic location, population density, and poverty level were correlated to the specific anesthesia service model that rendered the care, associating care to certain populations from anesthesia providers both before and after the opt-out legislation.

The focus on California is largely due to the ability to capture a large percentage of the population requiring anesthesia services through both CMS and other publicly available data. A report in 2015 from CMS estimated that U.S. national health expenditures (NHE) totaled over $3 trillion. In California, healthcare expenditures in 2016 were estimated to total more than $367 billion, with Medicare beneficiaries spending $74.7 billion (20.3%) of the total cost (Tatum, Carter, Ravi, & Kaldani, 2014; Sorensen, Nonzee, & Kominski, 2016). The share of Medicare spending in California is equal to the national level of 20% (Tatum et al., 2014).

The Affordable Care Act has greatly increased the numbers of Californians with insurance. Since the ACA implementation, 3.8 million Californians have obtained insurance from the state's health exchange (Tatum et al., 2014; Sorensen et al., 2016). While increasing the numbers of insured Californians can be recognized as a success, it also raises the question of whether these newly insured Californians might actually be able to access healthcare. There are still barriers to entry of patients to healthcare services in California. Prior to the ACA, the number of physicians was inadequate to meet the needs of the population. With retiring physicians and chronically low reimbursement rates for these physicians, a growing pool of insured patients will exacerbate the problem of access to care (Tatum et al., 2014; Sorensen et al., 2016).

Data obtained from CMS for this research was representative of 5 million beneficiaries throughout California. Additionally, the publicly available data comes from a large database gathered annually from all California healthcare facilities. California's Office of Statewide Health Planning and Development (OSHPD), a group that leads in collecting data and disseminating information about California's healthcare infrastructure, collects these data (California office of statewide health planning and development, 2018). OSHPD claims to promote an equitably distributed healthcare workforce, and publishes valuable information about healthcare outcomes. OSHPD also collects and publicly discloses facility-level data from more than 6,000 CDPH-licensed healthcare facilities - hospitals, long-term care facilities, clinics, home health agencies, and hospices (California office of statewide health planning and development, 2018). These data included financial, utilization, patient characteristics, and services information. In addition, approximately 450 hospitals report demographic and utilization data on approximately 16 million inpatients, emergency department, ambulatory and surgical patients.

This dissertation combined a novel approach to examine the literature in an integrative review of factors associated with opt-out designation and access to care. The two-year time point data analysis provided an adequate time span to more fully understand how anesthesia delivery and access have been affected by policy changes designed to increase access to anesthesia and surgical services while maintaining quality of care.

Chapter Aims

The specific dissertation aims were to:

1. Identify factors such as workforce distribution, scope of practice regulations, defining how to measure access to care associated with opt-out legislation and its influence on access to anesthesia care (Chapter two);
2. Examine differences in surgical volume, surgical complexity, patient acuity, and cost from the pre/post opt-out legislation time period across the three anesthesia delivery service methods (Chapter three);
3. Examine the effects of opt-out legislation on access to care defined by anesthesia provider model correlation to geographic location, population density, and poverty levels (Chapter four).

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CHAPTER TWO: PUBLICATION ONE – INTEGRATIVE REVIEW FACTORS ASSOCIATED WITH OPT-OUT LEGISLATION AND THE IMPACT ON ACCESS TO ANESTHESIA CARE: A REVIEW OF THE LITERATURE

Abstract

Background: Opt-out legislation was intended to promote greater access to anesthesia care. Three components of access include patient entry into the healthcare system, identifying sites where patients receive services, and finding providers who meet the needs of patients.

Purpose: 1) Examine the body of evidence pertaining to anesthesia services and identify consistent themes relating to opt-out legislation. 2) Critically examine factors affecting opt-out legislation. 3) Clarify ways in which opt-out legislation can lead to greater patient access to anesthesia care.

Methods: Utilizing integrative review methods, this paper analyzes anesthesia service publications from the years 2001 – 2017 and synthesizes consistent themes related to opt-out legislation.

Results: Fifty-one studies met inclusion criteria. Three key themes identified: workforce distribution for anesthesia was not successfully meeting population needs; scope of practice regulations significantly affected anesthesia practice; and a standardized model is needed to analyze access to care.

Practice Implications: Research has fallen short in highlighting CRNA practice and anesthesia workforce arrangements following opt-out designation. The need to decrease the cost of care and increase accessibility argues for efficient use of anesthesia

professionals. Still, limited research exists that has tested the impact of opt-out legislation.

Keywords: Anesthesia, Nurse Anesthetists, Medicare Legislation, Supply and Distribution

Factors Associated with Opt-Out Legislation and the Impact on Access to Anesthesia Care: An Integrative Review of the Literature

Submission to *WORLDViews on Evidence-Based Nursing* (Word Limit 5,000)

Introduction

Both Certified Registered Nurse Anesthetists (CRNAs) and physician anesthesiologists (MDAs) provide anesthesia care in the United States (U.S.). Understanding the nature of this care is important for the discussion of strategies to solve problems related to access to anesthesia care and the shortage of practitioners. There are currently about 30,000 anesthesiologists practicing in the U.S., down from 35,000 in 2011 (Daughtry, Benito, Kumar, & Michaud, 2010; Moghim, 2017). There was an estimated shortage of 3,800 MDAs in 2011, and trends suggest that this shortage will only grow in the coming years (Moghim, 2017). By 2020, the shortage of MDAs is expected to grow to 12,500, although there is projected to be a 3 % net annual increase in the supply of CRNAs showing a projected shortage of 4,479 MDAs by 2020 and a surplus of 7,970 CRNAs (Daughtry et al., 2010; Moghim, 2017).

Since the 1970s, inequities have existed in the geographic distribution of anesthesia professionals and patient populations. CRNAs have historically been the predominant anesthesia providers in rural hospitals and to Medicare beneficiaries (Liao, Quraishi, & Jordan, 2015; Manchikanti, Pampati, Falco, & Hirsch, 2015; Matsusaki & Sakai, 2011; Minnick & Needleman, 2008; Orkin, 1978). Up to 80% of anesthesia cases across the U.S. use a supervision model that results in restrictions imposed on CRNA independent practice (Daughtry et al., 2010). This type of model limits access to anesthesia care and diminishes CRNAs' abilities to practice to the fullest extent of their qualifications and scope of practice (SOP) (Jordan, 2011; Wilson, 2012).

Since the 1990s, many advanced practice nurses (APN) have actively sought legislative support for their SOP because their expertise could aid immensely in the expansion and affordability of healthcare in the U.S. Unfortunately, their practice is often limited by restrictive collaborative agreements with physicians; CRNAs' independent practice is compromised, and they cannot perform certain responsibilities without a physician present. Broadening of CRNA SOP could potentially include such areas as increased autonomy and independence of practice, redefinition of their professional ability to encompass more services and responsibilities, and establishment of licensure requirements.

In 2001, the Executive Branch of the U.S. Federal Government released a rule *Medicare and Medicaid Programs; Hospital Conditions of Participation: Anesthesia Services* allowing states to opt out of the federal requirement stipulating that a physician must supervise the delivery of anesthesia care by a CRNA (American Association of Nurse Anesthetists, 2001). Since its inception, nineteen states have enacted the opt-out designation as a means to improve access to anesthesia care. However, the effects of opt-out legislation in achieving greater access to anesthesia care have not been adequately investigated. The CRNA independent model decreases the costly and duplicative requirements of a supervision model while promoting all anesthesia professionals to practice to their fullest extent. The MDA supervision model of CRNAs may not be sustainable due to cost, reimbursement issues, and availability of providers, in which even MDAs have raised issues with this (Fassett & Calmes, 1995; Jordan, 2011; Liao et al., 2015; Merwin, Stern, & Jordan, 2006; Merwin, Stern, Jordan, & Bucci, 2009).

The opt-out rule supports any hospital or organization that seeks to provide greater availability to anesthesia care and cost cutting by allowing CRNAs to function as independent practitioners. In addition, the Affordable Care Act (ACA) has expanded the role of nurses and other professionals to be able to practice to the fullest extent of their training while caring for these newly insured populations. The main debate related to these changes in the practice of anesthesia has occurred when CRNAs try to acquire the statutory authority to perform procedures and provide services that MDAs have also been trained to do. In general, this argument is guided by disagreements related to access and cost of effective anesthesia care. Based upon a review of the literature, the aim of this manuscript was to identify factors such as workforce assessment, practice regulations, and outcomes measure that are associated with opt-out legislation and the influence on access to anesthesia care. Access is based on the conceptual framework of Penchansky and Thomas' *Five Dimensions of Access to Care* (Penchansky & Thomas, 1981).

Review of the Literature

Studies have examined the downstream effects of opt-out legislation both on quality of care and improvement of access to anesthesia care (Sun, Dexter, & Miller, 2016). Dulisse and Cromwell (2010) compared inpatient mortality rates and anesthesia complications between opt-out and non-opt-out states. They found that opting out of the MDA supervision requirement had no effect on inpatient deaths or anesthesia-related complications (Dulisse & Cromwell, 2010). A recent Cochrane Collaborative review of studies contrasting physician and non-physician anesthesia providers found that no definitive conclusions could be made regarding the superiority of quality measures for one anesthesia care provider vs. another (Lewis, Nicholson, Smith, & Alderson, 2014). This conclusion was based on relatively low rates of anesthesia complications and lack of significant evidence in the literature that examines reliable outcomes in the delivery of anesthesia care from these providers. Moreover, the complexity of perioperative care also contributed to an inability to differentiate outcomes.

Studies evaluating the impact of the opt-out regulation have not reliably demonstrated improved access to care. These studies have limitations including evaluation of selected surgical populations, limited outcome measures, and findings noting smaller growth in anesthesia utilization rates for opt-out states when compared to non-opt-out states during the same timeframe (Schneider, Ohsfeldt, Li, Miller, & Scheibling, 2017; Sun, Miller, & Halzack, 2016; Sun, Miller, & Halzack, 2017). A greater understanding of the impact that opting out of supervision with anesthesia care involving CRNAs in the U.S. is important for designing studies. This will better serve the need of informing the full scope of benefits that could be realized with the opt-out regulation that intended to solve the national shortage of anesthesia care providers and to improve access to anesthesia care (Matsusaki & Sakai, 2011). This integrative review seeks to identify factors associated with the 2001 opt-out legislation including the impact on access to anesthesia care. A comprehensive framework that accounts for the influence of workforce and SOP for CRNAs guides this review.

Theoretical Framework. It is essential to define the concept of access to care because it is often subjected to various interpretations. Access is an important concept in health policy and health services research. To some authors, the term "access" applies to entry into the healthcare system (Jordan, 2011). Others characterize access as a collection of variables that influence the entry into or utilization of the healthcare system (Schneider et al., 2017; E. Sun et al., 2016; Sun et al., 2016; Sun et al., 2017). Penchansky and Thomas (1981) published an article titled "The Concept of Access: Definition and Relationship to Consumer Satisfaction." In the opening sentence of this article, they note: "'access' is a major concern in health care policy and is one of the most frequently used words in discussions of the health care system." The same is certainly true today. In many policy discussions, access is equated with health insurance coverage. Although those who have defined access have all included other, nonfinancial, aspects of access in their definitions Penchansky and Thomas (1981) present access as a concept that summarizes variables of availability, accessibility, accommodation, affordability, and acceptability that play a role in the "fit" between the patient and the healthcare system. The latter explanation provides a more nuanced and complex identification of multiple variables likely to influence access to care.

Given the multiple interpretations of access to healthcare, several conceptual definitions provide structure to the term. Access is often synonymous with the patient's financial burden and available resources in a given geographic area of a health system. To this point, access has been viewed as a more political definition rather than an operational one (Aday & Anderson, 1974). The way in which access is measured or methods used to obtain these measures are often vague and loosely defined mainly by location of patients to the facility or their current insurance status. In the anesthesia literature, access is commonly described by disparities in rural healthcare compared to urban settings. Additionally, some researchers contend that access can best be evaluated through outcome indicators such as utilization rates and satisfaction scores (Aday et al., 1974).

Penchansky et al. proposed an understanding of access that accounts for the interaction of key elements that determine the use of healthcare services (Penchansky & Thomas, 1981). In this framework of understanding the concept of access, there needs to be a “fit” between the patient’s needs and the system’s ability to meet those needs (**Figure 2-1**). This fit is measured across five dimensions: availability, accessibility, accommodation, affordability, and acceptability (Penchansky & Thomas, 1981).

Figure 2-1. Penchansky and Thomas' *Five Dimensions of Access* and how it relates to consumer satisfaction. Taken from Penchansky, R., & Thomas, J. W. (1981). The Concept of Access: Definition and Relationship to Consumer Satisfaction. *Medical Care*, *19*(2):127–40.

The term "availability" describes the volume of healthcare services. Accessibility is defined by the geographic relationship between the consumer and the providers of healthcare. Accommodation relates to the usability of the services within the organization or healthcare system. Affordability is defined by the financial capacity and incidental costs for both the service provider and the consumer. Lastly, acceptability represents the mindsets of the consumers toward the providers and vice-a-versa.

Availability

This domain is largely based on geographic location with appropriate use of health services (Penchansky & Thomas, 1981). The ratio of usual source of care providers per number of persons within a population is a key indicator of availability. Rural communities are one of the most common jurisdictions with shortages of usual source of care providers (Irons & Moore, 2015). For example, Patterson et al. reported that in 2010, the ratio of primary care physicians to populations in urban areas was 100 per 100,000, while in rural communities, it was less than half this rate, forty-six per 100,000 (Petterson, Phillips, Bazemore, & Koinis, 2013). These rates are especially important as 21% of the U.S. population lives in rural areas, but only 10 % of physicians practice in these areas (Egger Halbeis & Macario, 2006). In rural hospitals, CRNAs deliver 70% of anesthesia care, and 37% of these CRNAs provide care in areas with fewer than 50,000 residents (Seibert, Alexander, & Lupien, 2004). The lack of available care hinders rural residents' ability to obtain needed health services both at the right time and in the right place.

Acceptability

Acceptability pertains to patients' attitudes toward both their providers and practice characteristics (Penchansky & Thomas, 1981). Characteristics of providers may include gender or ethnicity, facility type, as well as clinician attitudes toward patients (Penchansky & Thomas, 1981). Patients may often value acceptability over affordability and availability (Donebedian, 1972; Penchansky & Thomas, 1981). Meeting patients' expectations may be the primary factor for sustaining the patient-provider relationship. Ability to seek healthcare embodies the concepts of personal autonomy and capacity to choose to seek care, knowledge about health care options and individual rights that would determine expressing the intention to obtain healthcare.

The public typically sees physicians as the dominant anesthesia provider and the practice of anesthesia only specific to the medical profession instead of both medicine and nursing (O'Grady, 2008). There is a lack of public knowledge of the choice of an anesthesia provider due to the contractual nature of such services. This lack of knowledge is related to the components unique to anesthesia service, including the available providers, because these providers are enmeshed and predetermined within the healthcare institution.

Accommodation

Accommodation involves consumer needs and the resources available to meet these needs (Penchansky & Thomas, 1981). Deficiency in this area can cause patients to avoid treatment altogether. Recommendations for improving anesthesia services in this country start with reorganizing the structure of delivery, as indicated with the opt-out policy (Dower, Moore, & Langelier, 2013). Instead of anesthesia services being provided with physicians positioned in the supervision role, there is a need to restructure our anesthesia services in a parallel integrative delivery.

Affordability

Penchansky and Thomas defined affordability as the relationship between the prices of services and the consumer's ability to afford the services offered (Penchansky & Thomas, 1981). The medical direction model has been well studied from an econometric analysis perspective and found to be the least cost effective (Hogan, Seifert, Moore, & Simonson, 2010). Results show that the model of CRNAs practicing independently is the least costly option and captures the most profit for hospitals with the medical supervision model having the second lowest cost (Hogan et al., 2010).

Accessibility

Accessibility is defined as the relationship between the location of healthcare services and the patient's geographic location (Penchansky & Thomas, 1981). With implementation of the ACA, knowledge of where the various anesthesia providers exist and the population demographics they serve is of vital importance (Abraham, 2014). By 2014, 32 million additional people now have health insurance, and the Congressional Budget Office estimates that by 2023, an additional 13 million individuals will obtain coverage through Medicaid and 24 million will have exchange-based plans (Abraham, 2014). Although many of them already use the healthcare system, they are expected to seek more specialty care services, such as anesthesia (Kaplan, Brown, & Simonson, 2011). Surgery, labor and delivery, trauma stabilization, and pain management all require anesthesia professionals (Jordan, 2011). With an aging population and the millions of previously uninsured Americans moving into the healthcare system because of health reform, the need for anesthesia services will continue to grow (Jordan, 2011).

In 2010, the U.S. Department of Health and Human Services unveiled *Healthy People 2020*, a ten-year comprehensive plan for improving the health of all Americans (Daughtry et al., 2010). The plan is guided by twelve overarching goals, one of which is to improve access to health services. A key measure of this goal is to increase the number of Americans with a usual source of care by 10% by the year 2020 (Daughtry et al., 2010). In the wake of these efforts, it is important for health services administrators, policymakers, and other stakeholders to understand the complexities of "access" to a usual source of care. The framework of Penchansky and Thomas will be considered when analyzing the impact of the removal of CRNA supervision with the opt-out legislation to allow better access to anesthesia care for the populations (Penchansky & Thomas, 1981).

Methods

Search Strategy A search of the literature was performed in PubMed/Medline, EMBASE, Scopus, CINAHL, and the Cochrane Central Registry of Clinical Trials. Databases were searched for original research on the topics of opt-out, access, and anesthesia. Search time limits were set between January 1, 2001 and January 1, 2017 given the initial proposed opt-out ruling on January 18, 2001 and subsequent action into legislation on November 18, 2001 (American Association of Nurse Anesthetists, 2001). Corresponding exploded MeSH or EMTREE terms were used consistently across all databases (**Table A.2-1**). References, lists of retrieved articles, reviews, and meta-analyses were then scanned for secondary references. Manual search strategies included a snowballing technique to review "related articles" of all included studies not identified in the initial search. A library science professional was consulted to verify the inclusiveness of the search.

Articles published in English that investigated the topic of opt-out, access, and anesthesia were retained for this review. No set limits were imposed on study samples related to age or other patient demographics, geographic location of the study, or type of surgery. Studies were excluded if the focus of the investigation was not related to access to healthcare services or the delivery of the services. Studies not disclosing specific information on anesthesia, CRNAs, APRNs, MDAs, and workforce arrangement were also excluded. Full-length publications were selected. Clinical reviews, non-English publications, and letters to the editor were excluded. This search of the literature yielded 155 potentially relevant citations **(Figure 2-2).**

Study Design. The primary author independently screened all titles and abstracts for eligibility and conducted an additional screening process of publications retained for analysis to confirm the accuracy of meeting inclusion criteria. Study information including study design, study population, location, sample size, outcomes, limitations, and level of evidence were compiled into an evidence table **(Table 2-2)**. Analyses for the results from eligible studies were divided into common themes for reporting, which focused on differences among workforce patterns, SOP variations, and geographic imbalance of providers after the implementation of the opt-out practice legislation.

Levels of Evidence. The Preferred Reporting Items for Integrative Reviews and Meta-Analyses (PRISMA) guidelines were followed in the conduct and reporting of this review (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009). Studies were evaluated for methodological quality, informational value, and representativeness of anesthesia workforce and opt-out legislation, and strength of evidence was graded using Melnyk and Fineout-Overholt's (2011) seven-tier hierarchy rating system (level 1 - highest to, level 7 - lowest) (Daly et al., 2007). The review process was based on an analysis of data in the sample, data reduction, data display, data comparison, conclusion drawing, and verification carried out throughout the results section and key findings synthesized.

Results

This integrative review yielded 155 potential publications pertaining to the defined scope of content. After duplicates were removed, there remained 152 publications. Forty-two publications met exclusion criteria leaving 110 manuscripts for screening. Nineteen full-text articles were excluded from eligibility after not including search topic, as well as thirty-two editorials, yielding sixty-eight full-text articles for eligibility. Of these, twenty-four were retrospective studies, and fourteen were prospective cohort studies. The high yield of editorials raises concern for the lack of evidence existing on issues such as access. Some of the editorials were well balanced in their opinions and provided a basis to encourage the production of new evidence. Thirty-eight studies met inclusion criteria for synthesis and analysis, and these were categorized into three contextual themes based on the primary focus of the study: manpower (n = 19), scope of practice (n = 20), and access to anesthesia care specifically addressing rural and underserved populations (n = 12). The categories were not mutually exclusive, and therefore, fifteen of these investigations overlapped with two or three of these categories.

Category Characteristics

The cross-sectional distribution of publication year that addressed the primary categories was not balanced. As expected, most of the publications in the early 2000s focused on anesthesia manpower. Subsequently, a trend was noted when studies transitioning to anesthesia service methods with respect to quality, cost, and outcomes. In the more recent years from 2010 forward, research on CRNAs and opt-out legislation with regard to access to care, may have been influenced by the advent of the Institute of Medicine (IOM) *Future of Nursing Report* (2010) recommendations on removing SOP barriers (Institute of Medicine, 2010; Dower et al., 2013).

Manpower

Of this group of studies, three were designed as non-experimental, descriptive studies that used surveys to gather regional data (Abenstein, Long, McGlinch, & Dietz, 2004; Dexter, Ledolter, Smith, Griffiths, & Hindman, 2014; Fallacaro & Ruiz-Law, 2004). Dexter and colleagues looked at the quality of clinical supervision provided by MDAs who are supervising residents and CRNAs (Dexter, Logvinov, & Brull, 2013). MDAs' mean supervision scores were not positively correlated with total (weekly) hours of clinical activity. Mean average scores for MDA supervision were low with no correlation between CRNAs and residents (Dexter et al., 2014).

Studies addressing manpower dealt with workforce labor issues and geographic imbalance of anesthesia providers. CRNAs are the predominant anesthesia professionals in areas serving more Medicare beneficiaries and where there is a disproportionate number of persons insured with Medicare and less of private insurers (Liao et al., 2015). Conversely, MDAs are more likely to practice in geographic and hospital settings where there are relatively fewer Medicare beneficiaries and where private payment for anesthesia services is relatively high (Liao et al., 2015). Demographics for rural health providers indicate that those who are originally from a rural area are more likely to practice in this type of healthcare setting (Liao et al., 2015; Lindsay, 2007; Schubert, Eckhout, & Tremper, 2003). A common theme for preferences among rural providers is that they value greater autonomy, experience, and acceptance of non-physician providers (Daughtry et al., 2010; Jordan, 2011; Lindsay, 2007). Lindsay found that CRNAs preferred rural areas because they had fewer disputes about professional boundaries. These rural providers also tend to have a broader SOP and work longer hours in greater isolation with fewer resources.(Lindsay, 2007)

A study from the Rural Health Research Center (RHRC) reported that in nineteen states, the per capita number of CRNAs was the same or larger in rural areas compared with urban areas (Liao et al., 2015; Schubert et al., 2003). Three out of the nineteen states are opt-out states. Five states - California, Texas, Florida, New York, and Georgia -have shortages of both types of anesthesia professionals and are expected to have the largest potential influx of patients that account for more than 10 million newly insured patients with the ACA (Liao et al., 2015). Anesthesia shortages will likely continue to be an especially pressing problem in rural areas, which generally have an older population than urban and suburban areas (Liao et al., 2015). According to Daughtry et al. (2010), by 2020, the shortage of MDAs is expected to grow to 12,500, although there is projected to be a 3 % net annual increase in the supply of CRNAs showing a projected shortage of 4,479 MDAs by 2020 and a surplus of 7,970 CRNAs. The current supply of MDAs would have to increase by 3,800 to meet U.S. demand, and the current supply of CRNAs would have to increase by 1,282 to meet U.S. demand (Daughtry et al., 2010). One study predicted that procedures in non-hospital settings will increase overall from 4 to 7 % in five years (Fallacaro & Ruiz-Law, 2004). At the same time, hospital procedures are expected to decrease from 54 % to 44 % (Fallacaro & Ruiz-Law, 2004).

Abenstein and colleagues assessed whether improvements in quality of care with physician-directed anesthesia can be obtained at a cost deemed reasonable by societal standards (Abenstein et al., 2004). Survey results indicate that the mean cost difference of $1.75 in favor of CRNAs was not statistically significant. However, the economic implications of a small difference in reimbursement could be important considering that the average practice surveyed delivered 15,000 to 25,000 anesthesia encounters per year (Abenstein et al., 2004).

Kalist et al. compared the features of a labor market in the U.S. and how differences in regulation affect the earnings of CRNAs, and the extent of supervision of CRNAs by MDAs (Kalist, Molinari, & Spurr, 2011). There are differences in language of state statutes that can be used to persuade institutions within the state, for example, managed care organizations and hospitals, that certain anesthesia practice arrangements should be adopted. Additionally, less supervision exists in states that grant CRNAs a high level of professional independence.

In more recent literature, Quraishi and colleagues observed the volume of distribution of anesthesia services over a fifteen-year period from 2000-2014 (Quraishi, Jordan, & Hoyem, R. 2017). CRNA services represented the largest percentage increase of all billing modifiers, with an average 8.3% increase per year for allowed services and an average 7.5% increase per year for Medicare payments. In comparison, billing for anesthesiologist-only services decreased from 33.2% to 25.8% of their AA billing modifiers over the study period (Quraishi et al., 2017). When more healthcare services are undergoing scrutiny to achieve cost-efficient, value-driven care, the increased use of the CRNA independent billing modifier highlights a change in how the anesthesia workforce is used while aligning with federal and state regulations (Quraishi et al., 2017).

Scope of Practice

Articles in this section illustrate the complexities of studying facilities with anesthesia care teams and the difficulty of developing generalizable measures of productivity, tasks, attitudes, and characteristics of CRNAs and MDAs working together. SOP for CRNAs working in the team setting varied between hospitals within the same state as well as occasionally within the same hospital (Minnick & Needleman, 2008b). Five studies had non-experimental designs surveying CRNAs, anesthesiologists, and hospital administrators (Daughtry et al., 2010; DesRoches et al., 2013; Dexter et al., 2013; Kaplan et al., 2011; Minnick & Needleman, 2008). There was a reported widespread variation in CRNA practice roles that created a need to better understand the salient features of the CRNA SOP. The SOP includes all components of anesthesia care delivery from pre-anesthesia assessment and implementation of care to the management of a patient's postoperative course. CRNAs practice within a restricted scope, in which their practice is limited, and in some cases, they cannot personally perform procedures without an MDA present (Dumouchel, Boytim, Gorman, & Weismuller, 2015). Overall, CRNAs report that they spend nearly 75% of their clinical time doing procedures or intraoperative tasks while MDAs spend 66%, somewhat less than CRNAs (Daughtry et al., 2010). This is ultimately due to the supervisory role the MDA assumes in the anesthesia care process.

In 2009, Jones et al. reported 27% of CRNAs practice in non-medically directed or unsupervised settings, and 73% practice in medically-directed environments (Jones & Fitzpatrick, 2009). Taylor found that the SOP of CRNAs was positively correlated with collaboration in that the broader the CRNAs' SOP, the more favorably they viewed collaboration (Taylor, 2009). However, as the percentage of practice with MDAs increased, the CRNAs' positive attitudes toward collaboration were significantly decreased (Taylor, 2009). Dumouchel et al. reported higher CRNA morale distress in medically supervised settings than in independent practice settings (Dumouchel et al., 2015).

Negrusa and colleagues were the first to test whether states with SOP laws allowing CRNAs to practice independently experience the same risk of anesthesia complications as states that require supervision or direction/collaboration (Negrusa, Hogan, Warner, Schroeder, & Pang, 2016). There was no evidence that the odds of a complication differ by SOP or delivery model. In the current healthcare delivery environment, which focuses on reducing cost, increasing patient safety, and interdisciplinary practices, MDAs and CRNAs need to achieve consensus regarding optimal utilization of both types of providers in ACTs in their respective full SOP (Alves, 2005). With the elimination of supervision provisions for CRNAs, it may be possible to overcome many constraining issues and support CRNA full SOP.

