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TECHNICAL
REPORT

An Analysis of the Labor Markets for Anesthesiology

Lindsay Daugherty, Raquel Fonseca,
Krishna B. Kumar, Pierre-Carl Michaud

Sponsored by Ethicon Endo-Surgery, Inc.

HEALTH

This work was sponsored by Ethicon Endo-Surgery, Inc. The research was conducted in RAND Health, a division of the RAND Corporation.

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Preface

Anesthesia is an important specialty within medicine and nursing, and professionals practicing this specialty are integral members of health-care teams, especially those involved in surgical procedures. The anesthesiology labor markets are diverse and intricate. Though "workforce studies" have previously examined these markets, debate still persists on the methodologies used to study them and on whether these markets are characterized by shortage or surplus.

Ethicon Endo-Surgery funded this study in order to conduct a comprehensive examination of the labor markets for Anesthesiologists and nurse anesthetists. For the study, we used survey-based, noneconomic, and economic approaches to assess the labor markets for anesthesiology. The study was intended to compare conclusions across different methodologies.

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The authors of this report are listed in alphabetical order. Krishna B. Kumar, a senior economist at RAND and a professor at the Frederick S. Pardee RAND Graduate School, is the principal investigator of this project. He may be reached via email at Krishna_Kumar@rand.org or by phone at 310-393-0411 x7589.

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Executive Summary

Anesthesiology is an important specialty within medicine and nursing. Several groups of highly skilled professionals are involved in the provision of anesthesia services in the United States. There are around 40,000 Anesthesiologists (ANs) and anesthesiology residents and 39,000 licensed Certified Registered Nurse Anesthetists (CRNAs) and student CRNAs in the United States, and they provide most anesthesiology services. Labor markets for highly skilled professionals, such as those for anesthesia professionals, can be very "thin," both because of natural limitations in the aptitude and ability in the population to undergo the rigorous study and training needed for practicing and because of the regulation of the supply of these professionals. These labor markets may not follow the precepts of "competitive" labor markets, in which wages are flexible enough to result in an equilibrium in which supply equals demand. In these markets, shortages or surpluses can occur. Shortages in this critical area of health care can lead to problems in the provision of health services.

In this report, we summarize a study we have conducted on the labor markets for ANs and CRNAs. The research questions that guide our study are as follows:

- What are characteristics of the AN and CRNA labor markets—their demographics, employment arrangements, compensation, and usage of time?
- How do these characteristics differ by geography and facility?
- What are their perceptions of and preferences for anesthesia technologies, and how do these depend on the above characteristics?
- Are these labor markets characterized by shortage or surplus?

Summary of Methodology

In our surveys, conducted in 2007, we gathered information about ANs and CRNAs on demographics, general employment (including compensation), time usage, preference for technology, and future plans. Questionnaires for these two surveys were developed in collaboration with the respective professional organizations, the American Society of Anesthesiologists (ASA) and the American Association for Nurse Anesthetists (AANA). These societies also generously made available their membership who could be reached electronically and requested to participate in the survey. While the ANs and CRNAs could be relied on to provide individually relevant data, they might be unable to provide data relevant for the entire facility or group with which they were affiliated. In order to gather information at this level—e.g., remuneration level, total number of procedures per day, number of ANs and CRNAs required per day,

waiting times—we surveyed directors of anesthesiology (ANDIRs). Unlike ANs and CRNAs, ANDIRs do not have a professional association on which to rely for contact information. Therefore, we relied on a stratified random sample we purchased from a vendor. Finally, since surgeons are typically the direct users of anesthesia services, we surveyed them to get broad details on AN and CRNA usage.

We use the data from these surveys to first characterize the AN and CRNA labor markets by demography, facilities, earnings, time usage, and preference for technology, focusing in particular on the regional heterogeneity that exists in these characteristics. In doing this, we go beyond summarizing statistics of the survey responses. We conduct statistical analysis to disentangle the source of heterogeneity—for instance, to examine whether the observed geographical variation is driven by the concentration of larger facilities in certain regions.