Access to Care for Rural and Underserved Populations

Nine studies looked at access to care using workforce data in relation to population density and practitioner location as a way to determine access to anesthesia services (Abraham, 2014; Atiyeh, Gunn, & Hayek, 2010; Daughtry et al., 2010; Fallacaro & Ruiz-Law, 2004; Kullgren & McLaughlin, 2010; Liao et al., 2015; Matsusaki & Sakai, 2011; Seibert et al., 2004). Of these studies, five consisted of descriptive studies using survey methodology looking at regional data (Abraham, 2014; Atiyeh et al., 2010; Daughtry et al., 2010; Fallacaro & Ruiz-Law, 2004; Kullgren & McLaughlin, 2010). Three studies were non-experimental surveys that used established datasets and panel surveys from various years to account for healthcare services across the nation (Abraham, 2014; Fallacaro & Ruiz-Law, 2004; Kullgren & McLaughlin, 2010). All of the studies tried to define certain characteristics for CRNAs' and MDAs' choices for methods and location of practice. Many of these studies focused only on location of practice settings but Liao's work advanced this area of investigation by correlating with the location of CRNA patient provider and patient demographics including insurance and socioeconomic status (Liao et al., 2015).

There remains a clear urban/rural difference in the anesthesia labor market. The primarily urban geographic distribution of anesthesiologists has continued since the 1980s. Studies that are more recent continue to provide evidence that CRNAs are the primary anesthesia provider in more rural and underprivileged hospitals (Daughtry et al., 2010; Fallacaro & Ruiz-Law, 2004; Seibert et al., 2004). Daughtry et al. and Fallacaro et al. both reported that rural facilities are more likely to employ CRNAs and less likely to employ MDAs (Daughtry et al., 2010; Fallacaro & Ruiz-Law, 2004). CRNAs and MDAs tend to work separately more often in rural areas than in urban ones (Abraham, 2014; Fallacaro & Ruiz-Law, 2004; Seibert et al., 2004). Liao and colleagues also suggested that issues around access to care are more apparent at the local level such as in rural and inner city areas (Liao et al., 2015). CRNAs are more likely to practice in locations where low-income, Medicaid, and uninsured patients reside. As such, if these vulnerable populations were in need of anesthesia care, CRNAs are more readily available to provide the required care (Liao et al., 2015).

From a national perspective, many uninsured adults face nonfinancial healthcare barriers in addition to their well-documented financial challenges. Health reform efforts must address both types of barriers in order to maximally improve access for the uninsured population (Kullgren & McLaughlin, 2010). Abraham et al. reported that economic factors that affect access or eligibility to insurance were identified as median household income, poverty, and unemployment (Abraham, 2014). The importance of these variables were the fundamental foundation of the ACA and its implications on improving access to insurance by expanding Medicaid eligibility and opening the health insurance marketplace for the uninsured (Dower et al., 2013). Together these variables represent a set of interrelated socioeconomic factors that affect healthcare access to anesthesia services and resources. In all of the above studies, these variables were chosen as a proxy for anesthesia access and therefore the need for greater accessibility to these services.

Discussion

From the results of this review, the following three key themes were identified: the workforce distribution of anesthesia providers was not successfully meeting the needs of populations to be served; the SOP regulations significantly affected the practice potential of providers; and the need for a more standardized model of measurement for access to care. Understandably, the articles discussed have at times an underlying political perspective, as they reflect the rising cost of healthcare and measures directed to respond to these costs. The studies also tend to endorse professional advancement or promotion of both MDA and CRNA groups.

Workforce Distribution of Anesthesia Providers

Current and predicted shortfalls to anesthesia manpower can be explained by the growth of an aging population, increasing demand for surgery, changes to working hours, migration of anesthetists, pressure on healthcare costs, and in some states a reduction in the number of medical graduates choosing to specialize in anesthesia (Egger Halbeis, & Macario, 2006; Liao et al., 2015). Similar pressures are seen in other fields of healthcare, resulting in a trend toward the use of a nurse-led rather than a traditional physician-led service (Lindsay, 2007). This theme of workforce distribution aligns itself with the *Availability* concept from the Penchansky and Thomas model. The supply and demand of anesthesia providers may not meet the needs of our growing and aging population that require surgical and anesthesia services.

A serious concern regarding anesthesia care is that much less is known about the developing needs and provisions in rural and remote areas than about urban areas (Atiyeh et al., 2010). Modern surgical techniques with more minimally invasive approaches can be brought to rural areas. Sophisticated surgery, requiring anesthesia services, can thus be performed in a high-volume and cost-effective manner, even in temporary settings (Atiyeh et al., 2010). Urban hospital networks have been far more extensive than in the past with their outreach to provide services in these suburban and rural communities more than they have been in the past. The development of business models used to direct the expansion of medical practices has pushed hospital services out into the communities by developing practices in clinics and surgical centers, or at least collaborations with the organizations already present in the community. This has promoted a stronger and more lucrative practice for health systems. These considerations lend themselves for the need to provide greater access to anesthesia services and the use of opt-out legislation and the opportunity for CRNAs to practice independently.

Scope of Practice Regulations

Issues regarding CRNA SOP entail restrictive language specifying the extent of physician involvement in the delivery of anesthesia. A restrictive SOP for CRNAs is a policy mandating the requirement for physician supervision, such as either in the ACT model being enforced at the facility level or in the state law (Daughtry et al., 2010; Lindsay, 2007). Examples of such restrictions include supervision, immediate presence, timely onsite consultation, and physical presence and availability on the premises (Lindsay, 2007). Such regulations that define legal SOP pose a concern that they will not support workforce innovations needed for an evolving healthcare system. These laws and regulations limit the effective and efficient use of the anesthesia workforce by causing inequities between professional competence and legal SOP. Additionally, the regulations have a lack of uniformity across states. The challenges with SOP issues directly relates to the *Accommodation* (clients' needs) and *Acceptability* (provider preference and expectations) from the Penchansky and Thomas model. Removing CRNA SOP barriers and increasing public awareness of CRNA availability will help to better serve patients' needs with the delivery of anesthesia and set better expectations.

Efforts to reduce healthcare spending focus on decreasing costs and providing mechanisms intended to increase quality. To lower costs, informed purchasers of healthcare services may seek lower-cost professionals and methods of care delivery, which in some circumstances will reduce, and in others increase, demand for CRNA services. This will shape and potentially enhance SOP for CRNA and increase the demand for CRNA services. As these changes evolve, the type of practitioner providing care will become less important than the result of treatment, further eroding the artificially defined SOP boundaries.

As Dower et al. argued, such reforms are needed to strengthen the practice of healthcare professions, including aligning scopes of practice with professional competence for each profession in all states (Dower et al., 2013; Lindsay, 2007; Wilson, 2012). This includes the need to reassure the regulatory flexibility that recognizes overlapping roles for health professionals. Ultimately, healthcare professionals need to provide the best evidence for practice and have the public base make a well-informed decision based on reported outcomes. Abraham et al. believe that workforce innovations needed to implement the 2010 ACA programs require an adaptable regulatory system capable of evolving with the healthcare environment (Abraham, 2014). The healthcare professions regulation system in place today does not have the flexibility to support these changes.

Access to Care, Patient Satisfaction, and a Standardized Model of Measurement

Barriers that prevent fully qualified individuals from providing care independently are not optimizing the healthcare delivery system. The ACA of 2010 proposes to offer the ability for patients to gain better access, afford quality care, reduce costs, and allow for an educated healthcare decision (Dower et al., 2013). These goals would be better supported by knowing who is delivering the anesthesia and what model would be more efficient and cost effective for them. *Affordability* and *Accessibility* from the Penchansky and Thomas model supports defining access by cost and location of services. These concepts can be measured with tangible means by location of provider to patient and how much the patient will be paying for those services. Changes in the healthcare environment due to the ACA seek to expand healthcare to thirty million or more people. This will require more of an interdisciplinary approach to care than what exists at present. To accomplish this, the MDAs cannot be the sole or principal provider of anesthesia care (Malina & Izlar, 2014). Outcomes from the literature previously studied on anesthesia providers on cost and mortality are no longer in question. Therefore, to identify a model that could best complement the intentions of the ACA would appeal to both the hospital administrators' and the public's interest.

Conclusion

Historically, but even more so in the last decade since the opt-out ruling, CRNAs have had their ability to practice independently continuously challenged. Their education and training, skills, and quality of care have been brought into question by physicians seeking to block efforts for independent CRNA practice. The opt-out legislation, within the field of anesthesia has been met with more resistance by physician groups. Needed political action efforts include lobbying state politicians to influence governors to acknowledge the opt-out policy. This policy is a significant domain that affects independent practice for CRNAs. Additionally, other factors of workforce distribution, practice restrictions, and geographic imbalance of anesthesia services could have a direct impact on the public, health systems, and policy makers.

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CHAPTER THREE: PUBLICATION TWO - THE IMPACT OF OPT-OUT LEGISLATION IN CALIFORNIA ON ANESTHESIA SERVICES COMPARING ACROSS THREE DELIVERY METHODS

Abstract

Background: In 2009, California passed legislation acknowledging the Centers for Medicare and Medicaid Services (CMS) permitting states to opt-out of physician supervision of certified registered nurse anesthetists (CRNAs).

Purpose: We examined the effects of opt-out legislation on access to care, anesthesia service charges, and length of stay (LOS) with CRNA independent practice.

Methods: A secondary analysis was conducted on 2008 (pre opt-out) and 2013 (post opt-out) California CMS Medicare Part B claims data. Mixed linear modeling assessed differences in outcomes when controlling for patient, surgical, and clinical characteristics across three methods of delivering anesthesia care.

Findings: Post opt-out legislation was associated with significantly higher patient volume and lower anesthesia service charges for independent CRNA anesthesia care compared to anesthesiologist alone and anesthesiologist and CRNA collaborative models. LOS was similar for all three delivery methods.

Discussion: CRNA independent practice can lead to greater access to anesthesia care and reduce anesthesia charges.

Keywords: Anesthesia, Nurse Anesthetists, Medicare Legislation, Opt-out Legislation

The Impact of Opt-Out Legislation in California on Anesthesia Services Comparing Across Three Delivery Methods

Submission to *Nursing Outlook* (No Word Limit)

Introduction

Surgical anesthesia in the United States (U.S.) is administered by anesthesiologists (MDA) and nurse anesthetists (CRNAs). CRNAs are anesthesia professionals who safely administer more than 49 million anesthetics to patients annually in the U. S., according to the American Association of Nurse Anesthetists (AANA) 2019 Member Profile Survey (American Association of Nurse Anesthetists, 2019). In many circumstances, MDAs and CRNAs work collaboratively as an anesthesia care team (ACT), through established arrangements to provide anesthesia services. These teams function in various ways to share responsibilities in delivering care related to surgical services, procedural sedation, and pain management. However, CRNAs and MDAs can work independently of each other, assuming total responsibility for the delivery of anesthesia care. CRNAs are not required by federal or state law to work with anesthesiologists, but in many healthcare settings, the ACT is commonly employed as the default method of anesthesia delivery. Because there are various patterns for distribution of labor across anesthesia teams, ACTs represent variations of care that are not standardized. For example, CRNAs and MDAs can work independently of each other, assuming total responsibility for care. In some health systems, all three practice methods (MDA independently, CRNA independently, and MDA/CRNA team or ACT) are used concurrently. Ratios of MDAs or proceduralists supervising CRNAs differ by facility. Therefore, the variation of methods within the facilities makes it difficult to measure the outcomes or impact from the type of anesthesia provided.

These three anesthesia care delivery methods have been investigated and discussed in the research literature (American Association of Nurse Anesthetists, 2019). The extent to which CRNAs require supervision through the ACT is determined at the facility level and guided and/or regulated by federal, state, and insurer regulations. On November 13, 2001, the Executive Branch of the U.S. Federal Government, intending to increase access to anesthesia care, released Conditions of Participation for the Medicare and Medicaid programs (*Medicare and Medicaid Programs; Hospital Conditions of Participation: Anesthesia Services, 42 CFR 482.52)* allowing states to opt-out of the federal requirement that a physician supervise the administration of anesthesia given by a CRNA (Federal Register, 2001). Prior to this legislation, CMS required CRNA supervision by a physician, either an anesthesiologist or proceduralist, as a condition for reimbursement for provider services and payments to healthcare facilities for the respective CRNA's services. The 2001 Condition of Participation was significant in that it did not require physician supervision of CRNAs for payment for services. For opt-out of supervision to occur, the governor of each state must issue a letter attesting that consultation with the state medical and nursing boards about access to and quality of anesthesia services was completed, that citizens would benefit from removal of the supervisory requirement, and that opt-out is consistent with state law (Federal Register, 2001). Before adopting opt-out, for example, California's governor had to meet these requirements and determine that this exemption was consistent with state law and in the interests of the people of

California (American Association of Nurse Anesthetists, 2010). Since the conditions of participation were announced, nineteen states have opted out with ten of these states basing their decision on increased access to anesthesia care. States adopting the opt-out Medicare regulation allow CRNAs to practice to the fullest extent of their license and scope of authority promoting independent practice (Sun, Dexter, & Miller, 2016; Sun, Miller, & Halzack, 2016).

The opt-out legislation is not the only regulation affecting independent practice for CRNAs as other advanced practice nurses (APRNs) face barriers to independent practice in the form of facility policies and scope of practice (SOP) regulations defined by individual states. There have been ongoing debates by medical professional societies and state medical boards that have continuously challenged CRNAs' ability to practice independently and lobbied to prevent the expansion of opt-out legislation to other states. Medical societies and boards have questioned CRNAs' education and training, skills, and level of quality care, despite compelling evidence of the safety and quality of CRNA practice (Neuman & Martinez, 2011). In January 2017, the Veterans Health Administration (VA) granted full practice authority to nurse practitioners, clinical nurse specialists, and certified nurse midwives. This legislation was designed to increase veterans' access to VA health care by expanding the pool of qualified healthcare professionals authorized to provide primary healthcare and other related healthcare services to the full extent of their education, training, and certification. However, this legislation did not apply to CRNAs (United States Department of Veterans Affairs, 2016). The VA claimed there was not an access to anesthesia care problem in VA facilities, despite independent evidence to the contrary (United States Department of Veterans Affairs, 2016). The VA has to acknowledge that a problem exists before the problem can be solved. By granting full practice authority to CRNAs, the VA would make full use of more than 900 CRNAs already practicing in VA facilities (American Association of Nurse Anesthetists, 2020; United States Department of Veterans Affairs, 2016).

Considering the impact of the VA ruling on limiting CRNA independence, broadening the scope of practice is both necessary and inevitable. In a recent AANA document, reviewing the current VA system, an independent assessment identified delays in cardiovascular surgery for lack of anesthesia support, rapidly increasing demand for procedures requiring anesthesia outside the operating room, and slow production of colonoscopy services in comparison with the private sector. Extending Full Practice Authority to CRNAs and other APRNs will expand veterans' access to these critical services (American Association of Nurse Anesthetists, 2020; United States Department of Veterans Affairs, 2016).

Allowing CRNAs to practice in the VA system and across the U. S. without supervision would potentially alleviate the shortage of anesthesia providers and lead to greater access to anesthesia care. There are currently 30,000 MDAs practicing in the U.S., down from 35,000 over the past ten years (Moghim, 2017). According to a 2012 ASA survey results, it was estimated by 2020, the shortage of MDAs is expected to be down another 12,500 (Moghim, 2017). Meanwhile, the ASA projected a surplus of about 8,000 CRNAs (Moghim, 2017). There is, in fact, a capacity for greater use of CRNAs across the nation. Since there is a projected surplus, the capacity to utilize opt-out to its fullest extent across the array of anesthesia methods is necessary. The future direction of healthcare should include greater emphasis on team-based care while promoting these various providers, such as CRNAs, to practice to the fullest extent of how they were trained and certified. However, few studies have examined the impact/outcomes of opt-out in states that have chosen to apply it. Studies that examine the impact of opt-out should address access to care, anesthesia care-related costs, and LOS, among other parameters.

Studies to Date

To evaluate outcomes of opt-out decisions, Dulisse et al. (2010) studied opt-out states and non-opt-out states from a Medicare database to assess inpatient mortality and the rate of anesthesia complications. Their findings revealed no evidence that opting out of MDA oversight requirements resulted in an increase in inpatient deaths or complications (Fassett & Calmes, 1995). Following the implementation of the opt-out legislation, the U.S. Agency for Healthcare Research and Quality (AHRQ) was charged with assessing whether anesthesia outcomes differed between opt-out states and other states (Dulisse & Cromwell, 2010; Schneider, Ohsfeldt, Li, Miller, & Scheibling, 2017). The study analyzed Medicare data from 1999 through 2005, so they could see the data before and after opt-out legislation, and reported no evidence of increased inpatient deaths or complications in states that opted out of the oversight requirement by an anesthesiologist (Dulisse & Cromwell, 2010; Schneider et al., 2017). A recent Cochrane review concluded that no definitive statement could be made concerning the superiority of one anesthesia care provider over another (Lewis, Nicholson, Smith, & Alderson, 2014).

Studies of costs and expenses revealed similar findings. Sun et al. (2016) utilized data from the National Inpatient Sample (NIS) to assess whether opt-out was associated with an increase in the percentage of patients receiving a therapeutic procedure for appendicitis, bowel obstruction, choledocholithiasis, or hip fracture (Sun et al., 2016). Additionally, Sun et al. (2016) analyzed claims data from Medicare fee-for-services to detect differences in average anesthesia utilization rates three years before the 2001 opt-out legislation and three years after the California state legislation (1999 to 2011) between opt-out and non-opt-out states (Sun et al., 2016; Sun, E.C., Dexter, F., Miller, T.R., & Baker, L.C., 2017). These investigators concluded in both studies that no differences existed for average anesthesia utilization rates after opt-out legislation was passed. However, California was an exception, experiencing an overall 5% increase in utilization rates after opt-out legislation was enacted (Sun et al., 2016, & Sun et al., 2017). This increase was not further analyzed to determine if differences were related to different anesthesia providers or improved access to services.

More recently in 2018, Sun et al. used health insurance claims for a random 20% sample of U.S. Medicare beneficiaries enrolled in the traditional fee-for-service Medicare plan. Their retrospective analysis of national claims data between 2004 and 2011 examined differences in inpatient mortality, spending, and length of stay (LOS) between cases where an anesthesiologist supervised an anesthesiologist assistant compared to cases where an anesthesiologist supervised a nurse anesthetist. Their unadjusted LOS was higher for cases with anesthesiologist assistant care teams 95% CI (6.7 *vs*. 6.4 days; p = .06), but the risk-adjusted LOS was approximately 6.4 days for both groups, with 95% CI, (6.4 to 6.7) for nurse anesthetists *vs*. 95% CI, (6.3 to 6.5) for anesthesiologist assistants. These data did not adjust for provider experience or differences in supervision ratios between anesthesiologist assistants and CRNAs. Also, differences in case assignment based on unobservable measures of patient complexity were only reflective of each specific given hospital examined. The facility differences were not analyzed in the data. There were no significant differences between patients who received care from an anesthesiologist assistant care team compared to those who received care from a CRNA care team for most of the facility and patient characteristics. The supervision ratios are more conservative with a medical direction method for MDA and anesthesiologist assistant to remain less than 1:4 and at a higher cost than the CRNA/MDA team. Anesthesiologist assistants can only practice with an MDA supervision at this very conservative ratio. Additionally, they do not require a background of a medical or nursing degree.

In the past twenty years, the debate regarding cost effectiveness of different care patterns although not necessarily opt-out implications have increased, fueled by both insurers and health systems attempting to minimize healthcare costs and provide a greater service to patients. Cromwell & Snyder (2000) examined payment characteristics of different ACTs and different employment arrangements. The all-MDA anesthesia care delivery was used as the control practice to which the other scenarios were compared. Results showed that an ACT with ratios of 1:4 MDA: CRNA was 59% of the cost of an

MDA-only care delivery. The researchers determined that an all-MDA practice was the most expensive. The least expensive was an independent practice method with two CRNAs for every MDA. A group of studies (Abenstein, Long, McGlinch, & Dietz, 2004; Cromwell & Snyder, 2000; Hogan, Seifert, Moore, & Simonson, 2010) focused on cost effectiveness of anesthesiologists compared to CRNAs via simulated cost mockups and showed the CRNA-only methods was significantly more cost effective than an MDA-only method. Even as the evidence of cost effectiveness of CRNAs exists and is fairly robust, there are still gaps in the literature examining cost and the impact of opt-out legislation. Given the variation in supervision ratios of CRNAs and anesthesiologist, it is important to analyze and contrast the cost effectiveness of at least the three major anesthesia care delivery methods.

Study Design

Previous studies of opt-out legislation have focused on access to care, but few have addressed the financial implications of opt-out and clinical outcomes beyond mortality and anesthesia-related outcomes. We examined the impact of the opt-out legislation on access to care, anesthesia service charges, and LOS across the three anesthesia care delivery methods (MDA or CRNA alone, or ACT) using California CMS Medicare Part B claims data. Using CMS data from California, an early adopter of the opt-out and a state utilizing the three anesthesia care delivery methods, allowed us to test differences in these outcomes before and after imposing the opt-out legislation. The focus on California is largely due to the ability to capture a large percentage of the population requiring anesthesia services through both CMS and other publicly available data. The share of

Medicare spending in California is equal to the national level of 20%. A report in 2015 from CMS estimated that U.S. national health expenditures (NHE) totaled over $3 trillion. In California, healthcare expenditures in 2016 were estimated to total more than $367 billion, with Medicare beneficiaries spending $74.7 billion (20.3%) of the total cost (Sorensen et al., 2016; Tatum et al., 2014). So, California is closely representative of a generalizable national sample.

The Affordable Care Act has greatly increased the numbers of Californians with health insurance. Since the ACA implementation, 3.8 million Californians obtained insurance from the state's health exchange (Sorensen et al., 2016; Tatum et al., 2014). While increasing the numbers of insured Californians can be recognized as a success, it also raises the question of whether these newly insured Californians might actually be able to access health care. There are still barriers to entry of patients to healthcare services in California. Prior to the ACA, the number of physicians was inadequate to meet the needs of the population. With declining health status, retiring physicians, and chronically low reimbursement rates for these physicians, a growing pool of insured patients will exacerbate the problem of access to care (Sorensen et al., 2016; Tatum et al., 2014). If we are going to support opt-out legislation with its intent to increase access to anesthesia care, there is a need to examine the legislation specifically in California before and after the 2009 enactment.

Methods

This study is a secondary analysis examining the effects of anesthesia care delivery methods on access to care (patient volume), LOS, and anesthesia service charges using data from patients receiving anesthesia for surgical services in California hospitals and outpatient facilities in 2008 (prior to opt-out) and 2013 (after opt-out legislation). This comparative design is used to examine the change in outcomes, anesthesia procedure charges, and LOS, while adjusting for changes in patient factors over time (e.g., surgical volume, surgical complexity, and patient acuity) in the three anesthesia delivery types before and after opt-out legislation implementation **(Table A.3-1).** Prior to receiving the CMS databases with protected health information (PHI), investigators complied with necessary requirements outlined in the CMS contractual agreement for investigator training and storage for CMS data. The University of Pennsylvania Institutional Review Board reviewed and approved the study protocol.

Data were retrieved from the Medicare Part B National Data Files from 2008 and 2013. These files incorporate all Medicare Fee-for-service Part B Physician/Supplier data for allowed services, charges, and payments for each procedure. The dataset is designed so one can identify total allowed anesthesia service charges and total allowed Medicare payments by a Healthcare Common Procedure Coding System/Current Procedural Terminology (HCPCS/CPT) in relation to prominent CMS billing identifiers. For identification of anesthesia procedures, anesthesia codes (HCPCS/CPT 00100-01999) was used.

Patient data were identified using five CMS databases: MedPAR Research Identifiable File (RIF), Carrier RIF, Outpatient RIF, Master Beneficiary Summary File, and the Provider of Services (POS) file. Additionally, publicly available data from the California Office of Statewide Health Planning and Development (OSHPD) was incorporated for additional anesthesia provider and facility information including type of facility, location, and provider identification. The sample initially included just under five million beneficiaries who received anesthesia care for surgical procedures in either 2008 or 2013. However, the overall final sample with complete data across datasets yielded approximately a total sample of 300,000 patient Medicare claims for those encounters.

Independent Variable: Anesthesia Care Delivery

The primary independent variable of interest, anesthesia care delivery, was assigned using anesthesia service types identified by CMS claims billing modifiers. These modifiers are a two-position alpha or numeric code appended to a CPT code to clarify the services being billed. Modifiers provide a means by which a service can be altered without changing the procedure code. The study sample was divided into the three anesthesia care delivery methods that were defined by CMS claims billing modifiers. We evaluated patient outcomes across the three anesthesia delivery methods: 1) MDA independently, 2) CRNA independently, and 3) MDA/CRNA also known as an anesthesia care team (ACT). Claims were limited to those with billing modifiers that included: AA to denote MDA working independently (MDA only); AD, QX, QK, and QY to designate physician medically directing or supervising a CRNA or anesthesiology resident (ACT); and QZ to indicate when a CRNA works independently (CRNA independent). A decision was made on collapsing the ACT model to include supervision of either CRNA, anesthesia resident, and even student nurse anesthetist by the various modifiers listed for ACT by definition bill for any non-physician anesthetist provider. The supervision ratios required for billing do not reflect the levels of training adequately enough to study respective outcomes for each provider (e.g. CRNA, medical resident, student nurse anesthetist) and thus this is the reason for collapsing all of these providers into the ACT method. The determination of the anesthesia delivery arrangement was obtained by claims files from both MDAs and CRNAs associated with the procedure claims of patients undergoing the respective HCPCS coding.

Additionally, we used modifiers to help eliminate the appearance of duplicate billing and unbundling. Modifiers increased accuracy in reimbursement, coding consistency, editing, and to capture payment data. There are two types of staffing patterns and billing ramifications: medical direction or medical supervision. Medical direction requires compliance with regulations and limits MDA to directing four or less CRNAs. Medical supervision requires that the MDA does not have to be physically present consistently for the duration of the procedure. A single MDA can supervise more than four concurrent cases, and therefore more than four can be performing other patient services while cases are being managed by a CRNA.

Outcome Variables: Length of Stay and Anesthesia Service Charge

The main outcomes of interests included assessing changes in LOS and anesthesia procedure charges prior to and after opt-out legislation using 2008 and 2013 CMS files, respectively. LOS was defined as the number of days between the admission and discharge dates plus one day so that a patient admitted and discharged on the same day had a LOS of one day.

Anesthesia service charges were derived from the CMS MedPAR file and define the total anesthesia charge amount (rounded to whole dollars) for anesthesia services provided during the beneficiary's stay. Medicare reimbursement for anesthesia is unique because of its own anesthesia fee schedule and billing modifiers that dictate the level of involvement by an MDA for reimbursement. For Medicare billing, CMS *Claims Processing Manual* explicitly describes how CRNAs and MDAs should bill for procedures (Centers for Medicare and Medicaid Services, 2001). Medicare anesthesia services are permitted 100% of the allowed reimbursement except for the medical direction (AD) modifier, which receives less.

The functions of modifiers determine the following: whether the allowed service can be billed at the medical direction rate based on the Tax Equity and Fiscal Responsibility Act of 1982 (TEFRA) requirements; and allocation of the percent of reimbursement for an allowed service based on provider type procedures (Centers for Medicare and Medicaid Services , 2001). More specifically, the CRNA-only and MDA-only modifiers are permitted 100% of the allowed reimbursement. However, the ACT modifier used by the anesthesiologists (which reflects the medical direction rate and case concurrency) is permitted at only 50% of their allowable reimbursement rate, and the modifier used by CRNAs consists of 50% of their allowable reimbursement rate. It is often the complexity of anesthesia billing coupled with determining adequate anesthesia workforce relative to reimbursement that poses a major hurdle for billers, administrators, providers, and researchers (Quraishi, Jordan, & Hoyem, 2017).

Patient Variables

Patient characteristics such as beneficiary identifier, patient demographics (e.g., age, gender, location), and comorbidities were identified from the CMS claims dataset **(Table**

A.3-2). The Elixhauser Comorbidity Index was used to quantify patients' acuity levels, or a proxy for case complexity, based on their comorbidities (Elixhauser, Steiner, Harris, & Coffey, 1998; Moore, White, Washington, Coenen, & Elixhauser, 2017). The Elixhauser set of comorbidities is frequently used for risk adjustment (Elixhauser et al., 1998). To determine the presence of a comorbidity, all of a beneficiary's inpatient, outpatient, and carrier claims that were filed during the two years (2008 and 2013) for surgery and anesthesia services were examined. Patients were assigned a comorbidity if they had at least one claim with a relevant Qualifying *International Classification of Disease*, Ninth Edition, diagnosis code (Elixhauser et al., 1998).

Surgical Variables

Surgical characteristics were identified using surgical procedures listed within the CMS files, known as Healthcare Common Procedure Coding System (HCPCS), which are derived from CPT codes. Those procedures were grouped based on varying complexity and anatomical region consisting of head, neck, chest wall, thoracic, upper abdominal, lower abdominal, pelvis, perineum, spine, upper leg, and knee **(Table A.3-3).**

Statistical Analyses

The dataset was merged on Medicare beneficiary ID for each of the separate years of 2008 and 2013 with the additional variables of age, gender, surgical procedure, Elixhauser comorbidities, facility type, and anesthesia group **(Table A.3-4) (Table A.3-5).** Once the analyzable dataset was composed, descriptive statistics were calculated for both pre- and post- periods including, means, standard deviations, medians, and interquartile ranges (for continuous variables), and frequency counts and percentages (for categorical variables) for all variables of interest. Sample characteristics were compared using z tests, ANOVAs, and chi-square tests to detect any statistically significant between-group and year difference. Missing data were addressed by identifying that any values missing at random would have little effect on outcomes of interest. Therefore, no further sub-analysis of missing data was necessary. Additionally, given duplicate patient claims, a decision was made to remove duplicate claims so that only the initial claim documented per beneficiary were included.

To examine changes in outcomes as a result of opt-out status, while accounting for facility-level time-invariant unmeasured confounders, a three-level hierarchical (patient, anesthesia provider, and facility level) mixed linear modeling (MLM), or multilevel model was constructed. The MLM technique is appropriate for nested structures as per the design for this study, where beneficiary (level one = micro level) is nested within the anesthesia provider (level two = macro level), and the facility where procedures occur (level three = facility). MLM is commonly used in studies of surgical patient populations to account for clustering, whether it be among patients undergoing a common procedure, those who are treated by a common provider, or those admitted to a common facility. The appropriate use of analytic methods such as MLM helps produce more accurate inferences that can ultimately inform patient and anesthesia care (Tan, Qu, Mascha, & Schubert, 1999).

The flexibility of an MLM approach accounts for varying patterns of missing data as well as varying timing of the measures due to the collinearity between observations within each level. For this study, it was anticipated, for certain outcomes, there may be many observations of beneficiaries in the data collection, whereas for others there may be single point in time data (e.g. rarely used or complex procedures performed on unique patient populations), all of which can be accommodated via MLM. Furthermore, cross-level interactions can be tested (e.g. procedure type and anesthesia care delivery type) (Aguinis, Gottfredson, & Culpepper, 2013). This modeling technique offered the ability to identify sources of variation between the patient, anesthesia provider, and facility levels, the interaction between variables at different levels, and more precise estimates of patient-specific effects. Multilevel modeling consists of using generalized estimating equation (GEE) for nonlinear outcomes and regression for continuous outcomes (e.g. MLM). Often in MLM, a sequence of less restricted/more complex models may be tested to assess model change and, in part, guide model selection (Burnham & Anderson, 2002).

Model Selection

For both outcomes (LOS and anesthesia service charges) a null model (intercept only model) and a simple model (facility, anesthesia care delivery type, and beneficiary ID) without controlling for any confounding or testing predictor variables were generated and compared **(Table A.3-6)**. The goodness of fit (GOF) was compared using the Akaike Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and proportional change in variance (PCV) between the simple model and subsequent models with more adjustment variables (patient characteristics, anesthesia provider, and facilities). Each subsequent model was tested for random effects in four steps (Wagenmakers & Farrell, 2004). First, an unconditional means model was used to determine the significance of the one random-effect term. The unconditional means model also provided an estimate of the intraclass correlation coefficient (ICC), which describes the portion of the total variance that is attributable to clustering within the data **(Table A.3-7).** Second, patient-level variables of age, gender, surgical procedure, and Elixhauser comorbidities were added. Third, a facility-level variable was added. Finally, we incrementally tested all patient, provider, and facility variables with random effects **(Table A.3-8).** This resulted in all models having the following random effects including age, gender, surgical procedure, Elixhauser comorbidities, and facility type.

In comparing the simple and full models, we first tested the simple model with no predictors, and the intercept (e.g. anesthesia care delivery type) was statistically significant ($p < .001$). When testing the mean average LOS between facilities, there was a high degree of variability found between LOS and facilities **(Table A.3-9)**. The ICC was 0.522 (95% confidence interval (CI) [0.497, 0.704] $p < .001$). In testing the Estimates of Covariance Parameters, the variance for facilities was 59.19% ($p < .001$). If the ICC was smaller between our simple and full models and between facilities (hospital and ASC), this would indicate a further need for multiple regressions to test a violation of independence. The residual error reduced from 54.03 to 33.33 when accounting for this variability at the facility level. This indicates that even when adjusting for the variability within the groups, and between pre- and post-opt legislation years in the model, there was a proportionate reduction in unexplained variance in the final full model with the interaction term, the 2008, and the 2013 full models accounting for any random effects.

This initial model assessment was followed by a more formal linear MLM analysis to test for overall pre- and post-differences while adjusting for random effects and controlling for any confounding effects, including age, gender, surgical procedures, and patient comorbidities accounted for separately from the list of Elixhauser comorbidities (Elixhauser et al., 1998; Moore et al., 2017). Patient comorbidities were added to the MLMs to measure patient acuity or complexity across the three anesthesia care delivery types for the two time periods before and after opt-out legislation. The intention was to control for patient and surgical characteristics that can influence the occurrence of the outcomes of LOS and service charge. Using MLM accounts for clustering at patient and anesthesia provider level and enables a more precise understanding of the effect of independent variables (e.g. anesthesia care delivery type) on the outcomes (e.g. LOS and anesthesia service charge amount) **(Table A.3-10).** Therefore, we identified a best fitting model for each outcome, anesthesia service charge, and LOS, which included an interaction term between year and anesthesia care model. Additionally, we examined each outcome stratified by year. This allowed outcomes to be examined independently per year (2008 and 2013) and to evaluate changes in outcome following opt-out legislation (e.g. final model with interaction term). Descriptive analysis was reported independently per year (2008 and 2013). The focus of the results will consist of the final model with year as interaction to show the effect change between the years and the impact of the opt-out legislation. Models included all parameters (i.e., age, gender, procedure code, claim facility type, and anesthesia care delivery type) for both years 2008 and 2013, and fit were compared using AIC and BIC.

To confirm that the final model was appropriate, we visually inspected that the residuals were approximately normally distributed. Sidak test between predictors and outcome variables was performed to adjust for multiple comparisons. The level of significance was set at α = .05 for testing of all hypotheses, though the per-comparison α was modified in the event of exploratory analyses to avoid inflation of Type I errors. All analyses were performed using SPSS statistical software, Version 25 (IBM SPSS Software Armonk, New York).

Results

Sample Characteristics

The total sample size included 298,508 cases with 148,153 cases in 2008 and 150,355 cases in 2013 (Table 1). The majority of patients in the sample were between the ages of 65 and 84 (81.7%), and female (55.7%) **(Table 3-1)**. There was a statistically significant ($p < .001$) increase in age group of 65 – 74 years from 2008 (44.4%) and 2013 (45.3%). The most common procedures patients underwent were abdominal (14.6%), upper leg (11.6%), lower abdominal (10.5%), head (10.5%), intrathoracic (10.1%), and knee (9.5%). However, when stratified by year there was a statistically significant change in the volume of HCSPCS procedures following opt-out legislation. Across the top five procedures, total volume of abdominal cases increased from 2008 (13.6%) to 2013 (15.5%) ($z = -14.55$, $p < .001$), as did chest procedures from 3.3% to 3.5% ($z = 3.28$, $p = .001$), and knees, from 9.0% to 9.9% ($z = -7.53$, $p < .001$). There was a slight decrease in the volume of head procedures from 11.2% in 2008 to 9.7% in 2013 ($z = 13.26$, $p < .001$) as well as intrathoracic procedures, 10.5% to 9.6% ($z = 8.67$, $p < .001$). Spine and spinal cord procedures stayed relatively consistent from 2008 (5.2%) to 2013 (5.5%) ($z = -2.79$, $p = .005$). There was a small increase in the proportion of cases conducted at surgical centers, rather than hospitals, from 1.3% of all cases in 2008 to 1.5% in 2013 ($\chi^2 = 10.1$, $p = .001$). Complexity of care increased over time, evident by the proportion of patients with six or more Elixhauser comorbidities in 2013 (25.9%) compared to 2008 (8.4%) (z = -101.80, $p < .001$).

Independent CRNA and Procedure Volume (Access to Care)

Most of the anesthesia care was provided by anesthesiologists (89.9%). However, there was a significant association between opt-out legislation year and anesthesia delivery type. This was evident by the increase in the proportion of cases where anesthesia care was delivered by the independent CRNA in 2013 following the opt-out legislation (5.8%) compared to 2008 (3.8%) (z = 20.94, $p < .001$**) (Table 3-1).** This coincided with a statistically significant decrease in MDA independent anesthesia delivery from 90.2% in 2008 to 89.2% in 2013 (z = 5.55, $p < .001$). Additionally, there was a statistically significant decrease in the ACT anesthesia delivery from 6.0% to 5.0% (z = 11.83, $p = .000$).

Differences in Length of Stay by Anesthesia Care Delivery Type

The full MLM model found mean LOS between anesthesia group was significantly shorter with the independent CRNA care than ACT care in 2008 by approximately half a day (95% CI [0.1, 1.0], $p = .011$) when adjusting for patient- and facility-level covariates **(Table 3-2)**. There was no difference in length of stay in 2008 between MDA care and CRNAs. There was no significant difference in length of stay across the three care delivery types in 2013. This translates to a mean length of stay of 6.2 days (95% CI [5.3, 7.2]) for CRNA care, 6.8 days (95% CI [5.9, 7.8]) for MDA only care, and 7.1 days (95%

CI [6.2, 8.1]) for ACT care in 2008. For 2013, the LOS increased for all care delivery types with ACT care associated with an average of 15.8 days (95% CI [13.7, 17.9]), CRNA only care being the second lowest at 16.2 days (95% CI [14.1, 18.4]), and the highest for MDA only with 16.5 days (95% CI [14.3, 18.6]). This is for overall LOS across all procedures. The number of procedures increased from 2008 to 2013 as well as the complexity of procedures lending itself to higher LOS **(Table A.3-11).**

Several patient- and facility-level characteristics were associated with length of stay in the full model when adjusting for interaction term. Male patients in both 2008 and 2013 were estimated to have a slightly longer mean length of stay than females 6.87 days (95% CI [5.9, 7.8] vs. 6.59 days (95% CI [5.6, 7.5], and 19.64 days (95% CI [17.8, 21.4] vs. 19.55 days (95% CI [17.7, 21.3]. When adjusting for the interaction term, male patients were 1.1 days (95% CI [0.1, 0.2], $p < .00$) longer than females across all procedures. Hospitals, compared to surgical centers, were associated with shorter lengths of stay (95% CI [-1.2, -0.3], $p = .002$) as for procedure specific were head (95% CI [-1.7, -0.1], $p = .043$) and knee procedures (95% CI [-2.4, -0.6], $p = .001$) compared the other procedures. These differences remained even when stratified by year **(Table 3-3).**

Pairwise comparisons for type of procedure across anesthesia groups in 2008 resulted in statistically significant lower LOS in days for the CRNA only group in procedures requiring abdominal 16.27, 95% CI [14.39, 18.14], head 14.67, 95% CI [12.81, 16.53], intrathoracic 16.01, 95% CI [14.06, 17.92)], knee 14.00, 95% CI [12.11, 15.89], and spine and spinal cord procedures 15.52, 95% CI [13.51, 17.54]. The MDA-only group for the same procedures of abdominal 16.92, 95% CI [15.07, 18.77], head 15.16, 95% CI

[13.31, 17.01], intrathoracic 17.18, 95% CI [15.33, 19.03], knee 14.59, 95% CI [12.74, 16.44], and spine and spinal cord procedures 15.02, 95% CI [13.16, 16.87], had the second highest means. The ACT group had the highest means in LOS across all procedures for abdominal 17.27, 95% CI [15.40, 19.15], head 15.39, 95% CI [13.52, 17.26], second highest in LOS days for intrathoracic 16.26, 95% CI [14.38, 18.15], knee 14.18, 95% CI [12.30, 16.07], and spine and spinal cord procedures 15.57, 95% CI [13.68, 17.45]. A decision was made to focus on the top five significant procedures from the list of eleven analyzed **(Table A.3-11).**

Differences in Anesthesia Service Charge by Anesthesia Care Delivery Type

Anesthesia charge amount was an additional dependent variable added to our full model and analyzed by separate years as well as with the group year as the interaction term. Overall, mean anesthesia charge amount by HCPCS procedures and anesthesia group by year interaction of 2008 and 2013 respectively, had a significant increase in charges across all three types of care. For example, in the CRNA-only group charges were an average of $1,537. 47, 95% CI [$1,197, $1,877] in 2008 vs. $2,012, 95% CI [$1,683, $2,342] in 2013. The MDA-only care saw an average change of $2,477, 95% CI [$2,225, $2,729] in 2008 and $3,720, 95% CI [$3,469, $3,971] in 2013. ACTs care charge an average of $2,805, 95% CI [$2,507, $3,103] in 2008 and $3,261, 95% CI [$2,951, $3,571] in 2013. This translates to an average difference of $2,158.84 more in ACT charges (95% CI [1440.38, 2877.29], p <.001) and $2,464.43 more in MDA-only charges [$1,809.08, $3119.78] than CRNA charges in 2013 **(Figure 3-1)**. Even when adjusting for the lower costs of care across all anesthesia provider delivery types in 2008

(95% CI [-$727.91, -$223.68]) and the MDA by year interaction term (95% CI [-$1,024.48, -$508.98], $p < .001$), MDA charges were still more than CRNA charges in 2008 by an estimated $1,221.90 **(Table 3-4).**

Pairwise comparisons for type of procedure across anesthesia groups with accounting for beneficiary age, date of admission and discharge, and total Elixhauser groups resulted in statistically significant means for lower anesthesia charge amount in the CRNA-only group in abdominal $1,551, 95% CI [$1,212, $1,889], head $1,169, 95% CI [$861, $1,477], intrathoracic $1,293, 95% CI [$737, $1,850], knee $2,069, 95% CI [$1,670, $2,468], and spine and spinal cord procedures $2,790, 95% CI [$2,109, $3,472]. The MDA-only group for the same procedures abdominal $2,078, 95% CI [$1,825, $2,332], head $1,378, 95% CI [$1,122, $1,634], intrathoracic $4,146, 95% CI [$3,890, $4,402], knee $3,019, 95% CI [$2,763, $3,276], and spine and spinal cord procedures $4,871, 95% CI [$4,608, $5,134] had the highest mean anesthesia charge amount. The ACT group had the second highest mean in anesthesia charge amount knee $2,191, 95% CI [$1,809, $2,573] and overall highest charges for abdominal $2,256, 95% CI [$1,909, $2,603], head $1,494, 95% CI [$1,155, $1,833], intrathoracic $4,265, 95% CI [$3,889, $4,641], and knee $2,191, 95% CI [$1,809, $2,573]. Spine and spinal cord procedures were the overall highest charge amount with $4,959, 95% CI [$4,587, $5,331]. Pairwise comparison of hospital $2,260, 95% CI [$2,049, $24,72] and ASC $3,011, 95% CI [$2,626, $3,396)] claims by year interaction were also statistically significant (df = 26980, $p = .000$) **(Table A.3-11).**

Discussion

Much consideration on the legislation of opt-out focuses largely on whether this exemption has affected the safety and quality of anesthesia care. Further investigation is needed to document the ways in which opt-out legislation has actually increased access to care or the value of that care, the normative intent of the administrative legislation (Centers for Medicare and Medicaid Services (Centers for Medicare and Medicaid Services, 2001). Studies not only need to demonstrate greater utilization of anesthesia services per capita and geographic areas with the CRNA independent anesthesia care, but also comparative studies of patient volume compared to the overall anesthesia delivery methods. There are important health policy implications not just for surgical care, but also for healthcare more broadly. A more balanced approach to the delivery of healthcare with services provided by well-trained, highly qualified professionals, both physicians and CRNAs, may also promote accessibility to affordable care. Although prior literature discusses CRNA independent practice from the perspective of safety and quality, there are a limited number of studies examining whether opt-out has influenced CRNA independent practice and subsequently improved access to care (Sun et al., 2016; Sun et al., 2016), reduced facility LOS, and decreased costs of anesthesia care.

Our results comparing California CMS data prior to and following the enactment of opt-out legislation indicate that the opt-out legislation was associated with higher inpatient and outpatient surgery volumes across all anesthesia delivery types, but importantly, CRNA independent practice. It was evident that CRNA independent delivery of anesthesia also had overall significantly lower anesthesia service charges than the MDA or ACTs. In addition, our findings revealed a statistically significant difference in LOS across all three anesthesia delivery methods independently by year. In addition, the precision in CIs around our estimated results suggest that our null findings are due to a true association, as opposed to imprecision in our estimates. The key implication of our findings is that the specific composition of two of the anesthesia care team delivery types, CRNA independent and ACT, have a common denominator of CRNA direct care and resulted in statistically significant results in reduction of overall cost and similar LOS for complex case mix. Regarding cost and acuity of care in this sample, not all Elixhauser comorbidities are equally reimbursed and simply adding the number of comorbidities together may not accurately capture true costs of care. There were some missing anesthesia charges for beneficiaries with a higher total of Elixhauser comorbidities. Future work will need to examine sub analyses of charge outcomes per each of the common comorbidities identified in this study as they relate to anesthesia provider group (Ryan, Plate, Goltz, Attarian, Wellman, Seyler, & Jiranek, 2019). Independent CRNA care had an overall decrease in anesthesia charge amount between the 2008 and 2013 models, and by analyzing the year as the interaction of the change. Whether the MDA supervises a CRNA in the capacity of medical direction or less conservative MDA/CRNA ratios of medical supervision, there is a likely association with differences in patient LOS and cost outcomes.

Examining trend analysis of anesthesia billing is illuminating and can provide healthcare executives, administrators, and billers some insight as to how a facility compares to national trends to take corrective actions. The use of the ACT billing modifiers indicate that some facilities have not caught on to the inherent flexibility of the independent CRNA method with QZ modifier and its impact on cost effectiveness. Given the perceived barriers of state and federal regulations with the QZ modifier, further research looking at geographic variation of anesthesia procedures and billing modifiers based on state or county data may help further inform administrators on access to care for their facilities and health systems in general.

Research has shown that anesthesia care is safe with the independent CRNA and the expanded use of this model could increase access, particularly in underserved areas where physician recruitment is challenging (Dulisse & Cromwell, 2010; Negrusa, Hogan, Warner, Schroeder, & Pang, 2016; Pine, Holt, & Lou, 2003). In addition, independent practice CRNAs are more cost efficient (Health resources and services administration data warehouse.2016; Hogan, Seifert, Moore, & Simonson, 2010). Restructuring the anesthesia workforce, especially during shortages of providers, can achieve a reduction of personnel costs and utilization for anesthesia care, and allow for the reallocation of procedures and services amongst the independent CRNA method to provide better access to anesthesia care (Sun, Miller, Moshfegh, & Baker, 2018; Moghim, 2017). In responding to the more recent COVID-19 crises, the Secretary of Health and Human Services encouraged governors to maximize the capacity of the health care workforce to meet increasing demand of those patients being hospitalized (American Association of Nurse Anesthetists, 2020). The secretary's letter emphasized that it is critical that state policies, health systems, and providers themselves are equipped to ensure adequate support for this finite and overstretched workforce. From this, fourteen state governors temporarily authorized CRNAs to practice to the full scope of their practice as determined by their education, training, and current national certification by the National Board of Certification and Recertification of Nurse Anesthetists or other certifying body approved by the Board of Nursing (American Association of Nurse Anesthetists, 2020). The ability of legislators to identify the necessity of CRNAs to practice at full scope in a time of crises raises the question of why they are safe enough only when there is an immediate need. Ideally, all CRNAs should practice at the top of their education and certification. However, in states where physician supervision is required to meet state law, it significantly diminishes that opportunity.

Limitations

Investigations with large data sets have limitations. For the opt-out legislation to affect outcomes, two conditions must be fulfilled. First, the opt-out legislation must result in a shift in anesthesia service methods. If the legislation change does not affect anesthesia arrangements, then it alone could not affect the outcomes among the providers. The documented presence or absence of a supervising anesthesia provider on the surgical record may not adequately characterize the delivery type of anesthesia care in use at a facility, thus limiting the understanding of care delivery relationships among anesthesia providers. In addition, patterns of anesthesia care delivery are likely influenced by factors not accounted for in this study (e.g. availability of anesthesia providers by demographic location, lack of knowledge of healthcare administrators on the removal of CRNA supervision with the opt-out legislation, and public awareness independent CRNA practice). However, confounding on unobserved differences between the cases assigned to ACTs with anesthesiology residents and CRNAs could persist despite adjusting for observable factors described. As a first step toward minimizing confounding, our analysis also included fixed effects for each facility to control for time invariant observable and unobservable characteristics (e.g. academic status, general case mix) specific to the facility. Also, the collapsing of the ACT model to include CRNA, anesthesia residents, and student nurse anesthetists may be a limitation in understanding the ACT methods in better depth with regards to makeup of providers and their respective anesthesia outcomes. The modifiers listed for MDA supervision of anesthesia residents and student nurse anesthetists designate the supervision ratio at the time of anesthesia care provided of these trainees; however, additional information on their personal length and level of training cannot be retrieved through CMS data at the provider level.

Patient data are expected to be a fair representation of the population as the dataset extends beyond facility level to patient and provider level. Patient data comprised a large sample, adding adequate power to the study. The Medicare population tends to be older, and with substantial chronic disease, thus may have differing surgical needs and experiences than that of the general public. The surgical services offered in these facilities as well as the policies and practice environment surrounding anesthesia care also may vary. Future studies could be designed to overcome these limitations. Identifying facilities by bed size, location, primary anesthesia delivery method, and types of procedures performed will help to compare like facilities and within facility differences.

Conclusion

Determining the composition of anesthesia care delivery in any clinical care setting depends on a number of factors such as the status of a facility as a medical teaching institution, its location, and the scope of practice for anesthesia providers defined by state law and regulations and policies specific to care settings. Considerable variations exist in the manner in which all of these factors dictate practices between and within states. Minnick et al. (2008) reported that anesthesia privileges for CRNAs working in a team setting varied between facilities even within the same state. For a small percentage of facilities, privileges differed within the facility itself (Minnick & Needleman, 2008). Our work suggests that the opt-out legislation for California influenced CRNA practice with a 5% increase in overall volume of procedures and as noted in Sun et al. (2016) examination of the opt-out legislation (Sun et al., 2016; Sun et al., 2017). Additionally, independent CRNA anesthesia delivery had a decrease in LOS for select procedures compared to MDA and ACT while also being the most cost effective. Aside from opt-out legislation, multiple influences shape anesthesia staffing model choice for surgical facilities in opt-out and non-opt-out states. Variations in clinical practice are not well documented across different areas of anesthesia in facilities. Some variation in anesthesia care delivery is warranted and expected to adjust for attributes of that facility e.g. teaching vs. non-teaching. Differences in patient illness and preferences should drive individualization of anesthesia care in pursuit of better outcomes. However, in most cases, anesthesia practice variation between facilities, regarding what anesthesia delivery method exists, is unexplained by patient illness, risk factors, or preferences is associated with outcomes. Identification of reasons for such variation in the three anesthesia care delivery methods could help inform administrators of the need for standardization of MDA only, CRNA only, and an ACT of MDA/trainee composition that would provide best patient outcomes. Future work should focus on factors that drive facility-level change with respect to costs and variation in surgical episodes of care attributable to anesthesia staffing patterns.

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CHAPTER FOUR: PUBLICATION THREE - *THE EFFECT OF OPT-OUT LEGISLATION IN CALIFORNIA ON THE DEMOGRAPHIC BALANCE OF ANESTHESIA PROVIDERS*

Abstract

Background: In 2009, California passed legislation acknowledging the Centers for Medicare and Medicaid Services (CMS) permitting states to opt-out of physician supervision of certified registered nurse anesthetists (CRNAs).

Purpose: We examined the effects of opt-out legislation on access to care, facility bed size, county location, and county poverty level with CRNA independent practice.

Methods: A secondary analysis was conducted on 2008 (pre opt-out) and 2013 (post opt-out) California CMS Medicare Part B claims data. Logistic regression assessed the change in odds ratio between the independent variable, anesthesia provider, and the dependent outcome, facility size, prior to and after legislation.

Findings: Post opt-out legislation was associated with a statistically significant increase in the proportion of cases performed by CRNAs independently in non-metropolitan and rural areas where a large majority of patients are 1.5 % below poverty level. Metropolitan areas were predominantly MDA only followed by ACT anesthesia delivery methods.

Discussion: CRNA independent practice can lead to greater volume of procedures and access to anesthesia care in non-metropolitan and rural areas with lower poverty levels.

Keywords: Anesthesia, Nurse Anesthetists, Medicare Legislation, Opt-out Legislation, Access to Care

The Effect of Opt-Out Legislation in California on the Demographic Balance of Anesthesia Services and Access to Care

Submission to *Nursing Economics* (Word Limit 3,750)

Introduction

Since the early 1970s, there have been inequities in the distribution of anesthesia providers in certain demographic locations (Simonson, Ahern, & Hendryx, 2007). In the United States (U.S.), certified registered nurse anesthetists (CRNAs) have historically been the predominant providers in rural hospitals and in caring for Medicare patients (American Association of Nurse Anesthetists, 2019). However, up to 80% of anesthesia cases across the U.S. take place under the control of an anesthesia care team model (ACT) where an anesthesiologist (MDA) supervises the anesthesia care of CRNAs, and trainees such as anesthesia residents and student nurse anesthetists. Differences exists in responsibilities and anesthetic privileges across hospitals that employ providers, and these variations can be substantial (Daughtry, Benito, Kumar, & Michaud, 2010). A more standardized model could be beneficial for both hospital administrators and the public to understand who is providing these services. The Affordable Care Act (ACA) of 2010 proposes to offer the ability for patients to gain better access to afford the quality care, reduce costs, and allow for an educated healthcare decision over who is going to provide their care (Dower, Moore, & Langelier, 2013). Success in reaching these goals could be enhanced by knowing who is delivering anesthesia care, e.g. MDA only, CRNA only, or ACT, and what method might be more efficient and cost effective for certain patients. The comparative outcomes related to cost and mortality from the literature are not in question. Therefore, identifying a method that would best complement the intentions of the ACA should appeal to both the hospital administrators and the public's interest. CRNAs that practice independently in opt-out states are involved in providing anesthesia services to just under one-quarter of the American population that resides the rural and frontier areas of this country (Daughtry et al., 2010; Lewis, Nicholson, Smith, & Alderson, 2014).