We then turn our attention to analyzing whether the AN and CRNA labor markets are characterized by shortage or surplus. We use three approaches of increasing completeness and complexity for this purpose:

- The surveys included several workforce-related questions, including the number of open positions, the need for extra professionals to handle the current volume of cases, and whether the provider's practice could handle more cases if additional staff could be hired. We use the responses to these questions to assess the existence and extent of shortage or surplus. While we use statistical techniques to validate responses (for instance, to examine whether ANs and CRNAs perceive similar shortages) and address confounding factors (for instance, to explore whether delays in procedures result from shortages of professionals or inefficiencies in scheduling), this approach can at best be used in conjunction with other methods to assess the state of the labor market. Shortage or surplus is an aggregate phenomenon, and individual responses go only so far in shedding light on it or in capturing the multiple dimensions of labor markets.
- We conduct a demand-based analysis (DBA), the most commonly employed method in workforce analysis, which is sometimes referred to as *noneconomic analysis* (see Lane and Gohmann, 1995). We sum up the supply of full-time equivalent (FTE) workers present in a particular state using national averages of clinical hours worked, which we gathered from our surveys (49 hours per week for ANs and 37 for CRNAs). We then calculate the demand based on the actual volume of services provided, which is then reexpressed in terms of FTEs using time taken per unit of service (e.g., procedure, patient), again based on national averages. While, nationally, these two quantities would have to be equal, within a state, demand could exceed supply, in which case there is a shortage; if supply exceeds demand, then there is a surplus. There is substantial variation in outcomes across states. Furthermore, the unit of variation in regulations regarding residency, education, licensing, and reimbursement mechanisms is the state. We therefore conduct our analysis at the state level, which appears to be the appropriate unit of analysis. If instead of using actual hours worked from our surveys, we use an arbitrarily fixed workweek (for instance, 40 hours per week, as used in other studies), then, even nationally, supply will not equal demand. However, as we discuss in Appendix H, the conclusion of a shortage or surplus is highly sensitive to the assumption used for the fixed workweek.
- Finally, we use an econometric (economic) analysis to estimate statewide supply and demand and, hence, shortage or surplus. Whereas the DBA approach ignores wages and relies only on the quantity of labor to draw inferences on shortage/surplus, the eco-

nomic approach relies on estimating the relationship between demand/supply and wages. Economic theory suggests that labor supply increases with wages while labor demand decreases with wages. In this view, a change in wages induces a behavioral response on the part of working professionals and their employers that noneconomic approaches, such as DBA, cannot capture. If wages fully adjust, the market will be in equilibrium—that is, supply will equal demand. However, as we discuss in greater detail in Chapters Two and Four, a disequilibrium model, in which rigidity of wages causes excess demand (shortage) or excess supply (surplus), might be more suitable to analyze the anesthesiology labor markets. We estimate such a model to infer shortage/surplus by state. This approach makes the most complete use of information available on wages and other factors that vary by state and could influence supply or demand (e.g., percentage of population over 65, health maintenance organization [HMO] penetration, capacity of medical facilities). Given this way of distinguishing supply from demand, the model is capable of providing estimates of shortage/surplus not only at the state level but also at the national level.

These three approaches have their own strengths and drawbacks, but each contributes to our understanding of how the labor markets for anesthesia providers function, and, together, they provide a range of estimates, which can be used to gauge the robustness of our conclusions. If we lean toward the economic approach, it is due to its more extensive use of information—for instance, on wages and institutions—than the noneconomic approach.

Summary of Results

Survey Findings

The surveys, conducted in 2007, were a rich source of information on various aspects of the CRNA and AN labor markets. We found that there is a great deal of heterogeneity in work arrangements for both types of professionals. Only around 40 percent of CRNAs and ANs are employed by a single group, and 40 percent by a single facility or hospital.[1] The rest work for multiple groups or facilities or are locum tenens.[2] ANs work more hours and make about twice as much as CRNAs. ANs spend a greater percentage of their time on general anesthesia, while CRNAs spend more time than ANs do on monitored anesthesia care (MAC).

There are clear urban/rural differences in the labor markets for anesthesiology. CRNAs and ANs are more likely to be employed by a facility in rural areas and, as we would expect, tend to work in smaller facilities. Rural facilities are more likely to employ CRNAs and less likely to employ ANs. CRNAs and ANs tend to work separately more often in rural areas than in urban ones as well. Both ANs and CRNAs make more money in rural areas, and rural CRNAs also work longer hours. Urban ANs and CRNAs spend more time on general anesthesia and less time on other types of anesthesia.

There are even more-pronounced *regional* differences in the practice of anesthesiology. In the Western United States, facilities in which ANs and CRNAs operate are generally smaller than facilities in other parts of the country, and many of those facilities do not use CRNAs.

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[1] *Groups* refers to physician or CRNA group practices and hospitals, and *facilities* includes university and nonuniversity hospitals, academic medical centers, ambulatory surgical centers, and office suites.

[2] A practitioner who temporarily takes the place of another.

ANs in the West are most likely to be employed by groups, while CRNAs in the West are least likely to be employed by groups. In this region, CRNAs and ANs tend to work separately from one another, and interactions between them are less frequent than in other regions. Where CRNAs work in the West, they tend to spend a relatively large percentage of their time in regional/spinal and obstetrical anesthesia compared to their counterparts in the rest of the country. Western CRNAs earn the most, while Western ANs earn the least.