There are a number of MDA-only practices; however, there is no evidence that they provide anesthesia care in rural areas (Jordan, 2011; Liao, Quraishi, & Jordan, 2015). The Medicare opt-out designation is particularly crucial for rural Californians, where anesthesiologists are often unavailable or too expensive for limited hospital budgets. Baird et. al (2020) used a coarsened exact matching, difference-in-difference strategy analysis from a 2007 and 2013 MDA survey response to identify the causal effect of Medicare opt-out on MDA working patterns in California compared to non-opt states (Baird, O'Donnell, & Martsolf, 2020). They examined how outcomes changed for MDAs in California, which was not an opt-out state in 2007 but was an opt-out state in 2013, and compared the change in outcomes for MDAs in states that did not change status (Baird, O'Donnell, & Martsolf, 2020). They reported a limitation in matching workforce profiles of MDAs in California with other non-opt-out states. California MDAs may be different on average than MDAs in other states because they are working in different types of health markets that are limited to larger, higher paying services as opposed to rural, lower economically associated areas. Baird (2020) reported there was overall no change in MDA self-reported hours worked as a result of the opt-out legislation and no change in the number of hours not providing services due to delays or staffing issues, suggesting no change in overall unused time. Baird (2020) did find a decrease in the typical clinical workload and a smaller proportion of MDAs that say their number of hours have decreased in the supervision of CRNAs with opt-out legislation. The likely outcome of the limited impact on the practice of CRNAs from Baird's research is the assumption that healthcare employment is very difficult to change workforce composition and practice in a relatively small period of time. It is unlikely that a hospital would immediately and meaningfully move away from MDAs and their employment contracts simply because of opt-out legislation. Opt-out legislation would require active implementation by the participants in the healthcare system. After a state decides to opt-out of physician supervision of CRNAs, individual hospitals would need to intentionally change their policies around the practice of anesthesia. The aim of this research was to examine the effects of opt-out legislation on access to care. The analyses consider access defined by anesthesia provider method and the correlation to hospital location bed size, demographic location, population density, and poverty levels.

Studies to Date

Many studies have investigated the location of anesthesia providers in urban and rural settings. Until 2015, few studies compared the location of anesthesia provider to the patient demographic, insurance status, and socioeconomic level. Fallacaro et al. (2004) reported a correlation of anesthesia providers and their urban and rural distribution where physician anesthesiologists reside 91.6% in metropolitan areas and 8.4% in rural areas. CRNAs reside 81.4% in metropolitan areas and 18.6% non-metropolitan areas (Fallacaro

& Ruiz-Law, 2004). There were 3,100 counties across the U.S. observed, with 96% being non-metropolitan and both providers not residing in 843 counties where they practiced currently (Fallacaro & Ruiz-Law, 2004). Tai et al. (2004) surveyed patient and hospital attributes and the patient–physician relationship and how it influences the hospital choice of rural Medicare beneficiaries (Tai, Porell, & Adams, 2004). The findings identified certain patients' socioeconomic, health, and functional status, their satisfaction with and access to primary care, and their strong preferences of hospital attributes made them more likely to bypass facilities within closer proximity to their residence to seek care (Tai et al., 2004). In other words, these patients are bypassing adjacent hospitals in rural areas because they are seeking more experienced surgeons, and this decision has nothing to do with who is providing anesthesia. These decisions are driven primarily by facilities, volume of procedures, and surgical experience. The type of anesthesia delivery method, MDA only, CRNA only, and ACT, do not often factor into these decisions. This should inform federal program initiatives about the likely impacts of policy changes on the behaviors of individuals bypassing hospitals near to them. Rural hospitals could potentially expand their services and gain support to do so by entering into regional cooperatives or affiliation with urban networks.

Literature that is even more recent examined geographic balance, specifically identifying access to care through the relationship of provider location and patient demographics. Liao et al. attempted to determine a relationship between socioeconomic factors related to geography and insurance type and the distribution of anesthesia provider type (Liao et al., 2015). CRNA was associated with lower-income populations where anesthesiologists correlated with higher-income populations. Furthermore, they concluded CRNAs correlated more with vulnerable populations such as the Medicare-eligible population, uninsured population, and the unemployed (Liao et al., 2015).

Sun et al. investigated a different dimension of access to care and the influence of opt-out with the distance patients travel to obtain surgical procedures (Sun, Dexter, Miller, & Baker, 2017). They reported opt-out did not reduce the percentage of patients who traveled outside of their home zip code except in the case of total hip arthroplasty (2.2%-point reduction; $p = 0.007$) (Sun et al., 2017). For patients traveling outside of their zip code, opt-out had no significant effect on the distance traveled among any of the procedures they noted except the previously mentioned (Sun et al., 2017). The difference in this finding is that the other procedures are considered more urgent in nature where travel time can mean declining health. Only looking at access through distance traveled by patients Sun et al. was unable to identify the true effect of opt-out legislation on distances traveled for procedures that may be rarely performed in this population.

Schneider et al. used a fourteen-year dataset from the years 1998 through 2011 comparing three opt-out states to three non-opt-out states (Schneider, Ohsfeldt, Li, Miller, & Scheibling, 2017). They concluded there were no significant findings indicating opt-out status was associated with greater increase in cost and volume of inpatient vs. outpatient surgeries (Schneider et al., 2017). Some hospitals were not included in their sample, which contributed to fewer years of observation therefore reducing power for facility data. The timeframe of data covered three years before the 2001 legislation (1998) was enacted and one year (2010) from when the California legislation was enacted in 2009. Lastly, outcomes did not measure to what extent both the number of CRNAs or MDAs, and their typical workloads, changed because of the implementation of the opt-out legislation.

There are varying analytical approaches to identifying the impact of opt-out legislation and its intent on increasing access to anesthesia care. Focusing broadly on both urban and rural settings and including all facilities in both settings may improve better precision on estimating access on the provider and patient end. In addition to rural settings, urban hospital networks have been far more responsive with their outreach efforts to provide services in suburban and rural communities than in the past. Economic forces have encouraged hospitals to expand their presence in the broader communities, including establishing or expanding roles in clinics and critical access hospitals. These effects are designed to maintain their profitable financial balances. As these changes have occurred, political and professional responses have fully been necessary to accommodate patient access to and allow for care providers to practice of their training in these areas.

The governor's office and the California Association of Nurse Anesthetists have held that requiring physician supervision would limit access to care in the rural areas that have had difficulty attracting and retaining anesthesiologists. In addition, the need to compensate two providers in many of these institutions in order to maintain the supervision requirements when one anesthesia provider could deliver care at a lower reimbursement rate seemed appropriate. Therefore, on July 17, 2009, Governor Schwarzenegger sent a letter to CMS containing the required opt-out determinations and, in turn, elected to enact the federal supervision requirement concluding that this was in the interests of the people of California (Wilson, 2012). The purpose of this research was to further investigate the potential impact of opt-out policy implementation, focusing particularly on CRNA practice and patient access to care.

Currently there is a lack of scientific evidence to support CRNA independent practice and refute the belief that CRNAs must be supervised. The purpose of this research is to evaluate the impact of opt-out policy in the state of California through the outcomes of surgical services, patient complexity, and demographic variation with anesthesia delivery models. Because California was an early adopter of the opt-out model of medical supervision per the 2001 Conditions of Participation, this study uses data from California to examine patterns of access to and delivery of anesthesia care.

The focus on California is largely due to the ability to capture a large percentage of the population requiring anesthesia services through both CMS and other publicly available data. California is an important case because 71% of publicly funded health care expenditures exist in California and are higher than the 2015 national estimate of 65% (Sorensen, Nonzee, & Kominski, 2016; Tatum et al., 2014). The share of Medicare spending in California is equal to the national level of 20%. A report in 2015 from CMS estimated that U.S. national health expenditures (NHE) totaled over $3 trillion. In California, healthcare expenditures in 2016 were estimated to total more than $367 billion, with Medicare beneficiaries spending $74.7 billion (20.3%) of the total cost (Sorensen et al., 2016; Tatum et al., 2014). So, California is closely representative of a generalizable national sample.

The Affordable Care Act (ACA) has greatly increased the numbers of Californians with health insurance. Since the ACA implementation, 3.8 million Californians obtained insurance from the state's health exchange (Sorensen et al., 2016; Tatum et al., 2014). While increasing the numbers of insured Californians can be recognized as a success, it also raises the question of whether these newly insured Californians might be able to access healthcare. There are still barriers to entry of patients to healthcare services in California. Prior to the ACA, the number of physicians was inadequate to meet the needs of the population. With declining health status, retiring physicians, and chronically low reimbursement rates for these physicians, a growing pool of insured patients will exacerbate the problem of access to care (Sorensen et al., 2016; Tatum et al., 2014). If we are going to support opt-out legislation with its intent to increase access to anesthesia care, there is a need to examine the legislation specifically in California before and after the 2009 enactment.

Debates over the merits of opt-out have focused largely on whether this exemption has affected the safety and quality of anesthesia care. Less work has addressed if it has increased access to care or the value of that care, the normative intent of the administrative rule (Federal Register, 2001). The degree to which opt-out has increased access to anesthesia care still needs to be determined. There are important health policy implications not just for surgical care, but also for healthcare more broadly. A more balanced approach to the delivery of healthcare, with services provided by well-trained, highly qualified professionals, both physicians and advanced practice nurses, may increase accessibility to affordable care for all populations. Although prior literature discusses CRNA independent practice from the perspective of safety and quality, there are a limited number of studies examining whether opt-out has influenced CRNA independent practice and subsequently improved access to care (Sun, Miller, & Halzack, 2016; Sun, Dexter, & Miller, 2016). This research measures the effects of opt-out legislation in California on the access to and delivery of anesthesia and any changes that had an impact on CRNA independent practice, and access to anesthesia care.

Methods

This study is a comparative secondary analysis examining the effects of anesthesia care delivery methods using data from patients receiving anesthesia for surgical services in California hospitals and outpatient facilities for two years: 2008 (prior to opt-out) and 2013 (after opt-out legislation). This study design is used to observe a change in the outcomes of access to anesthesia defined by anesthesia provider location of service, facility bed size and location, population density, and socioeconomic factors among the three anesthesia delivery methods before and after opt-out policy implementation. This comparative design is used to examine the change in outcomes, bed size, and facility characteristics (hospital vs. ambulatory surgery center), while adjusting for changes in patient factors over time (e.g., surgical volume, county, and socioeconomic demographics) in the three anesthesia delivery methods before and after opt-out legislation implementation **(Table A.4-1).** Prior to receiving the CMS databases with protected health information (PHI), investigators complied with necessary requirements outlined in the CMS contractual agreement for investigator training and storage for CMS data. The University of Pennsylvania Institutional Review Board reviewed and approved the study protocol.

Data were retrieved from the Medicare Part B National Data Files from 2008 and 2013. These files incorporate all Medicare Fee-for-service Part B Physician/Supplier data for allowed services, charges, and payments for each procedure. The dataset is designed so one can identify total allowed anesthesia service charges and total allowed Medicare payments by a Healthcare Common Procedure Coding System/Current Procedural Terminology (HCPCS/CPT) in relation to prominent CMS billing identifiers. For identification of anesthesia procedures, anesthesia code (HCPCS/CPT 00100-01999) was used.

Patient data were identified using five CMS databases: MedPAR Research Identifiable File (RIF), Carrier RIF, Outpatient RIF, Master Beneficiary Summary File, and the Provider of Services (POS) file. Additionally, publicly available data from the California Office of Statewide Health and Planning (OSHPD), U. S. Area Health Resources File (HRSA), and Rural Urban Continuum Codes (RUCC) were incorporated for additional facility information including location, population density, and poverty level. The sample initially included just under five million beneficiaries who received anesthesia care for surgical procedures in either 2008 or 2013. However, the overall final sample with complete data across datasets yielded a total sample of 290,600 patient Medicare claims for those encounters.

Independent Variable: Anesthesia Care Delivery Method

The primary independent variable of interest, anesthesia care delivery, was assigned using anesthesia service types identified by CMS claims billing modifiers. These modifiers are a two-position alpha or numeric code appended to a CPT code to clarify the services being billed. Modifiers provide a means by which a service can be altered without changing the procedure code. The study sample was divided into the three anesthesia care delivery methods that were defined by CMS claims billing modifiers. We evaluated patient outcomes across the three anesthesia delivery methods: 1) MDA independently, 2) CRNA independently, and 3) MDA/CRNA also known as an anesthesia care team (ACT). Claims were limited to those with billing modifiers that included: AA to denote MDA working independently (MDA only); AD, QX, QK, and QY to designate physician medically directing or supervising a CRNA or anesthesiology resident (ACT); and QZ to indicate when a CRNA works independently (CRNA independent). A decision was made on collapsing the ACT model to include supervision of either CRNA, anesthesia resident, and even student nurse anesthetist by the various modifiers listed for ACT by definition, bill for any non-physician anesthetist provider. The determination of the anesthesia delivery arrangement was obtained by claims files from both MDAs and CRNAs associated with the procedure claims of patients undergoing the respective HCPCS coding.

Additionally, we used modifiers help to eliminate the appearance of duplicate billing and unbundling. Modifiers increased accuracy in reimbursement, coding consistency, editing, and to capture payment data. There are two types of staffing patterns and billing ramifications: medical direction or medical supervision. Medical direction requires compliance with regulations and limits MDA to directing four or less CRNAs. Medical supervision requires that the MDA does not have to be physically present consistently for the duration of the procedure. A single MDA can supervise more than four concurrent cases, and therefore more than four can be performing other patient services while cases are being managed by a CRNA.

Outcome Variables: Bed Size and Facility Characteristics

The main outcomes of interests included assessing changes if any, in bed size, facility location of anesthesia provider practice, and population demographics prior to and after opt-out legislation using 2008 and 2013 CMS and public files of OSHPD, HRSA, and RUCC, respectively (Centers for Medicare and Medicaid Services, 2001; Health Resources and Services Administration Data Warehouse, 2016; Rural Urban Continuum Codes, 2018). Bed size was identified by cross-linking the CMS facility identifier with the same facility identifier on the OSHPD facility annual reporting of bed size. Facility location was identified by cross-linking the RUCC and HRSA county code listed for each facility on the CMS database by facility identifier **(Table A.4-2) (Table A.4-3).**

Statistical Analyses

The dataset was merged on Medicare beneficiary ID for each of the separate years of 2008 and 2013 with the additional variables of facility type, location, population density, economic status, and anesthesia group. First univariate statistics (means, standard deviations [SD], frequencies [%]), were used to characterize the surgical case sample. Next, comparative statistics (e.g. chi-square test, t-test) assessed differences between the sample characteristics prior to and after legislation (e.g., 2008 vs 2013). Due to the potential multicollinearity between county-related factors, specifically RUCC and poverty level, an ANOVA assessed for potential differences that could be adjusted for in a multivariable model. The association between RUCC and anesthesia provider, stratified by year, was evaluated using a chi-square test (e.g. Cochran–Mantel–Haenszel). The association between county-related factors and the outcome of interest, facility size, were evaluated using bivariable logistic regressions. Finally, a multivariable logistic regression assessed the change in odds ratio between the independent variable, anesthesia provider model, and the dependent outcome, facility size, prior to and after legislation.

Missing data were addressed by identifying that any values missing at random would have little effect on outcomes of interest, due to the inherent nature of the large sample size. Therefore, no further sub-analysis of missing data was necessary. Additionally, given duplicate patient claims, a decision was made to remove duplicate claims so that only the initial claim documented per beneficiary were included.

Results

Sample Characteristics

Overall, there were 686 facilities in 2008 and 712 in 2013 seeing 143,159 cases and 147,441 surgical cases, respectively. The majority of cases were performed in large bed facilities, with 201 beds or more. Chi-square test indicated there was a small significant decrease in the proportion of cases conducted in small bed facilities, with less than 201 beds, from 23.2% in 2008 to 22.0% in 2013 ($p<.001$) **(Table 4-1)**. Previous chapters/publications have shown the increase in the number of cases performed by CRNAs following opt-out legislation. This is reflected here with a significant increase in the proportion of cases performed by CRNAs from 3.8% in 2008 to 5.8% in 2013. There was a significant difference in the proportion of cases conducted across metro and rural areas ($p<.001$). Over time, the proportion of cases performed in nonmetropolitan and adjacent areas declined from 3.2% in 2008 to 1.9% in 2013. Similarly, the proportion of cases performed in rural areas declined from 1.4% to 0.9% of all cases in 2008 and 2013, respectively. The assumption could be the closing or restructuring of healthcare systems moving to metropolitan or non-metropolitan area adjacent to larger cities, or patients bypassing rural care for treatment at metropolitan or associated facilities. The mean proportion of population living 1.5 times below the poverty level in the counties where surgical cases were conducted did not differ across years. On average, cases were conducted in counties with 21% of the population living 1.5 times below the poverty level.

Anesthesia Delivery Models by Rural Urban Continuum Codes

MDA provided most of the anesthesia care across all RUCC. A stratified chi-square test, known as a Cochran–Mantel–Haenszel test, indicated a significant difference in the proportion of anesthesia providers by RUCC across years **(Figure 4-1).** The proportion of CRNA practicing in each RUCC increased from 2008 to 2013 while the proportion of MDA and ACT decreased over this time period. The proportion of surgical cases had an overall decline from 2008 to 2013; however, those still conducted in rural counties with a CRNA providing anesthesia independently, increased from 10.2% in 2008 to 13.8% in 2013. The largest variation in anesthesia care delivery was seen in non-metro but adjacent facilities where by 2013 in nearly a quarter of all cases, CRNAs delivered anesthesia **(Table 4-2).**

RUCC and CMS Beneficiary by Poverty Level

Proportion of beneficiaries living below 1.5 times the poverty level was chosen for modeling because a two-way ANOVA found that there was a significant difference in the poverty level by RUCC per year and we wanted to account for this variation in the multivariable modeling. ANOVA indicated a significant difference in mean proportion of residents living under 1.5 times the poverty level by RUCC ANOVA: $F_{(1,298053)} = 67.05$, $p < .001$. Tukey's post hoc pairwise tests indicate mean difference between RUCC significantly differ by year $p < .001$. The metro vs. non-metro mean difference was 0.82 (95% CI: 0.57, 1.07). The metro vs. rural mean difference -0.26 (95% CI: -0.46, -0.06). Lastly, non-metro vs. rural mean difference -1.09 (95% CI: -1.40, -0.77) **(Table 4-3).** Additionally, there is a minor association between each additional increase in the proportion of individuals living below 1.5 times the poverty level in a county and the odds of a surgical case being performed at a facility with 201 or more beds (OR=1.01; 95% CI: 1.008, 1.011). This translates to about a 1% increase in the odds with each additional 1% in poverty **(Table 4-4).**

Anesthesia Delivery Method and Bed Size

Both MDA and ACT models are at increased odds of practicing at larger facilities than CRNAs when controlling for year, poverty level, and RUCC. Even after adjusting for the decrease in the number of facilities with <201 beds from 2008 to 2013, MDA and ACT models had greater odds of practicing in larger facilities compared to CRNAs. The interaction term indicates that after the opt-out legislation, MDAs were estimated to still have an additional 44% greater odds of practicing at larger facilities than CRNAs (AOR=1.44; 95% CI: 1.33, 1.56) and ACTs were estimated to have a 34% (AOR=1.34; 95% CI: 1.19, 1.51) greater odds of practicing at larger facilities compared to CRNAs. Each additional percentage of a county's residents living 1.5 times below the poverty level was associated with a marginal increase in the odds of a surgery being conducted at a larger facility (AOR=1.01; 95% CI: 1.01, 1.02) **(Table 4-5).**

Discussion

Our results comparing California CMS data prior to and following the enactment of opt-out legislation indicate that the opt-out legislation was associated with higher inpatient and outpatient surgery anesthesia delivered by CRNA independent practice. It was evident that CRNA independent delivery of anesthesia also had an increase in services to areas of lower population density also falling below the national 1.5% poverty level. In addition, our findings revealed a statistically significant difference in the number of practicing MDAs and ACTs in larger facilities located in densely populated areas. One industry concern is the impact of an aging workforce across all types of anesthesia healthcare providers. Studies predict that physician retirement decisions will have a considerable impact on the supply of physician anesthesia providers. A report by the American Society of Anesthesiologists (ASA) notes that the average anesthesiologist's age is 46.5 years, while the average for CRNAs is 38.6 years (Association of American Medical Colleges, 2017; Somnia Anesthesia, 2017). Anesthesiologists also have the highest attrition rates compared to CRNA colleagues (Somnia Anesthesia, 2017).

Increased age and high rates of attrition lead to the expectation that there will be fewer anesthesiologists in the future than the number practicing today. Projected staffing models with moderate to high use of advanced practice registered nurses, such as CRNAs, could help ease between 30% and 60% of the demand for physicians in the specialty (Somnia Anesthesia, 2017). The supervision and medical direction models lead to a process of two providers caring for the same patient. With opt-out legislation this will be lessened, and ultimately will lead to a greater expansion of anesthesia providers available to assist with surgical services.

In addition to using anesthesia workforce shortage as a proxy for measuring access to anesthesia care, Epstein et al. explored predictions using real data captured from an anesthesia information management system to determine the incidence and timing of simultaneous critical portions of cases in which MDAs were reimbursed under a medical direction model (Epstein & Dexter, 2012). This simulated model estimated risk of a supervision lapse to surgical suites with various numbers of operating rooms. This model identified a supervision ratio of 1:2, lapses in time of 20 to 40 minutes, occurring on 35% of days, with a peak incidence occurring before 8:00 a.m. (p = .0001) (Epstein & Dexter, 2012). The average time from operating room entry until anesthesia release time (post-induction to hand over to surgeon) during the first case of the day was 22.2 minutes, 95% CI [21.8–22.8] (Epstein & Dexter, 2012). This number could potentially increase throughout the day depending on the length of time for the surgical procedures. Overall, these delays could directly affect access and patient satisfaction due to an unexpected delay in wait time. Furthermore, there could be additional costs to the health system related to the need to hire more MDAs to maintain more conservative ratios, and the need to potentially reschedule or cancel procedures.

To date, only a few studies have focused on factors influencing access to care with the opt-out ruling (Sun et al., 2016; Sun et al., 2016; and Sun et al., 2017). While work in this area is emerging, predictions of lower numbers of practicing MDAs suggest the need for further development and use of CRNA independent practice models. With the implementation of opt-out legislation and the removal of CRNA supervision, the process of two providers caring for the same patient will be lessened and ultimately lead to more availability of anesthesia providers. This research presented a methodology and analytical approach to examining factors associated with opt-out designation and access to care. The two-year time point data analysis provided an adequate time span to more fully understand how anesthesia delivery and access have been affected by changes designed to increase access to anesthesia and surgical services while maintaining quality of care.

The ACA will place increasing demands on the healthcare workforce. According to the Kaiser Commission on Medicaid and the Uninsured (2013), in 2012 nearly 47 million nonelderly Americans were uninsured. The ACA will expand Medicaid coverage to nonelderly adults with incomes below 138% the federal poverty level ($15,856 for an individual). Based on an Urban Institute analysis, approximately 22.3 million uninsured individuals will qualify for Medicaid under the new provisions of the ACA (Liao et. al, 2015). These provisions of insurance to the uninsured will likely increase demand for healthcare and thereby increase the need for healthcare providers.

In particular, special attention to issues concerning the anesthesia workforce is critical because of the direct effect on access to surgical, anesthesia, and pain management services. Research regarding the anesthesia workforce has attempted to demonstrate shortages or geographic maldistribution (Daugherty et. al, 2010; Fallacaro & Ruiz-Law, 2004; Schubert, Eckhout, Ngo, Tremper, & Peterson, 2012). However, such research has fallen short in outlining the complex relationships between geography, population density, provider density, and key ACA factors such as income, insurance, and unemployment.

The Institute of Medicine (2011) report outlined the key policy issues needed to assure all APRNs rightfully assert their role in healthcare delivery. The IOM indicated all APRNs should be able to practice based on their education and competency to help bridge the gap between insurance coverage and access to care (Institute of Medicine, 2010; Liao et. al, 2015). The findings in this study indicate CRNAs are more likely found in locations where low-income, Medicaid, and uninsured patients reside. As such, if these vulnerable populations needed anesthesia care, CRNAs are more readily available to provide the required care. Additionally, researchers have suggested issues around access to care are more apparent at the local level such as in rural and inner-city areas (Liao et. al, 2015).

Limitations

Investigations with large data sets have limitations. For the opt-out legislation to affect outcomes, two conditions must be fulfilled. First, the opt-out legislation must result in a shift in anesthesia service methods. If the legislation change does not affect anesthesia arrangements, then it alone could not affect the outcomes among the providers. The documented presence or absence of a supervising anesthesia provider on the surgical record may not adequately characterize the delivery type of anesthesia care in use at a facility, thus limiting the understanding of care delivery relationships among anesthesia providers. In addition, patterns of anesthesia care delivery are likely influenced by factors not accounted for in this study (e.g. lack of knowledge of healthcare administrators on the removal of CRNA supervision with the opt-out legislation, and public awareness independent CRNA practice). However, confounding on unobserved differences between the cases assigned to ACTs with anesthesiology residents and CRNAs could persist despite adjusting for observable factors described. Also, the collapsing of the ACT model to include CRNA, anesthesia residents, and student nurse anesthetists may be a limitation in understanding the ACT methods in better depth with regards to makeup of providers and their respective anesthesia outcomes.

Patient data are expected to be a fair representation of the population as the dataset extends beyond facility level to patient and provider level. Patient data comprised a large sample, adding adequate power to the study. The Medicare population tends to be older, and with substantial chronic disease, thus may have differing surgical needs and experiences than that of the general public. The surgical services offered in these facilities as well as the policies and practice environment surrounding anesthesia care also may vary. We cannot exclude the possibility that the lack of effect could be explained by other confounding variables, such as unobserved factors occurring at the zip code or patient level. Future studies could be designed to overcome these limitations.

Identifying facilities by bed size, location, primary anesthesia delivery method, and types of procedures performed will help to compare like facilities and within facility differences.

Conclusions

In this study, we examined the effect of opt-out legislation on access to anesthesia care using a measure of access as facility characteristics and patient social demographics. Overall, we found that opt-out was associated with an increase in access as measured by not only the shift to rural and high poverty level locations, but the increase in volume of cases in independent CRNA practice in these areas.

There are many reasons why opt-out increases access to anesthesia care. Initially, this means that a federal insurer (CMS) will pay for cases where a CRNA is unsupervised by a physician, therefore increasing the number of available providers in our current workforce. Second, the availability of anesthesia care is a factor that limits access to surgical procedures, as we witnessed in the temporary closure of healthcare facility in Canada because they lack MDA availability and do not recognize the practice of CRNAs (Canadian Anesthesiologists Society, 2019). In responding to the more recent COVID-19 crises, the Secretary of Health and Human Services encouraged governors to maximize the capacity of the healthcare workforce to meet increasing demand of those patients being hospitalized (American Association of Nurse Anesthetists, 2020). The secretary's letter emphasized that it is critical that state policies, health systems, and providers themselves are equipped to ensure adequate support for this finite and overstretched workforce. From this, fourteen state governors temporarily authorized CRNAs to practice to the full scope of their practice as determined by their education, training, and current national certification by the National Board of Certification and Recertification of Nurse Anesthetists or other certifying body approved by the Board of Nursing (American Association of Nurse Anesthetists, 2020). The ability of legislators to identify the necessity of CRNAs to practice at full scope in a time of crises raises the question of why they are safe enough only when there is an immediate need. Efforts by the AANA are continuing to lobby with legislators to make this temporary state legislation more of a permanent mandate. Ideally, all CRNAs should practice at the top of their education and certification. However, in states where physician supervision is required to meet state law, it significantly diminishes that opportunity.

Several factors characterize the various anesthesia models such as its presence in medical teaching institutions, location, and the scope of practice of the state or specific hospital institution. The various types of anesthesia care for surgical services is important in understanding the advantages and disadvantages of using alternate anesthesia provider types or delivery models to provide these required services. The information gained from this research will help inform employers (e.g., hospitals, anesthesia provider groups) and other researchers about the quality and access implications of alternate delivery models. Findings from this research will provide an evidence base to inform federal and state regulators and legislators who are formulating rules and regulations for the delivery of anesthesia.

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CHAPTER FIVE: DISCUSSIONS AND FUTURE RECOMMENDATIONS

Discussion

Three common staffing models for delivering anesthesia exist in the U. S. Anesthesia services delivered by MDA only, delivered by CRNAs only, and delivered by MDA and CRNA teams. Given the opt-out legislation enacted by CMS in 2001, it is reasonable to expect that the use of CRNAs would vary by state opt-out status. Allowing CRNAs to provide anesthesia services independently may help alleviate perceived anesthesiology provider shortages, particularly in rural locations, without adversely affecting patient quality of care while reducing total anesthesia delivery costs (Coomer, Mills, Beadles, Gillen, Chew, & Quraishi, 2019). Therefore, the overall goal of this dissertation was to use CMS and publicly available data to assess the impact of this legislation and shifts in these services occurred specifically in California. Chapter 2 of this dissertation synthesized current published literature on the impact of opt-out legislation and ways access to anesthesia services are defined. Informed by the established association between opt-out legislation and the removal of physician supervision. Chapter 3 examined the effects of opt-out legislation on access to care, anesthesia service charges, and length of stay (LOS) with CRNA independent practice. Chapter 4 evaluated the changes in odds ratios between anesthesia providers adjusting for facility size and sociodemographic location prior to and after opt-out legislation enactment. The culminations of this work contribute to existing knowledge of opt-out legislation and its effect on CRNA independent practice. While focusing on a single state's actions to determine the true intent of the legislation, it was possible to elucidate how opt-out legislation can offer greater access to anesthesia care.

Major Findings of Chapter Two

There is a paucity of studies examining the effects of opt-out legislation in relation to access to anesthesia care. This integrative review yielded eight-six publications, thirty-two were editorials, six were integrative reviews, twenty-four were retrospective studies, and twenty-one were prospective cohort studies. Fifty-one studies met inclusion criteria for synthesis and analysis, and these were categorized into three contextual themes based on the primary focus of the study: manpower, scope of practice, and access to anesthesia care specifically addressing rural and underserved populations.

As expected, most of the publications in the early 2000s focused on anesthesia manpower. Subsequently, a trend was observed with studies transitioning to anesthesia service methods with respect to quality, cost, and outcomes. In more recent years from 2010 forward, research on CRNAs and opt-out legislation investigated access to care; however, there were notable gaps in the science. The manner in which access to care was measured differed across studies and research designs and methods did not always account for how CRNA services influenced clinical (e.g., length of stay) and economic outcomes. Overall, this integrative review demonstrates a compelling need for more research to support the stand that independent CRNA practice is associated with comparable or even superior outcomes compared to other models CRNA supervised practice.

From the synthesis and integration of opt-out legislation research, it is evident that political action is needed to include lobbying state politicians to influence governors to acknowledge opt-out legislation. If opt-out legislation is to be adopted by more states, this will require a focused approach to analyzing factors of workforce distribution, practice restrictions, and geographic imbalance of anesthesia services that could have a direct impact on the public, health systems, and policy makers. To date, there is no identification, standardization, and agreement for relevant outcomes of opt-out legislation and how these are measured. The cross-sectional nature of opt-out legislation research does not account for the shift, if any, in anesthesia practice methods from a health care system perspective. Healthcare employment is very difficult to change workforce composition and practice in a relatively small period of time, when trying to identify impact if any, from legislation enactment or policy changes. It is unlikely that a hospital would immediately and meaningfully move away from employment contracts simply because of opt-out legislation without observing some supportive data to do so. Therefore, opt-out regulations require active implementation by the participants in the health care system. After a state decides to opt-out, individual hospitals would need to intentionally change their policies around the practice of anesthesia. As such, future research must account for the variations in facility-level characteristics (e.g., bed size, geographic location, and patient populations served) and models of care delivery in order to capture outcomes of opt-out legislation. Additionally, future research efforts need to assess the impact of the opt-out policy and what specific opt-out state practicing CRNAs and healthcare facilities have been affected by this legislation.

Major Findings of Chapter 3

This secondary analysis was one of a few studies that looked at a state-specific change in the implementation of opt-out legislation. Findings highlight the positively correlated higher inpatient and outpatient surgery volumes across all anesthesia delivery types with the opt-out ruling, and importantly, CRNA independent practice. Results show that CRNA independent delivery of anesthesia also had overall significantly lower anesthesia service charges than the MDA or ACTs. The overall volume increased with the removal of CRNA-restricted SOP. Cost would increase with volume; however, the most cost-effective model (CRNA only) will be reimbursed appropriately therefore decreasing patient out-of-pocket costs. In addition, findings revealed a statistically significant difference in LOS across all three anesthesia delivery methods independently by year. The key implication of these findings was that the specific composition of two of the anesthesia care team delivery types, CRNA independent and ACT, has a common denominator of CRNA direct care. The analyses of data yielded statistically significant differences in the reduction of overall cost and LOS for complex case mix. Independent CRNA care had an overall decrease in anesthesia charge amount between the 2008 and 2013 models, and by analyzing the year as the interaction of the change. Whether the MDA supervises a CRNA in the capacity of medical direction or less conservative MDA/CRNA ratios of medical supervision, there is a likely association with differences in patient LOS and cost outcomes.

Major Findings of Chapter 4

This chapter explored the geographic variation in the prevalence of facility anesthesia staffing models using facility location by county code and anesthesia claims from the facilities. Stratifications of staffing models were analyzed and presented by location (rural/urban), and facility type (large hospital, small hospital, ASC), and population demographics. Results comparing California CMS data prior to and following the enactment of opt-out legislation indicate that the opt-out legislation was associated with higher inpatient and outpatient surgery volumes across all anesthesia delivery types, but importantly, CRNA independent practice. It was evident that CRNA independent delivery of anesthesia also had an increase in services to areas of lower population density also falling below the national 1.5% poverty level. In addition, our findings revealed a statistically significant difference in the practice of MDAs and ACTs in larger facilities located in densely populated areas. Further research in defining access by additional proxies in addition to the ones used in this study will better inform health care systems, administrators, and public policy makers in areas of greatest need for promoting access to quality care.

Limitations of Research

It is important to note several limitations of this doctoral research. The study's secondary analyses approach hinders the ability to demonstrate causation on the exact shift in CRNA independent practice at the facility level after opt-out implementation. Further, patterns of anesthesia care delivery are likely influenced by factors not accounted for in this study (e.g. availability of anesthesia providers by geographic location, lack of knowledge of healthcare administrators on the removal of CRNA supervision with the opt-out legislation, and public awareness independent CRNA practice). Because this study did not measure the variation in medical direction or supervision ratios, it was not possible to draw any conclusions about the ACT model. However, a confounding effect on unobserved differences between the cases assigned to ACTs with anesthesiology residents, anesthesiologist assistants, and CRNAs could persist despite adjusting for observable factors described.

Overall, results revealed facility type and size exhibited moderate correlations with anesthesia staffing, although the distribution of these methods appeared to be mainly dichotomous and most strongly associated with urban location for MDA and ACT, while rural location for CRNA only practice. Although the Medicare physician supervision opt-out policy alone did not appear to be a primary driver in facilities' chosen anesthesia service delivery methods, a state's opt-out status may work in conjunction with individual facility characteristics and metropolitan/non-metropolitan/rural facility location to influence a facility's anesthesia staffing. The Medicare opt-out policy for CRNA physician supervision may have been effective in increasing CRNA supply and therefore access to surgical care in rural areas. However, additional longitudinal data are required to confirm these cross-sectional findings.

The generalizability of this research may be questioned considering our analysis was limited to older Medicare patients undergoing inpatient and outpatient surgery and focused on a specific state's databases. However, California is a large and diverse state reflective of what would occur similarly at a national level. Currently, there is a lack of data focusing on the impact of opt-out legislation and how it may differ if researching a non-Medicare or younger population. Our study covered the time period between 2008 and 2013, and the cross-sectional method of data sampling prevented the ability to fully examine trends and patters in opt-out legislation implementation. Although a longitudinal evaluation of data might have produced differences in results by year, this observational method is rarely used to evaluate how the opt-out legislation affects CRNA practice. Such an approach would yield data that would have to be interpreted against numerous fluctuating factors that occur at the facility, state, and national levels.

Implications

Implications of this research include the continuation of leveraging of anesthesia research and the further exploration of opt-out legislation outcomes. In this work, researchers classified facilities into three anesthesia staffing models based on the anesthesia modifier codes billed on anesthesiology claims for surgeries performed at the facility: predominantly anesthesiologist, predominantly CRNA, or ACT. Facilities were classified as ASCs or hospitals; hospitals were further classified as large or small by urban/rural location and bed size. The prevalence of these facilities was assessed by location, facility type and size, and state opt-out status. Predominantly CRNA staffing models did not appear to be more common after opt-out legislation. Not to assume that opt-out legislation has failed to this point, but to identify that largely populated areas where MDA and ACT models exist there may be lack of awareness of legislative change. Yet, CRNAs were more prevalent in rural areas than urban areas and providing greater access to anesthesia care to lower socioeconomic populations. Further, few facilities in rural areas used predominantly anesthesiologist staffing models regardless of the state's opt-out status. The Medicare CRNA physician supervision opt-out policy alone did not appear to be a primary driver in facilities' choice of anesthesia staffing models; however, individual facility characteristics and rural/urban status did appear to be substantial contributors in determining a facility's anesthesia staffing model. Furthermore, CRNAs do appear to provide access to anesthesia services in areas where those services would not otherwise have been available. This originally was the intent to the opt-out legislation of providing greater access to anesthesia care to the general population. Identifying this in California will hopefully lead other states to report the same outcomes.

State regulators considering changes in practice regulations and the impact of opt-out legislation continue to focus on safety outcomes to guide their decision- making. Despite several studies documenting equivalent safety outcomes, political challenges to removing barriers to independent or autonomous practice for CRNAs still remain. Nevertheless, CRNAs offer a quality neutral cost-efficient alternative to physicians. There must be diligent efforts in research that demonstrates the consistency in quality of care amongst the anesthesia provider models, MDA only and CRNA only delivery. It will be critical for CRNA advocates to remain steadfast and critical of research that attempts to distort scientific findings toward a political end that continues to attempt to limit CRNAs to practice to the fullest extent of their training.

Future Directions

Patterns of anesthesia care delivery are likely influenced by factors not accounted for in this study (e.g. lack of knowledge of healthcare administrators on the removal of CRNA supervision with the opt-out legislation, and public awareness independent CRNA practice). CRNA utilization, whether in a predominantly CRNA or team model, is one approach to reducing the costs of anesthesia services. Several studies of the provision of anesthesia services have been conducted to examine the differences in costs and quality of care between CRNAs and anesthesiologists. Studies examining costs have shown that predominately CRNA models consistently provide cost-effective care relative to other anesthesia models. Consistent with prior research (Daugherty et al., 2011; Fallacaro & Ruiz-Law, 2004; Liao et al., 2015), a large variation was found in the prevalence of CRNAs (predominantly CRNA and team) and CRNA only practice was most in rural locations. These results show that in urban locations, predominantly MDA only models tended to be dominant, and in rural locations, few facilities used predominantly MDA staffing. Thus, future research initiatives to investigate anesthesia costs may be most effective if targeted toward increasing use of CRNAs only practice in urban locations.

Thus, although the Medicare physician supervision opt-out policy alone did not appear to be a primary driver in facilities' chosen anesthesia service delivery method, a state's opt-out status may work hand-in-hand with individual facility characteristics and rural/urban facility location to influence a facility's anesthesia staffing model. The Medicare opt-out legislation for CRNA physician supervision may have been effective in increasing CRNA supply and therefore access to surgical care in rural areas. However, additional longitudinal data are required to confirm these cross-sectional findings. The study designs in both Chapter 3 and Chapter 4 can be replicated by state or even more specific by a large health system within an opt-out state. Overlapping that with qualitative data from patient surveys may provide better clarity on the impact of opt-out legislation.

Allowing CRNAs to provide anesthesia services independently may help alleviate perceived anesthesiology provider shortages, particularly in rural locations without adversely affecting patient quality of care while reducing medical expenditures. Future work should focus on factors that drive facility-level change with respect to costs and variation in surgical episodes of care attributable to anesthesia staffing models.

Barriers that prevent fully qualified individuals from providing care independently are not optimizing the healthcare delivery system. The ACA of 2010 proposes to offer the ability for patients to gain better access, afford quality care, reduce costs, and allow for an educated healthcare decision (Dower et al., 2013). These goals would be better supported by knowing who is delivering the anesthesia and what model would be more efficient and cost effective for them. To accomplish this, the MDAs can no longer be the sole or principal provider of anesthesia care (Malina & Izlar, 2014). Therefore, there is a need to identify an anesthesia delivery method that could best compliment both hospital administrators' goals with the public's interest.

Research performed previously failed to ask what is important to patients. What would patients tell us about their experience with a particular anesthesia provider, and how do we measure them? How do we develop a research plan that addresses this type of data? There are opportunities in these settings to begin to conceptualize research that is patient-experience based. Research from patient perspectives will shift the research paradigm for anesthesia care from procedure, cost, and outcome studies to those that examine the patient experience with their respective anesthesia provider.

Studies of this type will also require broad rethinking of different types of measurements and outcomes. Types of patient satisfaction outcomes are not measured in the current data sets but could be addressed using the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS), a dataset that measures patient satisfaction through their hospital stay. Satisfaction measures related to patient-determined outcomes throughout their perioperative experiences could be integrated. Taking this further, different patient-indicated parameters could be developed for different locations of services (e.g. inpatient, outpatient) or different types of services (e.g. pain control, obstetric procedures, colonoscopies, major procedures). Studies could focus on data by county or zip code that might be more usable than national data sets for determining workforce needs and development of consistent definitions of service methods that address patient needs.

A patient-centered approach lends itself to data-based policy strategies. Studies that examine patient experiences via patient-defined parameters could ostensibly lead to broadened state regulations that allow all providers to practice to the fullest extent of their knowledge and skills. A state regulatory environment that supports the wider workforce could be more cost-effective for the consumer and provide better access to services in their communities. Patient-focused research could lend itself to new evidence-based management strategies that could be applicable to all healthcare settings.

Conclusion

In conclusion, this dissertation research expands the current understanding of opt-out legislation on CRNA independent practice from a surgical volume, case complexity, cost, facility size and type, and patient sociodemographic perspective. The implementation of the Medicare CRNA physician supervision opt-out provision in 2001 presents opportunities to explore whether this policy has influenced anesthesia staffing models in U.S. hospitals and ambulatory surgery centers (ASCs). Currently, nineteen states have exercised the opt-out provision (Schneider et al., 2017). Although studies have found using CRNAs is a cost-effective approach to delivering anesthesia, few have investigated the impact of the opt-out policy on the prevalence of predominantly CRNA models in different surgical facilities and hospitals (Hogan et al., 2010). Considering this legislation, we examined the prevalence of three anesthesia staffing models in a single state, California. The predominant anesthesiologist staffing model remained common, particularly in urban, highly population dense, and above the national poverty level. CRNAs appeared to provide access to anesthesia services in areas, particularly rural locations, where these services might not have otherwise been available. Allowing CRNAs to deliver anesthesia services independently may alleviate the perceived anesthesiology provider shortages, particularly in rural locations without adversely affecting patient quality of care while reducing healthcare expenditures. This study's findings suggest that the opt-out legislation alone may not have yielded strong uptake of predominantly CRNA independent practice methods. Rather, multiple influences shape anesthesia staffing model choice for surgical facilities with opt-out legislation. With continued pressure to reduce healthcare costs, emphasis on cost reduction with surgical care will be substantially amplified. Future work should focus on factors that drive facility-level changes with respect to cost, surgical care, and patient access to care attributable to the specific anesthesia staffing models. This dissertation underscores the importance of sustaining efforts to investigate the benefits of opt-out legislation on anesthesia services and demonstrating safe, quality, cost-effective patient care.

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Appendices for Manuscript Submission

Table 2-1. **Summary of Findings for an Integrative Review**

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Abenstein et al., 2004	Assess whether improvements in quality of care with physician-directed anesthesia can be obtained at a cost deemed reasonable by societal standards	Prospective Observational	• all model assumptions are least favorable to physicians • cost-effectiveness analyses suggest incremental gains in life expectancy • physician-directed versus non-medically directed nurse model of care can be obtained at a cost deemed reasonable by society	Level 4	3
Abraham et al., 2014	Provide a comprehensive picture of the ACA target population and synthesize the current research evidence regarding the impact of insurance on medical care demand	Retrospective Analysis	• uninsured population is heterogeneous with respect to its demographic, economic, and health status attributes • those who enroll in coverage are disproportionately less healthy, then their utilization may differ from what is predicted by average rates	Level 6	3
Alves, 2005	Examine occupational stress in the anesthesia care team model	Prospective analysis	• CRNA practice with a variety of healthcare professionals in a multitude of settings with varying degrees in SOP, roles, and responsibilities • Nationally, 27% of CRNAs practice in non-medically directed or unsupervised settings, 73% practice in medically directed environments • Widespread variation in CRNA practice roles has created a need to better understand the salient features of the CRNA SOP in ACT • CRNAs need to achieve consensus regarding optimal utilization of both types of providers in ACTs	Level 4	3

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Dai et al., 2009	Examine the demographic distribution of CRNA manpower, the ratio of CRNAs to MDAs in each institute, job descriptions, professional expectations and job satisfaction	Prospective Observational	• validity and reliability of the questionnaire for the department chief and anesthesiology nursing staff was 0.8 and 0.7 • average clinical load (2002−2004) for MDAs was 1500−1700 cases/year and 350−380 cases/year for CRNAs • job stipulation for CRNAs in Taiwan was compatible with that in the U.S. • need to establish an official accreditation system and formal education programs, to institute well-defined and standardized job descriptions, and to improve resource allocation for CRNAs	Level 4	3
Daughtry et al., 2010	Conduct a comprehensive examination of the labor markets for anesthesiologists and nurse anesthetists	Prospective Observational	• clear urban/rural differences in the labor markets for anesthesiology CRNAs and MDAs are more likely to be employed by a facility in rural areas • West locations CRNAs are least likely to be employed by groups • CRNAs over MDAs are more likely to prefer better technology	Level 4	4
Demeere et al, 2002	Evaluate manpower for anesthesia in Belgium until 2020	Prospective Observational	• workload 10 hours/day • need for 51 anesthesiologists per year from 2004-2008 • increase to 58 per year from 2010-2020 • 75.4% identified need to increase workforce and consider CRNAs	Level 4	2
DesRoches et al., 2013	Mitigate shortages of primary care physicians and ensure access to health care services for a growing number of Medicare beneficiaries	Retrospective Analysis	• states with the highest rate of NPs billing were rural • 80% of the payments received by both NPs and primary care physicians were for evaluation and management services • beneficiaries assigned to an NP were more likely to be female • beneficiaries were significantly more likely than similar primary care physicians to practice in federally designated primary care shortage areas	Level 6	3

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Dexter et al., 2015	Evaluate a tool for sufficient reliability internal consistency for use by CRNAs and reporting supervision requirements	Prospective Observational	• de Oliveira Filho supervision instrument was designed for use by residents • instrument is reliable and valid when used by CRNAs	Level 4	2
Dulisse et al., 2010	Explore whether the CMS change in supervision rules showed any difference in patient outcomes	Retrospective Analysis	• CRNAs provided 20% of surgeries in opt-out states, and 10% in non-opt-out states • CRNAs practicing solo in opt-out states had a lower odds ratio of complications, 0.798 vs. 0.813	Level 6	3
Dumouchel et al., 2015	Determine if moral distress levels differed between CRNAs working in medically supervised versus independent practice in California	Prospective Observational	• Medically supervised CRNAs had a lower mean moral distress • scores (176.8) versus independent practice CRNAs (187.8) ($p = .002$) Lower scores indicate higher moral distress • CRNAs experienced moral distress in the following situations: when pressured to give anesthesia to un-optimized patients, when differences of opinion regarding anesthetic plans occurred, in dealing with end-of-life issues, when working with incompetent providers, and during interprofessional struggles between CRNAs and MDAs	Level 4	3
Enright 2013	Assess the challenges that face those who work in resource-poor areas of the world	Retrospective Analysis	• shortage of trained anesthesia providers, both physician and non-physician, particularly acute outside urban areas • residency training programs in low-income countries increase their output as MDAs must be available to supervise non-physician providers • increased efforts are needed to recruit trainees into the specialty of anesthesia and to retain them locally • time, effort, planning, and resources are required to ensure that anesthesia in low-income areas can reach internationally accepted standards result in wider access to care	Level 6	2

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Epstein 2012	Explored predictions of the French simulation study using real data captured from an anesthesia information management system to determine the incidence and timing of simultaneous critical portions of cases	Retrospective Analysis	• supervision ratio of 1:2, lapses occurred on 35% of days • peak incidence occurred before 8:00 AM, *p*_0.0001 • average time from operating room entry until anesthesia release time during first case starts was 22.2 min (95% C.I.:21.8–22.8) • decreasing supervision ratio from 1:2 to 1:3 has a large effect on supervision lapses • staggered starts or additional MDAs would be required	Level 6	3
Fallacaro et al., 2004	Correlation of anesthesia providers and their urban and rural distribution	Retrospective Analysis	• MDAs reside 91.6% in metropolitan areas and 8.4% in rural areas • CRNAs reside 81.4% in metropolitan areas and 18.6% non-metropolitan areas • 3100 counties observed and 843 are not resided in by both providers, 96% being non-metropolitan	Level 6	3
Hogan et al., 2010	Simulate costs associated with delivery of anesthesia under a variety of delivery methods and settings and estimate costs and revenues that would occur with each delivery model	Retrospective Analysis	• CRNAs are less costly to train than anesthesiologists • CRNAs acting independently provide anesthesia services at the lowest economic cost, and net revenue is positive • supervisory model is the second lowest cost, but reimbursement policies limit its profitability • medical direction 1:1 model is almost always the least efficient model	Level 6	3
Jones et al., 2009	Compare attitudes toward collaboration of CRNAs with those of MDAs	Prospective Observational	• no significant differences in attitudes were found • health discipline showed a statistically significant difference • CRNAs who deal with role conflict or unclear expectations as well as limited scope of practice may have increased job stress and dissatisfaction	Level 4	4

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Kalist et al., 2004	Analyze the decision to enter the occupations collectively known as APN to determine whether legislation on the scope of practice of APNs affects entry into advanced practice	Retrospective Analysis	• enrollments in states with high levels of professional independence with prescription authority are approximately 25 percent higher • enrollments are approximately 13 percent higher in states where APNs have prescription authority and 30 percent higher in states where APNs have more professional independence	Level 6	4
Kalist et al., 2011	Examine how the relative numbers of anesthesia providers, differences in regulation, affect the earnings of CRNAs, and the extent of supervision of CRNAs by MDAs	Retrospective Analysis	• formal state recognition and regulation of CRNAs have ratified existing practice rather than reshaping the parameters of the profession • differences in language of State statutes can be used to persuade institutions within the state • less supervision in states that grant CRNAs a high level of professional independence • MDAs may be less likely to be incurring the costs that would be necessary to maintain anticompetitive measures such as regulations requiring supervision of CRNAs	Level 6	4
Kaplan, 2012	Examine the 2010 CMS and NPI data to ascertain their usefulness to determine the distribution of APRNs in rural and urban areas of the U.S.	Retrospective Analysis	• 35,973 CRNAs were identified • national per capita ratio of all CRNAs to 10,000 population was 1.2 • 30,518 (84.8%) of CRNAs indicated they were practicing in urban areas • national per-capita ratio of rural CRNAs was 0.9 per 10,000 population. rural CRNAs, 66.8% (3,645) practice in large rural areas, 25.8% (1,410) in small rural areas, and 7.3% (400) in isolated small rural areas	Level 6	3
Kullgren et al., 2010	Identify types and frequencies of nonfinancial access barriers faced by low income uninsured adults, and determine how frequently nonfinancial barriers coexist with financial access barriers	Prospective Observational	• financial barriers were the most often cited barrier to access in each of the three groups • across all populations, one-third to one-half of respondents with financial access barriers also cited one or more nonfinancial barriers as contributing to their problems accessing health care	Level 4	4

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Kuo et al., 2013	Assess the growth in care provided by nurse practitioners from 1998-2010 and how this varies by practice setting, using CMS and NPI data	Retrospective Analysis	• in 1998, number of Medicare patients receiving care from NPs increased fifteen-fold • by 2010 states with the least restrictive regulations of NP practice had a 2.5-fold greater likelihood of patients' receiving their primary care from NPs than did the most restrictive states • relaxing state restrictions on NP practice in turn would reduce the current national shortage of primary care providers	Level 6	3
Liao et al., 2015	Identify trends in anesthesia services, charges, and payments by CRNAs and anesthesiologists	Retrospective Analysis	• volume of anesthesia Medicare Part B services had an average increase of 3.1% per year from 2000 to 2014 • in 2014, the top 25 anesthesia procedure codes accounted for 75% of all allowed Medicare least used billing modifier was the AD modifier (medical supervision rate), ranging from 0.4% to 0.6% utilization • CRNA services using the QZ modifier increased from 10.9% to 21.7% • billing for MDA only services (AA modifier) decreased from 33.2% to 25.8% over the study period	Level 6	4
Lindsay, 2007	Gain further insight into how mid-level practice location varied by gender	Prospective Observational	• family and community ties played a key role in influencing practice location • men were particularly drawn to the broad scope of practice and autonomous nature of rural practice • women in rural areas enjoyed the more personable environment and greater respect from colleagues and patients • CRNAs preferred rural areas because they had fewer disputes about professional boundaries	Level 4	3
Merwin et al., 2006	Determine the current trends in supply, demand, and equilibrium (the level of employment where supply equals demand) in the market for CRNAs	Prospective Observational	• supply of CRNAs has increased in recent years, stimulated by shortages of CRNAs and subsequent increases in the number of CRNAs trained • increases have not offset the number of retiring CRNAs to maintain a constant age in the CRNA population • The average age will continue to increase for CRNAs in the near future despite increases in CRNAs trained • supply of CRNAs in relation to surgeries will increase in the near future	Level 4	3

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Merwin et al., 2009	Build on prior estimates and descriptions of supply trends of CRNAs	Prospective Observational	• vacancy rate was higher in rural hospitals than in non-rural hospitals • vacancy rate was lower in ambulatory surgical centers • number of simulations were run to predict the effects of relevant changes in the market for surgeries and number of CRNAs • unusually large rate of new CRNAs entering the market, yet the vacancy rates remain relatively high	Level 4	3
Miller et al., 2016	Examine whether QZ modifier can be used to identify care that was provided without any MDA involvement or whether they provided care that is not represented in the administrative billing database	Retrospective Analysis	• among the 538 hospitals that exclusively reported the modifier QZ, 47.5% had affiliated MDAs; these hospitals accounted for 60.4% of the cases • results illustrate the challenges of using modifier QZ to describe anesthesia practice arrangements in hospitals • modifier QZ does not seem to be a valid surrogate for no anesthesiologist being involved in the care provided	Level 6	3
Negrusa et al., 2016	Test whether the odds of an anesthesia complication vary by SOP and delivery model (CRNA only, anesthesiologist only, or mixed anesthesiologist and CRNAs team)	Retrospective Analysis	• 8 in every 10,000 anesthesia-related procedures had a complication • complications were 4 times more likely in the inpatient setting (20 per 10,000) than the outpatient setting (4 per 10,000) • both settings, the odds of a complication were found to differ significantly with patient characteristics • complication odds were not found to differ by SOP or delivery model	Level 6	4
Quraishi et al., 2017	Identify trends in anesthesia services, charges, and payments by CRNAs and anesthesiologists	Retrospective Analysis	• volume of anesthesia Medicare Part B services had an average increase of 3.1% per year from 2000 to 2014 • in 2014, the top 25 anesthesia procedure codes accounted for 75% of all allowed Medicare least used billing modifier was the AD modifier (medical supervision rate), ranging from 0.4% to 0.6% utilization • CRNA services using the QZ modifier increased from 10.9% to 21.7% • billing for MDA only services (AA modifier) decreased from 33.2% to 25.8% over the study period	Level 4	4