The situation looks quite different in the Northeast. There, ANs and CRNAs tend to work in larger facilities than they do in the West. They are typically used in the same facilities and work more often on the same procedures. CRNAs in the Northeast spend more time in procedures, and a larger fraction of AN and CRNA procedures involve MAC. When we examine specific procedures, including colonoscopies and electrophysiology study (EPS) labs, preference for anesthesia providers over non–anesthesia providers is higher in the Northeast than in other regions. Northeastern CRNAs and ANs tend to work fewer hours and generally earn less than their colleagues in other parts of the country.

We also used our surveys to gather information on the technology preferences of anesthesia providers. Technology could be developed and used in anesthesiology to potentially ease any labor shortages; it is therefore important to understand how anesthesia providers feel about increased use of technology. Interestingly, we find that a majority of ANs and CRNAs across the country tend to prefer the adoption of more technology. CRNAs and ANs are most likely to prefer better technology in general anesthesia. ANs are less likely than CRNAs to want better technology for MAC and more likely than CRNAs to prefer better regional/spinal anesthesia technology. CRNAs and ANs are most likely to prefer better technology in patient monitoring and drug delivery over anesthesia machines and respirators/ventilators.

Again, we find geographical differences. Those in the Midwest are consistently less likely to prefer more technology than are those in the Northeast. However, the largest geographical differences are not in whether more technology was preferred but in which type of technology is preferred. Urban CRNAs are more likely to want better technology for anesthesia machines and patient monitoring, and urban ANs are more likely to want better technology for patient monitoring. Western CRNAs and ANs are also less likely to want more monitored anesthesia technology.

Analysis of Labor-Market Shortage/Surplus

As mentioned earlier, we use three methods to assess shortage/surplus in the labor market for anesthesia providers. Our survey-based approach, in which we directly questioned ANs, CRNAs, ANDIRs, and surgeons on various dimensions of shortage or surplus, yields a few interesting results. We find that a large number of ANs (47.4 percent) report that their "employer needs more ANs to meet current demand," and an even larger number of CRNAs report that their "employer needs more CRNAs to meet current demand" (79.1 percent). ANDIRs are also more likely than ANs to report needing more CRNAs to meet demand (29.1 percent versus 22.2 percent).

There is a statistically significant relationship between a CRNA or an AN reporting that there are "any open positions" in their primary employment arrangement and that their "employer needs more CRNAs/ANs to meet current demand." We find that CRNAs and ANs in the Northeast are significantly more likely to report open positions, particularly relative to the West, and CRNAs and ANs in urban areas are also significantly more likely to report open positions than are those in rural areas. The greatest evidence for a shortage of anesthesia pro-

viders is in the Northeast and in urban areas. Northeastern and urban CRNAs and ANs are most likely to report that their employer could handle more cases if they had more CRNAs/ANs. Interestingly, we find that urban CRNAs have not increased hours worked, despite indications of shortage.

This survey evidence is more suggestive than conclusive, which is the reason we conduct both a DBA and an economic analysis to further investigate shortages in these labor markets.

As mentioned already, in DBA, when we use the average clinical workweek gathered from our surveys to define FTE (49 hours for ANs and 37 for CRNAs) and our method for identifying supply and demand, we find that the national labor markets are (roughly) in equilibrium. However, there is wide variation in state-level estimates. We find that 25 states for ANs, and 19 for CRNAs, are in shortage. For ANs, the estimates range from a 36-percent surplus in Washington, D.C., to a shortage of 82 percent in Alabama. In absolute numbers, Florida, Alabama, and North Carolina exhibit the most shortage, and California, New York, and Massachusetts the most surplus. For CRNAs, the estimates range from a 38-percent surplus in South Dakota to a shortage of nearly the same percentage in Iowa. In terms of absolute numbers, Pennsylvania, Michigan, and Florida exhibit the most shortage, and Minnesota, North Carolina, and California the most surplus.

According to the economic approach, the current supply of ANs (FTE) would have to increase by 3,800 to meet U.S. demand, and the current supply of CRNAs (FTE) would have to increase by 1,282 to meet U.S. demand. We find that more than 54 percent of the states are experiencing a shortage of ANs, and more than 60 percent a shortage of CRNAs. Again, there are sizable variations across states. Delaware is seen to have a surplus of ANs of more than 26 percent, while Idaho has a shortage of more than 46 percent. Nevada has a surplus of CRNAs exceeding 53 percent, while New York has a shortage of nearly 28 percent.