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Schneider et al., 2017	To prove that opt-out rule adoption had little or no effect on surgery access or costs	Retrospective Analysis	• inpatient cost models, the coefficient of the opt-out variable was consistently positive and also statistically significant in most model specifications • access to inpatient surgical care, the opt-out rules did not increase or decrease access in opt-out states • opt-out states declared opt-out status toward the end of the timeline of available data • providing a small number of years post opt-out years for the facility fixed-effects panel models • data was randomly selected from a 20% sample of national hospitals during out study period • some hospitals were not included in the sample or contribute fewer years of observation times • did not measure to what extent either the number of CRNAs or MDAs typical workloads, actually changed as a result of the implementation of the opt-out policy	Level 6	4
Schubert et al., 2001	To prove the existence of a current MDA shortage and to project the balance of labor supply and demand in the future	Retrospective Analysis	• there is currently a 3.6% to 10.9% shortage of anesthesiologists nationwide, depending on the assumption of a 2% or 3% increase in annual demand since 1994 and a constant pattern of work distribution • approximately 1200 to 3800 anesthesiologists. If projected demand continues to increase at the rate of 1.5% to 2% annually • shortfall will amount to 2.6 % to 12.0 % of the labor supply by 2005, representing a deficit of 1000 to 4500 MDAs • by 2010, this shortfall is projected to disappear or continue to amount to about 11% of the supply • substantive shortfall of anesthesia personnel exists in 2001 and will continue for years to come, fueled by changing population demographics, population health trends, and accelerating advancements in surgical technology, growth in ambulatory and office-based surgery, pain medicine, and intensive care	Level 6	3

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Schubert et al., 2003	Incorporate newly available data about residency composition, American Board of Anesthesiology and CRNA certification	Retrospective Analysis	• current shortage of 1100 – 3800 MDAs in 2002, on the basis of past service demand growth assumptions of 2%–3%, respectively • by 2005 this number is expected to be 500 – 3900, depending on a future service demand growth of 1.5%–2%, respectively • to avoid a surplus of MDAs in 2006 –2010, model suggests that the number of graduates should level out at 1600 yearly, with a 1.5% service demand growth	Level 6	3
Seibert et al., 2004	To pilot test the Nurse Anesthesia Rural Practice Inventory in order to establish a database for rural data	Prospective Observational	• CRNAs provide a broad range of rural anesthesia services • Significant differences in independent and medically directed CRNAs • lack of agents, devices, and surgical specialists' representation based on hospital size	Level 4	3
Stensland et al., 2013	Test the validity of the assumption that rural beneficiaries systematically receive less care	Retrospective Analysis	• systematic differences in the amount of care used across regions of the country • very little difference within a region between rural and urban areas • Medicare payment policies are designed to ensure access, they should be assessed on the basis of achieving similar service use rather than similar local physician supply • should also be targeted to isolated rural providers needed to preserve access to care	Level 6	3
Sun et al., 2016	Address the issue of opt-out legislation in the U.S. Medicare population among opt-out states compared with non–opt-out states	Retrospective Analysis	• most (4 of 5) cohorts of opt-out states likely experienced smaller growth in anesthesia utilization rates compared with non–opt-out states • California had an overall 5% increase in Medicare utilization for anesthesia	Level 6	3
Sun et al., 2016_2	Examine the extent to which the opt-out rule increased access to anesthesia care for urgent cases	Retrospective Analysis	• Percent increase in rural procedures between opt-out and non-opt-out states • looked at access through lens of case utilization	Level 6	3

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
Sun et al., 2017	Examine a different dimension of access to care and the influence of opt-out: the distance patients travel to obtain surgical procedures	Retrospective Analysis	• did not reduce the percentage of patients who traveled outside of their home zip code except in the case of total hip arthroplasty (2.2%-point reduction; p = 0.007) • patients travelling outside of their zip code had no significant effect on the distance traveled among any of the procedures we examined, with point estimates ranging from a 7.9-km decrease for appendectomy (95% CI, −19 to 3.4; p = 0.173) to a 1.6-km increase (95% CI, −5.1 to 8.2; p = 0.641) for total hip arthroplasty • looking at access through distance traveled by patient unable to ascertain the effect of opt-out on travel distances for procedures that were rarely performed in this population but may be important from a policy standpoint • possible that opt-out may have reduced travel distances for procedures they did not examine	Level 6	3
Tai et al., 2004	Examine how patient and hospital attributes and the patient–physician relationship influence hospital choice of rural Medicare beneficiaries	Retrospective Analysis	• significant influences of patients' socioeconomic, health, and functional status, their satisfaction with and access to primary care, and their strong preferences for certain hospital bypassing behavior • rural hospitals can potentially expand new services such as long-term care, development of satellite clinics, and expansion of onsite outpatient capacity	Level 6	3
Taylor, 2009	Compare the attitudes of MDAs and CRNAs toward collaboration with each other	Prospective Observational	• divergent perspectives regarding collaboration previously demonstrated between physicians and nurses may also exist in the specialty field of anesthesia • provided no support for the supposition that gender contributes to the differences in attitude toward collaboration between physicians and nurses	Level 4	2

Citation	Objective	Study Design	Relevant Findings	Quality of Evidence	GRADE Score
VanBibber et al., 2006	Assess case-mix differences in the training needs of surgeons who will practice in rural settings	Retrospective Analysis	• procedures on the bowel, appendix, and gallbladder constitute 61% of general surgical inpatient procedures in rural hospitals, compared with 46% in urban hospitals • rural practices include substantially fewer operations on the stomach and esophagus (6% versus 11%), liver and pancreas (0% versus 1%), spleen and thyroid (3% versus 10%), and bowel (17% versus 19%) • general surgical procedures constitute 42% of inpatient procedures in rural hospitals versus 25% in urban hospitals • rural general surgeon more broadly trained in selected obstetric and gynecologic operations could potentially perform 66% of all inpatient procedures in rural hospitals • addition of simple vascular cases, head and neck operations, amputations, and nephrectomies could increase this potential to 71% of all cases	Level 6	3

* Level of evidence determined using rating system for the hierarchy of evidence (Melnyk & Fineout-Overholt, 2011). The hierarchy is a seven-tier scale, with the best evidence receiving the strongest rating. The strongest evidence to base clinical practice on is rated level 1 and includes both systematic reviews and meta-analyses of randomized controlled trials or evidenced-based clinical practice guidelines based on systematic reviews of randomized controlled trials. Level 2 comprises evidence from well-designed randomized control trials, Level 3 evidence comes from controlled trials with no randomization, and level 4 contains cohort and case-control research studies. Level 5 evidence is produced from systematic reviews of descriptive and qualitative studies, level 6 includes both single descriptive studies and qualitative work, and the weakest evidence, level 7, is expert opinions.

**The Grading of Recommendations Assessment, Development and Evaluation (short GRADE) working group began in the year 2000 as an informal collaboration of people with an interest in addressing the shortcomings of grading systems in health care. The working group has developed a common, sensible and transparent approach to grading quality (or certainty) of evidence and strength of recommendations. Many international organizations have provided input into the development of the GRADE approach which is now considered the standard in guideline development. 1. The certainty in the evidence (also known as quality of evidence or confidence in the estimates) should be defined consistently with the definitions used by the GRADE Working Group. 2. Explicit consideration should be given to each of the GRADE domains for assessing the certainty in the evidence (although different terminology may be used). 3. The overall certainty in the evidence should be assessed for each important outcome using four or three categories (such as high, moderate, low and/or very low) and definitions for each category that are consistent with the definitions used by the GRADE Working Group. 4. Evidence summaries and evidence to decision criteria should be used as the basis for judgements about the certainty in the evidence and the strength of recommendations. Ideally, evidence profiles should be used to assess the certainty in the evidence, and these should be based on systematic reviews. At a minimum, the evidence that was assessed and the methods that were used to identify and appraise that evidence should be clearly described. 5. Explicit consideration should be given to each of the GRADE criteria for determining the direction and strength of a recommendation or decision. Ideally, GRADE evidence to decision frameworks should be used to document the considered research evidence, additional considerations and judgments transparently. 6. The strength of recommendations should be assessed using two categories (for or against an option) and definitions for each category such as strong and weak/conditional that are consistent with the definitions used by the GRADE Working Group (although different terminology may be used), such as strong (1, 2).

Table 3-1. **Sample Characteristics for Chapter Three**

Table 1 - Sample Characteristics	Total N=298,508		2008 n=148,153		2013 n=150,355		*p*-Value†
Age of Beneficiary, years							<.001
65-74	132,597	44.4%	64,438	43.2%	68,159	45.3%	
75-84	111,435	37.3%	57,341	38.4%	54,094	36.0%	
85-94	51,647	17.3%	25,592	17.2%	26,055	17.3%	
95 and over	3,818	1.3%	1,776	1.2%	2,042	1.4%	
Length of Stay in days							<.001
≤ 30	295,135	98.9%	146,163	98.7%	148,972	99.1%	
>30	3,366	1.1%	1,990	1.3%	1,376	0.9%	
Claims Type							<.001
Specialty Center or Ambulatory Surgery Center	4,022	1.3%	1,896	1.3%	2,126	1.5%	
Hospital	294,486	98.7%	146,257	98.7%	148,229	98.5%	
Sex							<.001
Male	132,266	44.3%	65,167	44.0%	67,099	44.6%	
Female	166,242	55.7%	82,986	56.0%	83,256	55.4%	
Anesthesia Group							<.001
CRNA	5,593	1.9%	5,593	3.8%	8,802	5.8%	
Anesthesiologist	268,401	89.9%	133,667	90.2%	134,734	89.2%	
ACT	16,432	5.5%	8,893	6.0%	7,538	5.0%	
Procedure§							<.001
Abdominal	43,641	14.6%	20,256	13.7%	23,385	15.8%	
Other	38,581	12.9%	13,479	9.1%	14,895	10.1%	
Upper Leg	34,752	11.6%	16,896	11.4%	17,856	12.1%	
Abdominal Lower	31,412	10.5%	18,000	12.1%	20,581	13.9%	
Head	31,382	10.5%	15,564	10.5%	15,848	10.7%	
Intrathoracic	30,163	10.1%	5,223	3.5%	4,972	3.4%	
Knee	28,374	9.5%	16,687	11.3%	14,695	9.9%	
Perineum	20,234	6.8%	287	0.2%	352	0.2%	
Spine and Spinal Cord	16,150	5.4%	11,214	7.6%	9,020	6.1%	
Neck	12,985	4.3%	15,685	10.6%	14,478	9.8%	
Chest Wall	10,195	3.4%	7,843	5.3%	8,307	5.6%	
Pelvis	639	0.2%	7,019	4.7%	5,966	4.0%	
Number of Elixhauser Comorbidities							<.001
1	20,691	6.9%	11,575	7.8%	9,116	6.2%	
2	50,962	17.1%	29,096	19.6%	21,866	14.8%	
3	68,307	22.9%	39,047	26.4%	29,260	19.7%	
4	62,782	21.0%	34,271	23.1%	28,511	19.2%	
5	44,868	15.0%	21,666	14.6%	23,202	15.7%	
6 or more	50,898	17.1%	12,498	8.4%	38,400	25.9%	
Elixhauser Comorbidities							<.001
Hypertension	238,741	80.0%	88,973	60.1%	149,768	99.6%	
Diabetes	96,116	32.2%	32,868	22.2%	63,248	42.1%	
Cardiac Arrhythmia	93,289	31.3%	34,679	23.4%	58,610	39.0%	
Fluid and Electrolyte Disorders	82,912	27.8%	26,104	17.6%	56,808	37.8%	
Chronic Pulmonary Disease	73,456	24.6%	25,774	17.4%	47,682	31.7%	

Table 1 - Sample Characteristics						
Congestive Heart Failure	53,487	17.9%	20,706	14.0%	32,781	21.8%
Renal Failure	57,591	19.3%	15,502	10.5%	42,089	28.0%
Hypothyroidism	53,580	17.9%	17,398	11.7%	36,182	24.1%
Other Neurological Disorders	27,291	9.1%	8,016	5.4%	19,275	12.8%
Depression	33,193	11.1%	8,013	5.4%	25,180	16.7%
Peripheral Vascular Disorders	29,786	10.0%	10,793	7.3%	18,993	12.6%
Obesity	33,769	11.3%	7,448	5.0%	26,321	17.5%
Solid Tumor without Metastasis	38,394	12.9%	17,396	11.7%	20,998	14.0%
Valvular Disease	29,355	9.8%	10,237	6.9%	19,118	12.7%
Weight Loss	19,572	6.6%	5,827	3.9%	13,745	9.1%
Psychoses	5,729	1.9%	1,099	0.7%	4,630	3.1%
Coagulopathy	16,545	5.5%	3,845	2.6%	12,700	8.4%
Pulmonary Circulation Disorders	11,381	3.8%	3,517	2.4%	7,864	5.2%
Liver Disease	11,788	3.9%	2,829	1.9%	8,959	6.0%
Metastatic Cancer	15,885	5.3%	7,253	4.9%	8,632	5.7%
Rheumatoid Arthritis/collagen	13,145	4.4%	4,224	2.9%	8,921	5.9%
Deficiency Anemia	9,476	3.2%	2,686	1.8%	6,790	4.5%
Paralysis	7,042	2.4%	2,212	1.5%	4,830	3.2%
Blood Loss Anemia	5,700	1.9%	2,335	1.6%	3,365	2.2%
Lymphoma	4,399	1.5%	1,795	1.2%	2,604	1.7%
Peptic Ulcer Disease	3,826	1.3%	1,152	0.8%	2,674	1.8%
Alcohol Abuse	1,362	0.5%	349	0.2%	1,013	0.7%
AIDS/HIV	693	0.2%	57	<0.1%	636	0.4%
Drug Abuse	192	0.1%	7	<0.1%	185	0.1%

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; ASC, Ambulatory Center

† chi-square tests

§Procedures based on the Centers for Medicare & Medicaid Services Healthcare Common Procedure Coding System

Table 3-2. **Mixed Effects Regression Model Examining the Interaction of Anesthesia Provider and Year**

Table 2 - Mixed Effects Regression Model Examining the Interaction of Anesthesia Provider and Year on Anesthesia Service Charge Amount and Length of Stay

	Anesthesia Service Charge Amount, dollars ($)				Length of Stay, days			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Intercept	7832.39	7037.29	8627.49	<.001	12.5	10.4	14.6	<.001
Sex								
Female	Reference				Reference			
Male	289.87	236.19	343.54	<.001	0.1	0.1	0.2	<.001
Anesthesia Provider								
CRNA	Reference				Reference			
ACT	2158.84	1440.38	2877.29	<.001	-0.2	-1.1	0.7	.610
Anesthesiologists	2464.43	1809.08	3119.78	<.001	-0.5	-1.3	0.3	.212
Claims Type								
Specialty Center or Ambulatory Surgery Center	Reference				Reference			
Hospital	-750.56	-1094.31	-406.82	<.001	-0.7	-1.2	-0.3	.002
Procedures[§]								
Spine and Spinal Cord	Reference	.	.		Reference	.	.	
Abdominal	-1239.71	-1911.51	-567.90	<.001	0.7	-0.1	1.6	.083
Head	-1621.37	-2280.63	-962.11	<.001	-0.9	-1.7	-0.1	.043
Intrathoracic	-1496.97	-2303.03	-690.90	<.001	0.5	-0.5	1.5	.338
Knee	-721.00	-1419.72	-22.27	.043	-1.5	-2.4	-0.6	.001
Year								
2013	Reference				Reference			
2008	-475.80	-727.91	-223.68	<.001	1.2	0.8	1.5	<.001
Age of Beneficiary, years	-56.97	-60.55	-53.39	<.001	0.1	0.1	0.1	<.001
Number of Elixhauser Comorbidities	-77.04	-92.97	-61.12	<.001	0.5	0.5	0.5	<.001
Anesthesia Provider X Year[‡]								
CRNA X 2008	Reference				Reference			
ACT X 2008	19.95	-323.00	362.90	.909	0.6	0.1	1.0	.011
Anesthesiologists X 2008	-766.73	-1024.48	-508.98	<.001	0.0	-0.3	0.4	.814

[‡]Interaction term indicates service charge amount or LOS associated with other providers in 2008 vs CRNA care in 2013 (i.e. 2008 Anesthesia Provider Care = Anesthesia Provider + Year + (Anesthesia X Year Interaction)). In 2008 MDAs delivered care was estimated to cost $1,2221.90 more than CRNA care controlling for all other factors. Alternatively, in 2013 MDAs delivered care was estimated to cost $2,464.43 more than CRNA care.

Table 3-3. **Mixed Effects Regression Model of Length of Stay, in Days, by Year**

Table 3 - Mixed Effects Regression Model of Length of Stay, in Days, by Year								
	2008				2013			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Intercept	2.0	-0.2	4.2	.069	14.6	12.2	17.0	<.001
Sex								
Female	Reference				Reference			
Male	0.1	0.0	0.2	.220	0.1	0.1	0.2	<.001
Anesthesia Provider†								
CRNA	Reference				Reference			
ACT	1.1	-0.3	2.5	.114	-1.1	-2.1	0.1	.047
Anesthesiologists	-0.1	-1.4	1.2	.917	-0.9	-1.9	0.0	.539
Claims Type								
Specialty Center or Ambulatory Surgery Center	Reference				Reference			
Hospital	0.9	-0.7	2.5	.276	-0.6	-1.0	-0.2	.004
Procedure§								
Spine and Spinal Cord	Reference				Reference			
Abdominal	2.7	1.3	4.1	<.001	-0.5	-1.5	0.5	.321
Head	0.0	-1.3	1.3	.997	-1.6	-2.5	-0.6	.002
Intrathoracic	1.5	-0.2	3.2	.075	-0.5	-1.7	0.7	.416
Knee	-1.6	-3.0	-0.2	.027	-1.2	-2.3	-0.2	.020
Age of Beneficiary, years	0.1	0.1	0.1	<.001	0.0	-1.8	0.9	.535
Number of Elixhauser Comorbidities	0.1	0.1	0.1	.021	0.8	0.7	0.8	<.001

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists

†Anesthesia provider referenced is CRNA for interaction term

§Procedures based on the Centers for Medicare & Medicaid Services Healthcare Common Procedure Coding System

**Model is adjusted for procedure type and anesthesia provider, see Appendix for full model*

Table 3-4. **Mixed Effects Regression Model of Anesthesia Service Charge Amount, in Dollars, by Year**

Table 4 – Mixed Effects Regression Model of Anesthesia Service Charge Amount, in Dollars, by Year								
	2008, dollars ($)				2013, dollars ($)			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Intercept	5990.19	5041.18	6939.19	<.001	8278.93	7082.37	9475.50	<.001
Sex								
Female	Reference				Reference			
Male	241.01	179.86	302.16	<.001	315.25	230.69	399.82	<.001
Anesthesia Provider†								
CRNA	Reference				Reference			
ACT	3436.47	2652.57	4220.37	<.001	1051.28	-63.74	2166.31	.065
Anesthesiologists	1610.02	875.06	2344.98	<.001	2257.71	1240.92	3274.50	<.001
Claims Type								
Specialty Center or Ambulatory Surgery Center	Reference				Reference			
Hospital	-31.76	-579.90	516.39	.909	-531.56	-967.34	-95.77	.017
Procedure§								
Spine and Spinal Cord	Reference				Reference			
Abdominal	-670.76	-1468.98	127.46	.100	-1729.12	-2767.72	-690.52	.001
Head	-1236.13	-1992.00	-480.26	.001	-2085.65	-3125.14	-1046.15	<.001
Intrathoracic	-1147.36	-2085.72	-208.99	.017	-1819.23	-3070.44	-568.03	.004
Knee	-674.54	-2737.40	-1857.43	.096	-545.13	-1656.84	566.58	.337
Age of Beneficiary, years	-45.22	-49.33	-41.11	<.001	-64.32	-69.92	-58.72	<.001
Number of Elixhauser Comorbidities	-152.75	-174.69	-130.80	<.001	-9.84	-32.05	12.38	.385

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists

†Anesthesia provider referenced is CRNA for interaction term

§Procedures based on the Centers for Medicare & Medicaid Services Healthcare Common Procedure Coding System

**Model is adjusted for procedure type and anesthesia provider, see Appendix for full model*

Table 4-1. **Sample Characteristics for Chapter Four**

Table 1 - Sample Characteristics					
	2008		2013		*p*-Value
Facility Size†					
<201 Beds	33,351	23.2%	32,462	22.0%	<.001
201+ Beds	110,168	76.8%	114,979	78.0%	
Anesthesia Provider†					<.001
CRNA	5,593	3.80%	8,802	5.80%	
MDA	133,667	90.20 %	134,734	89.20%	
ACT	8,893	6.00%	7,538	5.00%	
Rural-Urban Continuum Code†					<.001
Metropolitan	141,519	95.30 %	145,556	96.60%	
Non-metropolitan but adjacent to metro	4,710	3.20%	2,907	1.90%	
Non-metro and not adjacent to metro	2,059	1.40%	1,308	0.90%	
Proportion of county population living 1.5 times under the poverty level, mean, SD*	21.0	6.26	21.1	6.26	0.999

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; MDA, medical doctor anesthesiologist
*† chi-square tests, * t-test*

Table 4-2. **Anesthesia Providers by Rural-Urban Continuum Code, over Time**

Table 2 - Anesthesia providers by Rural-Urban Continuum Code, over time												
	Metropolitan				Non-metropolitan but adjacent				Non-metro and not adjacent to metro			
	2008 (n=141,274)		2013 (n=145,292)		2008 (n=4,697)		2013 (n=2,891)		2008 (n=2,043)		2013 (n=1,292)	
CRNA	4,652	3.3%	7,146	4.9%	730	15.5%	708	24.5%	209	10.2%	178	13.8%
MDA	128,025	90.6%	130,698	90.0%	3,734	79.5%	2,147	74.3%	1,773	86.8%	1,091	84.4%
ACT	8,597	6.1%	7,448	5.1%	233	5.0%	36	1.2%	61	3.0%	23	1.8%

Note for all years χ^2=2140; df=4; P<.001

ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; MDA, medical doctor anesthesiologist

[†]Data from CMS Billing Codes; Rural-Urban Continuum Codes, and HRSA Area Resource File.

Table 4-3. **Rural-Urban Continuum Code and Marginal Mean Proportion of Residents Living Below 1.5 Times the Poverty Level**

Table 3 - Rural-Urban Continuum Code and Marginal Mean Proportion of Residents Living Below 1.5 Times the Poverty Level				
Rural-Urban Continuum Code	year	Mean	95% Confidence Interval	
Metropolitan	2008	21.277	21.244	21.309
	2013	21.086	21.054	21.118
Non-metropolitan but adjacent to metro	2008	20.037	19.858	20.215
	2013	20.263	20.036	20.490
Non-metro and not adjacent to metro	2008	20.893	20.623	21.163
	2013	21.344	21.006	21.682

Note: Output from: One-way ANOVA for each year separately
†Data from CMS Billing Codes; Rural-Urban Continuum Codes, and HRSA Area Resource File

Table 4-4. **<u>Logistic Regression Estimating Association Between Poverty Level and Presence of a Facility with 201 Beds in County</u>**

Table 4 - Logistic Regression Estimating Association Between Poverty Level and Presence of a Facility with 201 Beds in County				
	Odds Ratio	95% Confidence Interval		*p*-Value
Proportion of county population living 1.5 times under the poverty level	1.010	1.008	1.011	<.001
Note: Data from CMS Billing Codes; Rural-Urban Continuum Codes, and HRSA Area Resource File				

Table 4-5. **<u>Multivariable Logistic Regression Estimating the Association Between Anesthesia Provider Groups and the Odds of Practicing in a Facility with 201 or More Beds</u>**

Table 5 - Multivariable Logistic Regression Estimating the Association Between Anesthesia Provider Groups and the Odds of Practicing in a Facility with 201 or More Beds

	Adjusted Odds Ratio	95% Confidence Interval		*p*-Value
Anesthesia Groups				
CRNA	Reference			
MDA	2.24	2.12	2.36	<.001
ACT	3.21	2.96	3.49	<.001
Year				
2008	Reference			
2013	0.70	0.65	0.75	<.001
Anesthesia Group X YEAR				
CRNA X 2013	Reference			
MDA X 2013	1.44	1.33	1.56	<.001
ACT X 2013	1.34	1.19	1.51	<.001
Proportion of county population living 1.5 times under the poverty level	1.01	1.01	1.02	<.001

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; MDA, medical doctor anesthesiologist
[†]Data from CMS Billing Codes; Rural-Urban Continuum Codes, and HRSA Area Resource File.

Figures for Manuscript Submission

Figure 2-1. **Penchansky and Thomas' Five Dimensions of Access**
From: Penchansky, R., & Thomas, J. W. (1981). The Concept of Access: Definition and Relationship to Consumer Satisfaction. *Medical Care, 19*(2):127–40.

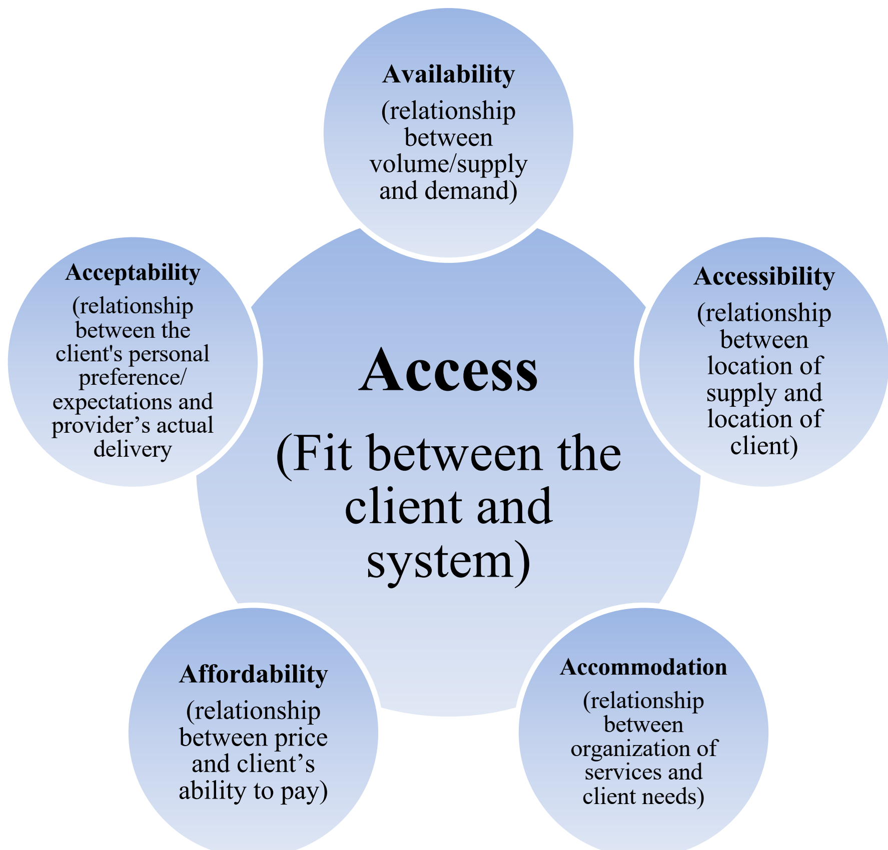


Figure 2-2. **PRISMA Flow Diagram**
From: Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & The PRISMA Group. (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta *A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal. pmed1000097

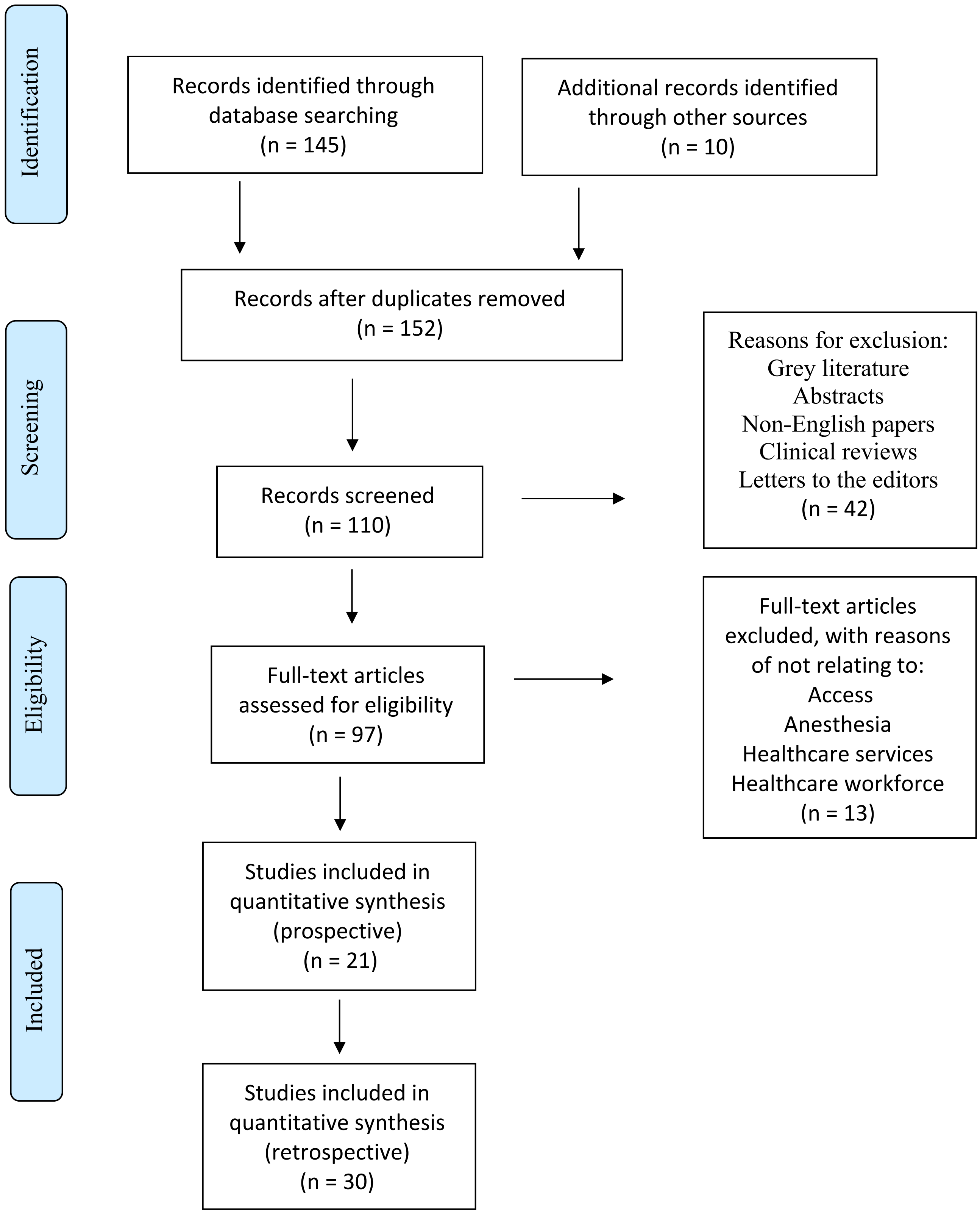
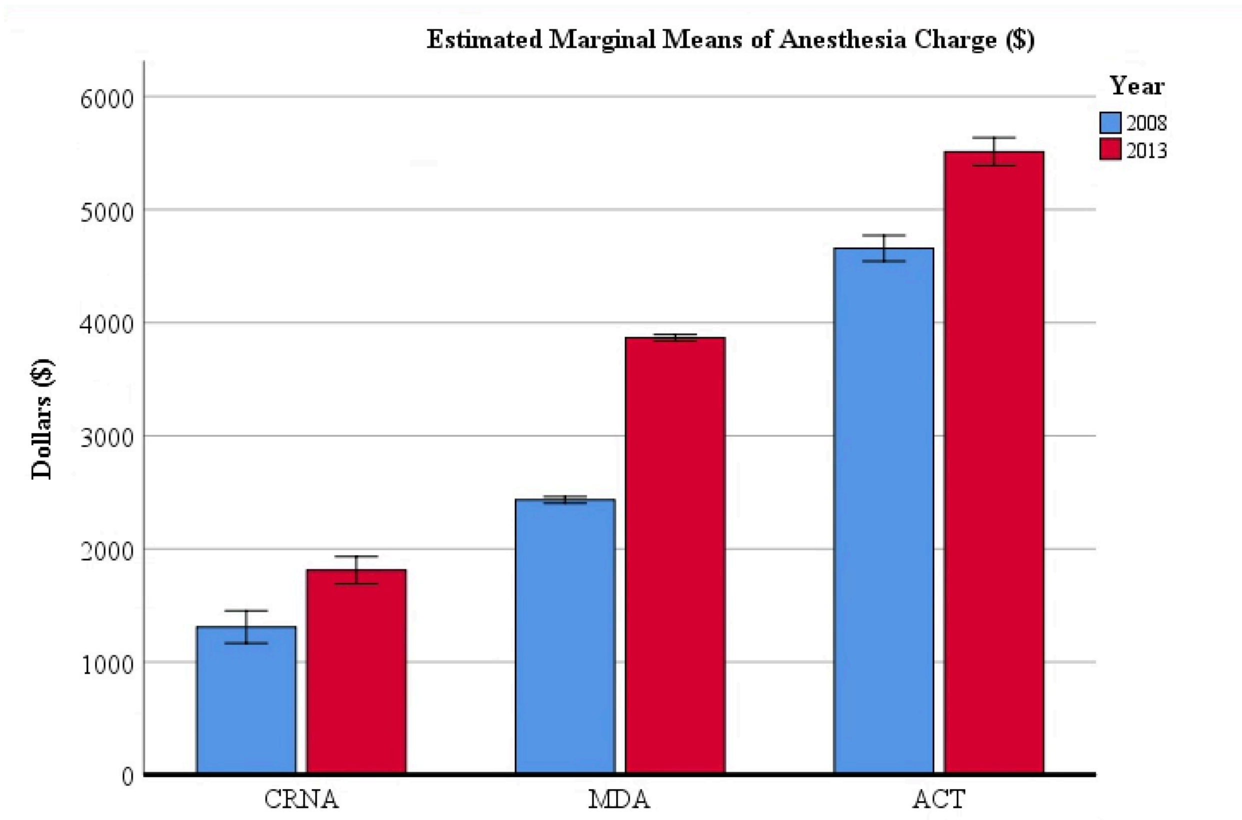
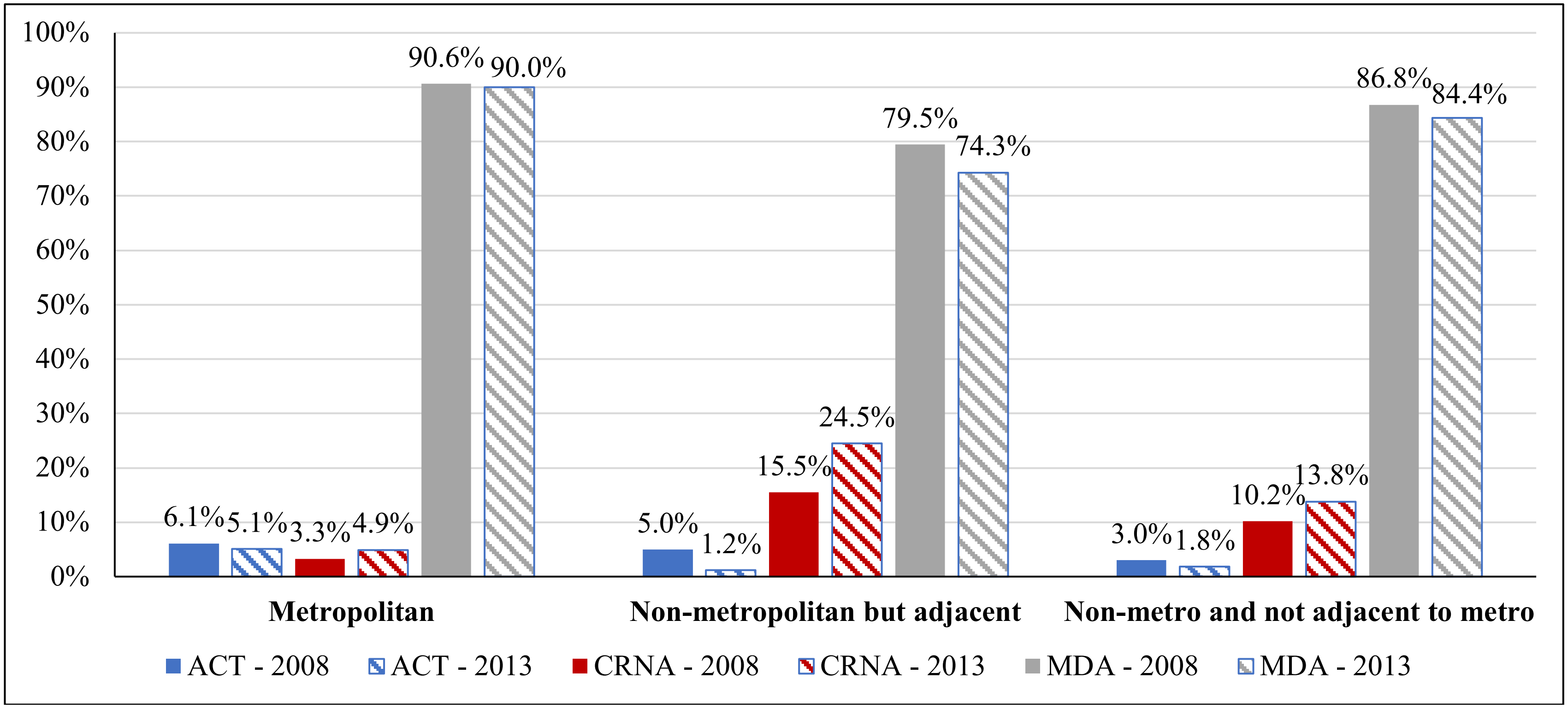


Figure 3-1. **Estimated Marginal Means of Anesthesia Service Charge**



*CRNA, certified registered nurse anesthetists; MDA, physician anesthesiologist; ACT, anesthesia care team. Anesthesia charge based on the Centers for Medicare & Medicaid Services total anesthesia service charge for the patient billing claim. Two-way ANOVA for anesthesia service charges for year by provider group.

Figure 4 – 1. **<u>Anesthesia Providers by Rural-Urban Continuum Code, over Time</u>**



* CRNA, certified registered nurse anesthetists; MDA, physician anesthesiologist; ACT, anesthesia care team. RUCC data was linked to anesthesia provider facility location. A stratified chi-square test, known as a Cochran–Mantel–Haenszel test, indicated a significant difference in the proportion of anesthesia providers by RUCC across years.

Appendices for Dissertation

Table A.1-1. **Definition of Key Terms**

Key Term	***Definition***
Medical Direction	Determines payment at the medically directed rate for the physician based on 50 percent of the allowance for the service performed by the physician alone. Payment will be made at the medically directed rate if the physician medically directs qualified individuals in two, three, or four concurrent cases and the physician performs the following activities: • Performs a pre-anesthetic examination and evaluation; • Prescribes the anesthesia plan; • Personally participates in the most demanding procedures in the anesthesia plan, including, if applicable, induction and emergence; • Ensures that any procedures in the anesthesia plan that they are unable to perform, are performed by a qualified individual; • Monitors the course of anesthesia administration at frequent intervals; • Remains physically present and available for immediate diagnosis and treatment of emergencies; and • Provides indicated post-anesthesia care The anesthesiologists must document being present for all seven of the above activities to receive reimbursement (Federal Register, 2001; Sun et al., 2016).
Medical Supervision	Determines payment when the anesthesiologist is involved in furnishing more than four procedures concurrently or is performing other services while directing the concurrent procedures (Federal Register, 2001; Sun et al., 2016).
Anesthesiologist (MDA)	Physicians trained in the delivery of anesthesia. The American Board of Anesthesiology or the American Osteopathic Board of Anesthesiology can certify them. After completing a medical degree, prospective anesthesiologists must complete four years of an intensive residency before qualifying for board certification. After initial certification, the requirement for recertification is every ten years. The primary professional association is the American Society of Anesthesiologists (Matsusaki & Sakai, 2011).

Key Term	***Definition***
Anesthesiology Assistant (AA)	A person who works under the direction of an anesthesiologist. AAs comply with all applicable requirements of state law, including any licensure requirements the state imposes on non-physician anesthetists. They are graduates of a medical school-based anesthesiologist's assistant education program accredited by the Committee on Allied Health Education and Accreditation; and includes approximately two years of specialized basic science and clinical education in anesthesia at a level that builds on a premedical undergraduate science background (Matsusaki & Sakai, 2011).
Anesthesia Care Team (ACT)	Refers to a type of practice model that consists of one or more anesthesia providers and most often with the anesthesiologist assuming a medical direction of care with CRNAs, anesthesia resident, and anesthesiology assistant (Cromwell & Snyder, 2000).
Proceduralist	A physician trained in airway management who is qualified to administer anesthesia under state law (Dulisse & Cromwell, 2010).
Certified Registered Nurse Anesthesia (CRNA)	A registered nurse licensed by the state in which the nurse practices and meets licensure requirements the state imposes with respect to non-physician anesthetists. CRNAs graduate from a nurse anesthesia educational program that meets the standards of the Council on Accreditation of Nurse Anesthesia Programs. All practicing CRNAs have passed a certification examination of the National Board Certification and Recertification of Nurse Anesthetists. After initial certification, the requirement for recertification is every four years (Wilson, 2012).
Opt-Out designation	In 2001, the CMS ruling: *Medicare and Medicaid Programs; Hospital Conditions of Participation: Anesthesia Services* states if a hospital is located in a state where the Governor has submitted a letter to CMS attesting that he or she has consulted with both State Boards of Medicine and Nursing about issues related to access to and the quality of anesthesia services in the state and has concluded that it is in the best interests of the state's citizens to opt-out of the current physician supervision requirement, and that the opt-out is consistent with state law. A hospital then may permit a CRNA to administer anesthesia without operating practitioner or anesthesiologist supervision (Federal Register, 2001).
Student Registered Nurse Anesthetist (SRNA)	Education to become a CRNA including a Bachelor of Science in Nursing (BSN), a current license as a registered nurse, and at least one year of experience as a registered nurse in an acute care setting. Nurse anesthesia programs are 36 months. All nurse anesthesia programs will graduate with a doctoral degree. All programs include clinical training in university-based or large community hospitals and pass the certification exam (Matsusaki & Sakai, 2011).

Table A.2 - 1. **Detailed Search Strategy**

Medline/PubMed and CINAHL search strategy	
Search	Terms
# 1	**("Nurse Anesthetists"**[Mesh] OR **"certified nurse anesthetist*"** OR **CRNA*) ("Nurse Anesthetists"**[Mesh] OR **"certified nurse anesthetist*"** OR **CRNA*)** AND **(distribut*** OR **geographic*)**
# 2	**(((("opt out" OR opt-out))** AND English[lang])) AND **(("Nurse Anesthetists"**[Mesh] OR **"certified nurse anesthetist*"** OR **CRNA*))** Sort by: Publication Date
# 3	**"Anesthesia/supply and distribution"**[Mesh] Sort by: Publication Date
# 4	#1 AND #2 AND #3
Note: Filters: English; Human studies	

EMBASE and Scopus search strategy	
Search	Terms
# 1	'**nurse anesthetist**'/exp OR '**certified nurse anesthetist***' AND (anesthesia/exp OR **anesthetist*** OR '**anesthesia**'/exp OR **anesth***)
# 2	'**opt out**'/exp OR **opt out***
# 3	#1 AND #2 AND [English]/lim AND [human]/lim
# 4	#1 AND #2 AND #3
Note: Filters: English; Human studies	

Table A.3-1. **Explanation of Data Files**

Data File	Data Source	Meaningfulness
CMS Files:		
Provider of Services	CMS – Public File	This file contains data on characteristics of hospitals and other types of healthcare facilities, including the name and address of the facility and the type of Medicare services the facility provides. The data are collected through the CMS Regional Offices. The file contains an individual record for each Medicare-approved provider and is updated quarterly.
MedPAR RIF	CMS – Medicare Utilization, Research Identifiable Files	This file contains inpatient hospital action stay records for all Medicare beneficiaries. MedPAR files contain the following information: • procedures, diagnoses, and DRGs • length of stay • beneficiary and Medicare payment amounts • summarized revenue center charge amounts MEDPAR files contain information for 100% of Medicare beneficiaries using hospital inpatient services.
Master Beneficiary Summary	CMS – Medicare Beneficiary Enrollment and Demographics, Research Identifiable Files	This file includes beneficiary enrollment information, such as the beneficiary unique identifier, state and county codes, zip code, date of birth, date of death, sex, race, age, chronic conditions, and national death index.

Data File	Data Source	Meaningfulness
Carrier RIF	CMS – Medicare Utilization, Qualified Provider Entity, Research Identifiable Files	This file contains final action fee-for-service claims submitted. Most of the claims are from non-institutional providers, such as physicians, physician assistants, and advanced practice nurses. Claims for other providers, such as free-standing facilities are also found in this file. Examples include free-standing ambulatory surgical centers. This file includes: • diagnosis and procedure (ICD-9 diagnosis, CMS Common Procedure Coding System (HCPCS) codes), • dates of service, • reimbursement amounts, • provider numbers (e.g., UPIN, PIN, NPI), and beneficiary demographic information
Outpatient RIF	CMS – Medicare Utilization, Qualified Provider Entity, Research Identifiable Files	This file contains final action, fee-for-service claims data submitted by institutional outpatient providers. Examples of institutional outpatient providers include hospital outpatient departments, and rural health clinics. This file includes: • diagnosis (ICD-9 diagnosis) • Healthcare Common Procedure Coding System (HCPCS) codes, • dates of service, • reimbursement amount, • outpatient provider number, • revenue center codes, and • beneficiary demographic information
Non-CMS files:		
OSHPD	Office of Statewide Health Planning and Development	This file contains data collected about California's healthcare infrastructure. OSHPD publishes valuable information about healthcare outcomes. There are 5,000 individual, licensed healthcare facilities that report demographic, financial and utilization data annually.

Data File	**Data Source**	**Meaningfulness**
RUCC	United States Department of Agriculture- Rural Urban Continuum Codes	USDA forms a classification scheme that distinguishes metropolitan counties by the population size of their metro area, and nonmetropolitan counties by degree of urbanization and adjacency to a metro area. This allows researchers to break county data into finer residential groups, beyond metro and non-metro, particularly for the analysis of trends in non-metro areas that are related to population density and metro influence.
HRSA Area Resource File	Health Resource and Services Administration	This file is a national resource for health workforce research, information, and data. Provides policymakers with information and data to help them make decisions regarding health workforce education, training, and delivery of care. To achieve this, they analyze the supply, demand, distribution, and education of the nation's health workforce.

Table A.3-2. **Elixhauser Comorbidity Index and Qualifying International Classification of Diseases, Ninth Revision, Clinical Modification ICD-9-CM Principal Diagnosis Codes**

Elixhauser Comorbidity	ICD9 CM Diagnosis Codes	Elixhauser Comorbidity	ICD9 CM Diagnosis Codes
Congestive Heart Failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.0-428.9	Lymphoma	200.00-202.38, 202.50-203.01, 203.02-203.82, 203.8-203.81, 238.6, 273.3
Valvular disease	093.20-093.24, 394.0-397.1, 397.9, 424.0- 424.99, 746.3-746.6, V42.2, V43.3	Metastatic cancer	196.0-199.1, 209.70, 209.71, 209.72, 209.73, 209.74, 209.75, 209.79, 789.51
Peripheral vascular disease	440-440.9, 441.00- 441.9, 442.0- 442.9, 443.1- 443.9, 444.21- 444.22, 447.1,449, 557.1, 557.9, V43.4	Solid tumor without metastasis	140.0-172.9, 174.0-175.9, 179- 195.8, 209.00- 209.24, 209.25- 209.3, 209.30-209.36, 258.01- 258.03
Pulmonary Circulation disorders	415.11-415.19, 416.0-416.9, 417.9	Rheumatoid arthritis/ vascular diseases	701.0, 710.0- 710.9, 714.0- 714.9, 720.0-720.9, 725
Hypertension (combine uncomplicated and complicated)	Hypertension, uncomplicated: 401.1, 401.9, 642.00-642.04 Hypertension, complicated: 401.0, 402.00- 405.99, 437.2, 642.10-642.24, 642.70-642.94	Coagulation deficiency	286.0-286.9, 287.1, 287.3- 287.5, 289.84, 649.30-649.34
Paralysis	342.0-344.9, 438.20-438.53, 780.72	Obesity	278.0, 278.00, 278.01, 278.03, 649.10-649.14, 793.91, V85.30- V85.39, V85.41-V85.45, V85.54
Other neurological disorders	330.1-331.9, 332.0, 333.4, 333.5, 333.71, 333.72, 333.79, 333.85, 333.94, 334.0- 335.9, 338.0, 340, 341.1-341.9, 345.00-345.11, 345.2-345.3, 345.40-345.91, 347.00-347.01, 347.10-347.11, 649.40-649.44, 768.7, 768.70, 768.71, 768.72, 780.3, 780.31, 780.32, 780.33, 780.39, 780.97, 784.3	Chronic Peptic ulcer disease	531.41, 531.51, 531.61, 531.70, 531.71, 531.91, 532.41, 532.51, 532.61, 532.70, 532.71, 532.91, 533.41, 533.51, 533.61, 533.70, 533.71, 533.91, 534.41, 534.51, 534.61, 534.70, 534.71, 534.91
Chronic pulmonary disease	490-492.8, 493.00- 493.92, 494-494.1, 495.0-505, 506.4	Fluid and electrolyte disorders	276.0-276.9
Diabetes without chronic complications	249.00-249.31, 250.00-250.33, 648.00-648.04	Blood loss anemia	280.0, 648.20- 648.24

Elixhauser Comorbidity	ICD9 CM Diagnosis Codes	Elixhauser Comorbidity	ICD9 CM Diagnosis Codes
Diabetes with chronic complications	249.40-249.91, 250.40-250.93, 775.1	Deficiency anemias HIV and AIDS	280.1-281.9, 285.21-285.29,285.9
Hypothyroidism	243-244.2, 244.8, 244.9	Alcohol abuse	291.0-291.3, 291.5, 291.8, 291.81, 291.82, 291.89, 291.9, 303.00-303.93, 305.00-305.03
Renal failure	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 585.3, 585.4, 585.5, 585.6, 585.9, 586, V42.0, V45.1, V45.11, V45.12, V56.0-V56.32, V56.8	Drug abuse	292.0, 292.82- 292.89, 292.9, 304.00-304.93, 305.20-305.93, 648.30-648.34
Liver disease	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 456.0, 456.1, 456.20, 456.21, 571.0, 571.2, 571.3, 571.40-571.49, 571.5, 571.6, 571.8, 571.9, 572.3, 572.8, 573.5, V42.7	Psychoses	295.00-298.9, 299.10, 299.11
Weight loss	260-263.9, 783.21, 783.22	Depression	300.4, 301.12, 309.0, 309.1, 311

Note: Data from: CMS ICD-9-CM Diagnosis and Procedure Codes: Abbreviated and Full Code Titles
https://www.cms.gov/Medicare/Coding/ICD9ProviderDiagnosticCodes/codes.html

Table A.3-3. **Elixhauser Comorbidity Index and Qualifying International Classification of Diseases, Ninth Revision, Clinical Modification ICD-9-CM Principal Procedure Codes for Years 2007 & 2012**

Surgical Procedures	ICD 9 CM Procedure Codes 2007	ICD 9 CM Procedure Codes 2012
Vascular	0041 to 0066, 3806 to 3994	3800 to 3994 8592 to 8959
Orthopedic	0070 to 0087 7701 to 8499	0070 to 0087 7701 to 8499
Transplant	0091 to 0093	0091 to 0093
Neurosurgical	0101 to 0589	0094 to 0589
Endocrine	0601 to 0799	0601 to 0799
Ophthalmic	0801 to 1699, 9504	0801 to 1699
Otorhinolaryngology	1801 to 2279, 2811 to 3198 7601 to 7699	1781 to 2279 2282 to 3189 4040 to 4042
Oral Maxillary Facial	2301 to 2799	2301 to 2819 7601 to 7699
Thoracic	3201 to 3499	3201 to 3499 4050 to 4069
Cardiothoracic	3500 to 3804	1751 to 1771 3500 to 3799
General/Colorectal	4022 to 5498	1711 to 1749 40 21 to 4029 4132 to 5495
Urology	5501 to 6499	5501 to 6499 9851 to 9859
Gynecology	6501 to 7599	6501 to 7499
Plastic and Reconstructive	8511 to 8692	8511 to 8693
Radiology	8702 to 8898	0001 to 0069 8694 to 8898

Note: Data from: CMS ICD-9-CM Diagnosis and Procedure Codes: Abbreviated and Full Code Titles https://www.cms.gov/Medicare/Coding/ICD9ProviderDiagnosticCodes/codes.html

Table A.3-4. **Table Shell of Variables**

CONCEPT	VARIABLE	DATA SOURCE	ANALYTICAL PLAN	AIMS ADDRESSED
Patient Characteristics	• Age • Gender • Ethnicity • Location • Medical Comorbidities • Admission Date • Discharge Date	CMS files: • Master Beneficiary Summary File Provider of Services File • Carrier RIF • Outpatient RIF • MedPAR *International Classification of Diseases*, ICD-9 codes	Descriptive Statistics Analysis of Variance Multilevel Modeling Logistic Regression Modeling	Aim 2.0 Aim 3.0
Surgical Type	• Procedure code • Provider code	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Procedure and Provider code *International Classification of Diseases*, Clinical Modification ICD-9- codes	Descriptive Statistics Analysis of Variance Multilevel Modeling Logistic Regression Modeling	Aim 2.0 Aim 3.0
Anesthesia Service	*Billing codes:* • AA: (MDA modifier) • QZ: (*CRNA modifier)* • QX: (*CRNA modifier –* pays 50%) • QK/QY/AD: (*physician modifier)*	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Procedure code • Provider code	Descriptive Statistics Analysis of Variance Multilevel Modeling Logistic Regression Modeling	Aim 2.0 Aim 3.0

CONCEPT	VARIABLE	DATA SOURCE	ANALYTICAL PLAN	AIMS ADDRESSED
Institutional Characteristics	• Type of facility • Hospital bed size • Geographic location	CMS files: • Carrier RIF • Outpatient RIF • MedPAR OSHPD Rural-Urban Continuum Codes	Descriptive Statistics Analysis of Variance Multilevel Modeling Logistic Regression Modeling	Aim 3.0
Access to Care	• Health service area • Population by county • Poverty level by county • Beneficiary distance fro facility	OSHPD Rural-Urban Continuum Codes U.S. HRSA Area Resource File	Descriptive Statistics Analysis of Variance Multilevel Modeling Logistic Regression Modeling	Aim 3.0
Outcomes of Interest	• Percent complications • Length of stay • Anesthesia Service Charge • Bed size • Facility location	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Procedure code • Provider code *International Classification of Diseases*, Clinical Modification ICD-9-CM procedure and diagnosis codes	Multilevel Modeling Logistic Regression Modeling	Aim 2.0 Aim 3.0

Table A.3-5. **<u>Table of Variables for Specific Aim Two</u>**

Independent Variables	**Data Source**	**Analytical Plan**	**Aims Addressed**
*Billing codes** • AA: (Anesthesiologist modifier) • QZ: (*CRNA modifier)* • QX: (*CRNA modifier* – pays 50%) • QK: (*physician modifier* {used in conjunction with QX modifier} • QY: (*physician modifier* {used in conjunction with QX modifier) • AD: (*physician modifier* {used in conjunction with QX modifier} • Anesthesia Service Charge	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Anesthesia provider code	Descriptive Statistics Analysis of Variance Mixed Linear Modeling	Aim 2.0
Dependent Variables	**Data Source**	**Analytical Plan**	**Aims Addressed**
Patient Characteristics • Beneficiary Identifier* *Surgical Characteristics* • Surgical procedures*	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Procedure code • Facility provider code *International Classification of Diseases*, Clinical Modification ICD-9-CM procedure codes	Descriptive Statistics Analysis of Variance Mixed Linear Modeling	Aim 2.0

Outcomes of Interest	**Data Source**	**Analytical Plan**	**Aims Addressed**
• Length of stay** • Anesthesia Service Charge**	CMS files: admission and discharge dates CMS files: Anesthesia service charge	Analysis of Variance Mixed Linear Modeling	Aim 2.0
Explanatory Variables	**Data Source**	**Analytical Plan**	**Aims Addressed**
• Age** • Gender* • Ethnicity* • Location* • Medical Comorbidities* • Admission Date** • Discharge Date**	CMS files: • MBSF • Carrier RIF • Outpatient RIF • MedPAR *International Classification of Diseases*, Clinical Modification ICD-9-CM diagnosis codes	Descriptive Statistics Analysis of Variance Mixed Linear Modeling	Aim 2.0
Denotes Variable Type: **Categorical variable (all are nominal)* ***Continuous variable (anesthesia service charge; length of stay, admission and discharge date are ratio variables)*			

Table A.3-6. **<u>Model Fit with and Without Random Effect</u>**

Table A.3-6 - Model Fit with and Without Random Effect		
Model	AIC †	BIC †
Null 2008	1013384.909	1013404.721
Null 2013	957340.720	957360.562
Full 2008	1012520.714	1012540.526
Full 2013	944575.978	944595.820
Full model 2008 with age as random	1012510.289	1012540.006
Full model 2013 with age as random	944035.542	944065.304

Note: Null model includes intercept only, MDA, anesthesiologist; ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; and beneficiary ID. Full model includes: Null model; hospitals; and ASC, Ambulatory Surgery Centers; age; gender; HCPCS procedure code, and Elixhauser Comorbidities.
†A goodness of fit (GOF) was compared using the Akaike Information Criterion (AIC) and Schwarz's Bayesian Criterion (BIC).

Table A.3-7. **Model Fit for Estimating LOS (days)**

Table A.3-7 - Model Fit for Estimating LOS (days)		
Model	AIC †	BIC †
HCPCS codes and severity of cases for 2008	505573.087	505591.509
HCPCS codes and severity of cases for 2013	475991.170	476009.640
Cases by year as interaction term	988578.609	988598.441

Note: Full model includes MDA, anesthesiologist; ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; beneficiary ID; Hospitals; and ASC, Ambulatory Surgery Centers; age; gender; HCPCS procedure code, and Elixhauser Comorbidities. The dependent variable is LOS in days.
†A goodness of fit (GOF) was compared using the Akaike Information Criterion (AIC) and Schwarz's Bayesian Criterion (BIC).

Table A.3-8. **Model Fit for Estimating Anesthesia Service Charges**

Table A.3-8 - Model Fit for Estimating Anesthesia Service Charges		
Model	AIC †	BIC †
HCPCS codes and severity of cases for 2008	1442613.243	1442635.665
HCPCS codes and severity of cases for 2013	1529556.697	1529579.167
Cases by year as interaction term	2987479.794	2987499.626

Note: Full model includes MDA, anesthesiologist; ACT, anesthesia care team; CRNA, certified registered nurse anesthetists; beneficiary ID; Hospitals; and ASC, Ambulatory Surgery Centers; age; gender; HCPCS procedure code, and Elixhauser Comorbidities. The dependent variable is Anesthesia Service Charge.

†A goodness of fit (GOF) was compared using the Akaike Information Criterion (AIC) and Schwarz's Bayesian Criterion (BIC).

Table A.3-9. **Mixed Effects Regression Model Examining the Interaction of Anesthesia Provider and Year on Anesthesia Service Charges and Length of Stay**

Table A.3-9 - Mixed Effects Regression Model Examining the Interaction of Anesthesia Provider and Year on Anesthesia Service Charges, in Dollars, and Length of Stay, in Days								
	Costs, dollars				Length of Stay, days			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Intercept	7832.39	7037.29	8627.49	<.001	12.5	10.4	14.6	<.001
Sex								
Female	Reference				Reference			
Male	289.87	236.19	343.54	<.001	0.1	0.1	0.2	<.001
Anesthesia Provider								
CRNA	Reference				Reference			
ACT	2158.84	1440.38	2877.29	<.001	-0.2	-1.1	0.7	.610
Anesthesiologists	2464.43	1809.08	3119.78	<.001	-0.5	-1.3	0.3	.212
Claims Type								
Specialty Center or Ambulatory Surgery Center	Reference				Reference			
Hospital	-750.56	-1094.31	-406.82	<.001	-0.7	-1.2	-0.3	.002
Procedures[§]								
Spine and Spinal Cord	Reference	.	.		Reference	.	.	
Abdominal	-1239.71	-1911.51	-567.90	<.001	0.7	-0.1	1.6	.083
Head	-1621.37	-2280.63	-962.11	<.001	-0.9	-1.7	-0.1	.043
Intrathoracic	-1496.97	-2303.03	-690.90	<.001	0.5	-0.5	1.5	.338
Knee	-721.00	-1419.72	-22.27	.043	-1.5	-2.4	-0.6	.001

Table A.3-9 - Mixed Effects Regression Model Examining the Interaction of Anesthesia Provider and Year on Anesthesia Service Charges, in Dollars, and Length of Stay, in Days

	Costs, dollars				Length of Stay, days			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Year								
2008	-475.80	-727.91	-223.68	<.001	1.2	0.8	1.5	<.001
Age of Beneficiary, years	-56.97	-60.55	-53.39	<.001	0.1	0.1	0.1	<.001
Number of Elixhauser Comorbidities	-77.04	-92.97	-61.12	<.001	0.5	0.5	0.5	<.001
Anesthesia Provider X Procedure†								
ACT X Spine and Spinal Cord	Reference	.	.	.	Reference	.	.	.
ACT X Abdominal	-1463.61	-2225.70	-701.53	<.001	1.0	0.1	1.9	.049
ACT X Head	-1843.91	-2591.69	-1096.13	<.001	0.7	-0.3	1.6	.159
ACT X Intrathoracic	803.06	-90.54	1696.65	.078	0.2	-0.9	1.3	.721
ACT X Knee	-2047.44	-2847.49	-1247.38	<.001	0.1	-0.9	1.1	.786
Anesthesiologists X Spine and Spinal Cord	Reference				Reference			

Table A.3-9 - Mixed Effects Regression Model Examining the Interaction of Anesthesia Provider and Year on Anesthesia Service Charges, in Dollars, and Length of Stay, in Days

	Costs, dollars				Length of Stay, days			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Anesthesiologists X Abdominal	-1553.28	-2232.49	-874.07	<.001	1.2	0.3	2.0	.008
Anesthesiologists X Head	-1871.97	-2539.85	-1204.10	<.001	1.0	0.2	1.8	.020
Anesthesiologists X Intrathoracic	771.85	-40.73	1584.44	.063	1.7	0.7	2.7	.001
Anesthesiologists X Knee	-1131.08	-1838.01	-424.16	.002	1.1	0.2	2.0	.015
Anesthesia Provider X Year[‡]								
CRNA X 2008	Reference				Reference			
ACT X 2008	19.95	-323.00	362.90	.909	0.6	0.1	1.0	.011
Anesthesiologists X 2008	-766.73	-1024.48	-508.98	<.001	0.0	-0.3	0.4	.814

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists

[†]Anesthesia provider referenced is CRNA for interaction term

[‡]Anesthesia provider referenced is CRNA for interaction term and 2013

[§]Procedures based on the Centers for Medicare & Medicaid Services Healthcare Common Procedure Coding System

Table A.3-10. **Mixed Effects Regression Model of Length of Stay, in Days, by Year**

Table A.3-10 - Mixed Effects Regression Model of Length of Stay, in Days, by Year								
	2008 Length of Stay				2013 Length of Stay			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Intercept	2.0	-0.2	4.2	.069	14.6	12.2	17.0	<.001
Sex								
Female	Reference				Reference			
Male	0.1	0.0	0.2	.220	0.1	0.1	0.2	<.001
Anesthesia Provider[†]								
CRNA	Reference				Reference			
ACT	1.1	-0.3	2.5	.114	-1.1	-2.1	0.1	.047
Anesthesiologists	-0.1	-1.4	1.2	.917	-0.9	-1.9	0.0	.539
Claims Type								
Specialty Center or Ambulatory Surgery Center	Reference				Reference			
Hospital	0.9	-0.7	2.5	.276	-0.6	-1.0	-0.2	.004
Procedure[§]								
Spine and Spinal Cord	Reference				Reference			
Abdominal	2.7	1.3	4.1	<.001	-0.5	-1.5	0.5	.321
Head	0.0	-1.3	1.3	.997	-1.6	-2.5	-0.6	.002
Intrathoracic	1.5	-0.2	3.2	.075	-0.5	-1.7	0.7	.416
Knee	-1.6	-3.0	-0.2	.027	-1.2	-2.3	-0.2	.020
Age of Beneficiary, years	0.1	0.1	0.1	<.001	0.0	-1.8	0.9	.535
Number of Elixhauser Comorbidities	0.1	0.1	0.1	.021	0.8	0.7	0.8	<.001
Anesthesia Provider X Procedure[†]								
ACT X Spine and Spinal Cord	Reference			.	Reference			.
ACT X Abdominal	-0.5	-2.1	1.1	.540	1.8	0.7	2.9	.002
ACT X Head	0.0	-1.5	1.4	.953	1.5	0.3	2.6	.012
ACT X Intrathoracic	0.0	-1.8	1.8	.983	0.4	-0.9	1.8	.535
ACT X Knee	0.8	-0.8	2.4	.327	-0.4	-1.6	0.8	.505
Anesthesiologists X Spine and Spinal Cord	Reference				Reference			
Anesthesiologists X Abdominal	-0.1	-1.5	1.3	.898	1.8	0.8	2.7	.001
Anesthesiologists X Head	0.6	-0.7	2.0	.383	1.4	0.4	2.4	.007
Anesthesiologists X Intrathoracic	1.6	0.0	3.3	.054	1.7	0.5	2.9	.004
Anesthesiologists X Knee	1.2	-0.3	2.6	.108	0.9	-0.2	2.0	.093

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetists

[†]Anesthesia provider referenced is CRNA for interaction term

[§]Procedures based on the Centers for Medicare & Medicaid Services Healthcare Common Procedure Coding System

Table A.3-11. **Mixed Effects Regression Model of Anesthesia Service Charge, in Dollars, by Year**

Table A.3 -11 – Mixed Effects Regression Model of Anesthesia Service Charge, in Dollars, by Year								
	2008 Costs				2013 Costs			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
Intercept	5990.19	5041.18	6939.19	<.001	8278.93	7082.37	9475.50	<.001
Sex								
Female	Reference				Reference			
Male	241.01	179.86	302.16	<.001	315.25	230.69	399.82	<.001
Anesthesia Provider								
CRNA	Reference				Reference			
ACT	3436.47	2652.57	4220.37	<.001	1051.28	-63.74	2166.31	.065
Anesthesiologists	1610.02	875.06	2344.98	<.001	2257.71	1240.92	3274.50	<.001
Claims Type								
Specialty Center or Ambulatory Surgery Center	Reference				Reference			
Hospital	-31.76	-579.90	516.39	.909	-531.56	-967.34	-95.77	.017
Procedure[§]								
Spine and Spinal Cord	Reference				Reference			
Abdominal	-670.76	-1468.98	127.46	.100	-1729.12	-2767.72	-690.52	.001
Head	-1236.13	-1992.00	-480.26	.001	-2085.65	-3125.14	-1046.15	<.001
Intrathoracic	-1147.36	-2085.72	-208.99	.017	-1819.23	-3070.44	-568.03	.004
Knee	-674.54	-2737.40	-1857.43	.096	-545.13	-1656.84	566.58	.337
Age of Beneficiary, years	-45.22	-49.33	-41.11	<.001	-64.32	-69.92	-58.72	<.001
Number of Elixhauser Comorbidities	-152.75	-174.69	-130.80	<.001	-9.84	-32.05	12.38	.385
Anesthesia Provider X Procedure[†]								
ACT X Spine and Spinal Cord	Reference			.	Reference	.	.	.
ACT X Abdominal	-1869.48	-2759.94	-979.01	<.001	-957.48	-2153.61	238.64	.117
ACT X Head	-1800.84	-2642.81	-958.87	<.001	-1859.59	-3065.96	-653.22	.003

Table A.3 -11 – Mixed Effects Regression Model of Anesthesia Service Charge, in Dollars, by Year

	2008 Costs				2013 Costs			
	Coefficient	95% Confidence Interval		*p*-Value	Coefficient	95% Confidence Interval		*p*-Value
ACT X Intrathoracic	1435.88	416.62	2455.14	.006	-259.17	-1686.62	1168.29	.722
ACT X Knee	-1622.93	-2531.06	-714.80	<.001	-2510.78	-3791.95	-1229.61	<.001
Anesthesiologists X Spine and Spinal Cord	Reference				Reference			
Anesthesiologists X Abdominal	-1101.68	-1908.45	-294.90	.007	-1887.48	-2937.51	-837.45	<.001
Anesthesiologists X Head	-1314.03	-2079.56	-548.51	.001	-2240.22	-3293.68	-1186.76	<.001
Anesthesiologists X Intrathoracic	1016.02	70.25	1961.78	.035	562.43	-699.14	1824.01	.382
Anesthesiologists X Knee	-598.19	-1402.14	205.77	.145	-1708.63	-2832.60	-584.66	.003

Note: ACT, anesthesia care team; CRNA, certified registered nurse anesthetist [§]Procedures based on the CMS Healthcare Common Procedure Coding System

Table A.4-1. **<u>Table of Variables for Specific Aim Three</u>**

Independent Variables	**Data Source**	**Analytical Plan**	**Aims Addressed**
*Billing codes** • AA: (Anesthesiologist modifier) • QZ: (*CRNA modifier)* • QX: (*CRNA modifier* – pays 50%) • QK: (*physician modifier* {used in conjunction with QX modifier} • QY: (*physician modifier* {used in conjunction with QX modifier) • AD: (*physician modifier* {used in conjunction with QX modifier}	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Provider code	Descriptive Statistics Logistic Regression Modeling	Aim 3.0
Dependent Variables	**Data Source**	**Analytical Plan**	**Aims Addressed**
Patient Characteristics • Beneficiary Identifier* *Surgical Characteristics* • Surgical procedures*	CMS files: • Carrier RIF • Outpatient RIF • MedPAR CPT Codes • Procedure code • Facility provider code *International Classification of Diseases*, Clinical Modification ICD-CM procedure codes	Descriptive Statistics Logistic Regression Modeling	Aim 3.0

Outcomes of Interest	Data Source	Analytical Plan	Aims Addressed
Facility Reporting of: • Bed size • Facility type • Location • Population demographics	OSHPD files CMS files Rural-Urban Continuum Codes U.S. HRSA Area Resource File	Logistic Regression Modeling	Aim 3.0
Explanatory Variables	**Data Source**	**Analytical Plan**	**Aims Addressed**
Patient characteristics • Age** • Gender* • Ethnicity* • Location* • Population by county* • Poverty level by county* • Beneficiary distance from facility** *Facility Characteristics* • Type of facility* • Hospital bed size* • Geographic location* • Health service area*	CMS files: • MBSF • Carrier RIF • Outpatient RIF • MedPAR Rural-Urban Continuum Codes U.S. HRSA Area Resource File OSHPD Rural-Urban Continuum Codes U.S. HRSA Area Resource File	Descriptive Statistics Logistic Regression Modeling	Aim 3.0
Denotes Variable Type: **Categorical variable (all are nominal, population by county, poverty level by county, and health service area are ordinal)* ***Continuous variable (beneficiary distance from facility and length of stay are ratio variables)*			

Table A.4-2. **California Rural Urban Continuum Codes from 2010 for Use with Analysis of Year 2008 and 2013**

FIPS	**State**	**County Name**	**Population 2010**	**RUCC 2013**	**Description**
06001	CA	Alameda	1,510,271	1	Metro - Counties in metro areas of 1 million population or more
06003	CA	Alpine	1,175	8	Non-metro - Completely rural or less than 2,500 urban population, adjacent to metro
06005	CA	Amador	38,091	6	Non-metro - Urban population of 2,500 to 19,999, adjacent to a metro area
06007	CA	Butte	220,000	3	Metro - Counties in metro areas of fewer than 250,000 population
06009	CA	Calaveras	45,578	6	Non-metro - Urban population of 2,500 to 19,999, adjacent to a metro area
06011	CA	Colusa	21,419	6	Non-metro - Urban population of 2,500 to 19,999, adjacent to a metro area
06013	CA	Contra Costa	1,049,025	1	Metro - Counties in metro areas of 1 million population or more
06015	CA	Del Norte	28,610	7	Non-metro - Urban population of 2,500 to 19,999, not adjacent to a metro area
06017	CA	El Dorado	181,058	1	Metro - Counties in metro areas of 1 million population or more
06019	CA	Fresno	930,450	2	Metro - Counties in metro areas of 250,000 to 1 million population

FIPS	State	County Name	Population 2010	RUCC 2013	Description
06021	CA	Glenn	28,122	6	Non-metro - Urban population of 2,500 to 19,999, adjacent to a metro area
06023	CA	Humboldt	134,623	5	Non-metro - Urban population of 20,000 or more, not adjacent to a metro area
06025	CA	Imperial	174,528	3	Metro - Counties in metro areas of fewer than 250,000 population
06027	CA	Inyo	18,546	7	Non-metro - Urban population of 2,500 to 19,999, not adjacent to a metro area
06029	CA	Kern	839,631	2	Metro - Counties in metro areas of 250,000 to 1 million population
06031	CA	Kings	152,982	3	Metro - Counties in metro areas of fewer than 250,000 population
06033	CA	Lake	64,665	4	Non-metro - Urban population of 20,000 or more, adjacent to a metro area
06035	CA	Lassen	34,895	7	Non-metro - Urban population of 2,500 to 19,999, not adjacent to a metro area
06037	CA	Los Angeles	9,818,605	1	Metro - Counties in metro areas of 1 million population or more
06039	CA	Madera	150,865	3	Metro - Counties in metro areas of fewer than 250,000 population
06041	CA	Marin	252,409	1	Metro - Counties in metro areas of 1 million population or more

FIPS	State	County Name	Population 2010	RUCC 2013	Description
06043	CA	Mariposa	18,251	8	Non-metro - Completely rural or less than 2,500 urban population, adjacent to metro
06045	CA	Mendocino	87,841	4	Non-metro - Urban population of 20,000 or more, adjacent to a metro area
06047	CA	Merced	255,793	2	Metro - Counties in metro areas of 250,000 to 1 million population
06049	CA	Modoc	9,686	6	Non-metro - Urban population of 2,500 to 19,999, adjacent to a metro area
06051	CA	Mono	14,202	7	Non-metro - Urban population of 2,500 to 19,999, not adjacent to a metro area
06053	CA	Monterey	415,057	2	Metro - Counties in metro areas of 250,000 to 1 million population
06055	CA	Napa	136,484	3	Metro - Counties in metro areas of fewer than 250,000 population
06057	CA	Nevada	98,764	4	Non-metro - Urban population of 20,000 or more, adjacent to a metro area
06059	CA	Orange	3,010,232	1	Metro - Counties in metro areas of 1 million population or more
06061	CA	Placer	348,432	1	Metro - Counties in metro areas of 1 million population or more
06063	CA	Plumas	20,007	7	Non-metro - Urban population of 2,500 to 19,999, not adjacent to a metro area

FIPS	State	County Name	Population 2010	RUCC 2013	Description
06065	CA	Riverside	2,189,641	1	Metro - Counties in metro areas of 1 million population or more
06067	CA	Sacramento	1,418,788	1	Metro - Counties in metro areas of 1 million population or more
06069	CA	San Benito	55,269	1	Metro - Counties in metro areas of 1 million population or more
06073	CA	San Diego	3,095,313	1	Metro - Counties in metro areas of 1 million population or more
06075	CA	San Francisco	805,235	1	Metro - Counties in metro areas of 1 million population or more
06077	CA	San Joaquin	685,306	2	Metro - Counties in metro areas of 250,000 to 1 million population
06079	CA	San Luis Obispo	269,637	2	Metro - Counties in metro areas of 250,000 to 1 million population
06081	CA	San Mateo	718,451	1	Metro - Counties in metro areas of 1 million population or more
06083	CA	Santa Barbara	423,895	2	Metro - Counties in metro areas of 250,000 to 1 million population
06085	CA	Santa Clara	1,781,642	1	Metro - Counties in metro areas of 1 million population or more
06087	CA	Santa Cruz	262,382	2	Metro - Counties in metro areas of 250,000 to 1 million population
06089	CA	Shasta	177,223	3	Metro - Counties in metro areas of fewer than 250,000 population
06091	CA	Sierra	3,240	8	Non-metro - Completely rural or less than 2,500 urban population, adjacent to a metro area

FIPS	State	County Name	Population 2010	RUCC 2013	Description
06093	CA	Siskiyou	44,900	6	Non-metro - Urban population of 2,500 to 19,999, adjacent to a metro area
06095	CA	Solano	413,344	2	Metro - Counties in metro areas of 250,000 to 1 million population
06097	CA	Sonoma	483,878	2	Metro - Counties in metro areas of 250,000 to 1 million population
06099	CA	Stanislaus	514,453	2	Metro - Counties in metro areas of 250,000 to 1 million population
06101	CA	Sutter	94,737	3	Metro - Counties in metro areas of fewer than 250,000
06103	CA	Tehama	63,463	4	Non-metro - Urban population of 20,000 or more, adjacent to a metro area
06105	CA	Trinity	13,786	8	Non-metro - Completely rural or less than 2,500 urban population, adjacent to a metro area
06107	CA	Tulare	442,179	2	Metro - Counties in metro areas of 250,000 to 1 million population
06109	CA	Tuolumne	55,365	4	Non-metro - Urban population of 20,000 or more, adjacent to metro area
06111	CA	Ventura	823,318	2	Metro - Counties in metro areas of 250,000 to 1 million population
06113	CA	Yolo	200,849	1	Metro - Counties in metro areas of 1 million population or more
06115	CA	Yuba	72,155	3	Metro - Counties in metro areas of fewer than 250,000

Note: Data from: Rural-Urban Continuum Codes. https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/

Table A.4-3. **Health Resources and Services Administration Data on Poverty Level by California County**

Primary Identifier	County Name	Below 1.00 Times the U.S. Federal Poverty Level	Below 1.50 Times the U.S. Federal Poverty Level	Below 2.00 Times the U.S. Federal Poverty Level	Below 1.00 Times the U.S. Federal Poverty Level Percent of Total	Below 1.50 Times the U.S. Federal Poverty Level Percent of Total	Below 2.00 Times the U.S. Federal Poverty Level Percent of Total
06001	Alameda	31395	56106	79346	8.51	15.21	21.51
06003	Alpine	19	42	54	8.44	18.67	24
06005	Amador	660	1003	1735	7.02	10.67	18.45
06007	Butte	6699	11786	16555	13.14	23.13	32.48
06009	Calaveras	948	1561	2598	7.81	12.85	21.39
06011	Colusa	639	1243	1877	11.89	23.13	34.92
06013	Contra Costa	21344	36819	52720	7.81	13.48	19.3
06015	Del Norte	992	1547	2215	16.99	26.49	37.93
06017	El Dorado	3202	5699	8594	6.77	12.06	18.18
06019	Fresno	47362	73454	94572	21.92	33.99	43.76
06021	Glenn	1020	1866	2695	15.69	28.7	41.45
06023	Humboldt	3753	6799	9972	12.24	22.17	32.52
06025	Imperial	7587	12972	17370	21.15	36.16	48.42
06027	Inyo	322	713	1114	7.26	16.07	25.1
06029	Kern	37996	61594	82304	19.38	31.41	41.97
06031	Kings	5866	10109	13824	18.41	31.73	43.39
06033	Lake	2701	4444	6260	16.77	27.6	38.87
06035	Lassen	678	1042	1495	10.71	16.46	23.61
06037	Los Angeles	313322	551377	763327	14.33	25.22	34.91
06039	Madera	6394	10492	14406	19.26	31.6	43.39
06041	Marin	3188	5679	8581	4.95	8.82	13.32
06043	Mariposa	503	838	1160	10.14	16.89	23.38
06045	Mendocino	2837	4914	7002	14.01	24.28	34.59
06047	Merced	13158	21120	28607	22.09	35.46	48.02
06049	Modoc	190	540	793	8.66	24.61	36.14
06051	Mono	57	356	609	2.08	12.99	22.23

Primary Identifier	County Name	Below 1.00 Times the U.S. Federal Poverty Level	Below 1.50 Times the U.S. Federal Poverty Level	Below 2.00 Times the U.S. Federal Poverty Level	Below 1.00 Times the U.S. Federal Poverty Level Percent of Total	Below 1.50 Times the U.S. Federal Poverty Level Percent of Total	Below 2.00 Times the U.S. Federal Poverty Level Percent of Total
06053	Monterey	11843	22118	31029	13.03	24.33	34.13
06055	Napa	2378	4868	7308	6.93	14.18	21.29
06057	Nevada	2110	3938	6060	8.08	15.08	23.2
06059	Orange	66223	118190	168706	9.11	16.26	23.2
06061	Placer	6010	10737	15941	6.33	11.31	16.8
06063	Plumas	407	894	1268	8.28	18.18	25.79
06065	Riverside	67418	116729	166627	13.1	22.67	32.37
06067	Sacramento	47049	76898	106236	13.71	22.41	30.95
06069	San Benito	1169	2385	3623	8.52	17.38	26.4
06071	San Bernardino	72813	121205	170514	15.68	26.1	36.72
06073	San Diego	77745	134826	191921	10.63	18.44	26.24
06075	San Francisco	12556	24552	34891	7.76	15.17	21.55
06077	San Joaquin	24509	41716	58378	14.96	25.46	35.63
06079	San Luis Obispo	4950	9382	14123	7.56	14.32	21.56
06081	San Mateo	8641	17358	27171	4.84	9.73	15.23
06083	Santa Barbara	9382	17220	25769	10.04	18.42	27.57
06085	Santa Clara	28786	53671	78618	6.44	12.01	17.6
06087	Santa Cruz	5149	9425	13427	8.63	15.79	22.5
06089	Shasta	4970	9302	14125	11.06	20.69	31.42
06091	Sierra	53	111	141	6.89	14.43	18.34
06093	Siskiyou	2065	3393	4666	17.34	28.49	39.18
06095	Solano	10579	17226	24625	10.25	16.7	23.87
06097	Sonoma	8724	17133	25431	7.36	14.46	21.47
06099	Stanislaus	20082	33861	47042	16.1	27.15	37.71
06101	Sutter	3442	6197	8670	14.69	26.45	37
06103	Tehama	2271	4058	6163	13.89	24.82	37.69
06105	Trinity	393	885	1198	11.92	26.83	36.33

Primary Identifier	County Name	Below 1.00 Times the U.S. Federal Poverty Level	Below 1.50 Times the U.S. Federal Poverty Level	Below 2.00 Times the U.S. Federal Poverty Level	Below 1.00 Times the U.S. Federal Poverty Level Percent of Total	Below 1.50 Times the U.S. Federal Poverty Level Percent of Total	Below 2.00 Times the U.S. Federal Poverty Level Percent of Total
06107	Tulare	24189	39552	50910	23.23	37.98	48.89
06109	Tuolumne	1433	2670	3880	9.85	18.36	26.67
06111	Ventura	15643	28760	42635	7.9	14.52	21.53
06113	Yolo	4533	8365	11997	10.19	18.8	26.97
06115	Yuba	3221	5097	7178	17.7	28	39.44
Note: Data from: HRSA Fact Sheets: Data by Geography. https://datawarehouse.hrsa.gov/							