The DBA and economic analysis agree in classifying states as experiencing shortage or surplus in only 44 percent of the cases for ANs, and in 52 percent of the states for CRNAs. States with high wages and income are more likely to be classified as facing shortage in the economic approach than in the noneconomic approach, presumably because the latter does not use any information other than the amount of labor. The survey-based approach of estimating shortage correlates well with the economic approach. Given its more complete use of available information, the economic approach might be more relevant for evaluating these labor markets.

The overall conclusion is that shortage of ANs and CRNAs is highly likely at the national level, with the survey approach providing hints of such a shortage and the economic analysis providing stronger confirmation.

Finally, to shed light on how the anesthesiology labor markets might evolve in the future, we use a simple linear projection of supply and demand to examine the evolution of both labor markets until 2020, starting at equilibrium. Using the clinical week averages from our surveys, average entry and exit rates from the recent past for both groups, and a growth rate in the demand for surgeries of around 1.6 percent between 1985 and 2004, we find a projected shortage of ANs by 2020, and an excess supply of CRNAs. However, there are scenarios in the entire range of parameter values we examine in which these situations reverse. These projections simply extrapolate the past and do not account for any changes in the future that might cause future trends to be different, such as changes in the rate of entry or exit from the profession, change in work practices, or an unexpected change in demand for anesthesia services.

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At RAND, Soeren Mattke, who initially oversaw the suite of projects of which the present one was part, provided us continuous support and valuable guidance, as did Katherine Harris later. We are also grateful to other RAND colleagues, particularly John Romley and Darius Lakdawalla, for their suggestions on the econometric methodology that we employ in assessing shortage/surplus. Emmett Keeler and Alan White provided detailed comments on an earlier draft, which has considerably improved this report. We are grateful to them for their review.

Surveys were at the heart of our research, and we are thankful to RAND's Survey Research Group, especially Suzanne Perry, and RAND's Multimode Interviewing Capability (MMIC) online survey group, especially Tania Gutsche and Albert (Bas) Weerman, for ensuring that the surveys were conducted efficiently and smoothly. Nancee Inouye provided valuable administrative support.

Abbreviations

AA	anesthesiology assistant
AANA	American Association for Nurse Anesthetists
AN	Anesthesiologist
ANDIR	director of anesthesiology
ARF	Area Resource File
ASA	American Society of Anesthesiologists
CRNA	Certified Registered Nurse Anesthetist
DBA	demand-based analysis
EPS	electrophysiology study
FTE	full-time equivalent
HMO	health maintenance organization
MAC	monitored anesthesia care
MMIC	Multimode Interviewing Capability
NRMP	National Resident Matching Program
TEE	transesophageal echocardiography

CHAPTER ONE

Introduction

Anesthesiology is an important specialty within medicine and nursing. Several groups of highly skilled professionals are involved in the provision of anesthesia services in the United States. Anesthesiologists (ANs) are physicians who, after four years of medical-school education, have received specialized residency training in anesthesiology. Certified Registered Nurse Anesthetists (CRNAs) are nurses who have received specialized training and certification in anesthesiology. The practice of anesthesiology is also served by anesthesiology residents who are undergoing training to become full-fledged ANs, student CRNAs, and anesthesiology assistants (AAs). Anesthesiology services are typically provided as part of other medical procedures. In other words, they are *intermediate* rather than *final* services. As such, surgeons and other medical practitioners, such as gastroenterologists, are the proximate users of anesthesiology services. Facilities where procedures are conducted, such as hospitals and ambulatory-care centers, round off the anesthesiology "system."

In this report, we summarize a study we have conducted on the labor markets for ANs and CRNAs. There are around 40,000 ANs and anesthesiology residents and 39,000 licensed CRNAs and student CRNAs in the United States, and they provide most anesthesiology services. Labor markets for highly skilled professionals, such as those for anesthesia professionals, can be very "thin," both because of natural limitations in the aptitude and ability in the population to undergo the rigorous study and training needed for practicing and because of the regulation of the supply of these professionals. These labor markets may not follow the precepts of "competitive" labor markets, in which wages are flexible enough to result in an equilibrium in which supply equals demand. In these markets, shortages or surpluses can occur. Shortages in this critical area of health care can lead to problems in the provision of health services.

Previous studies have identified potential shortages of both ANs and CRNAs. Eckhout and Schubert (2001) found that both physician and nonphysician anesthesia personnel are in short supply. Among CRNAs, there are concerns about the aging of the profession, which has a current mean age of 48 years, thus providing a workforce with many individuals close to retirement age.[1] We conducted a rigorous study of these labor markets to measure the potential size of any existing shortages or surpluses. The information in this report can be used by professional associations and the health-care industry to facilitate future planning.

Moreover, previous studies of the anesthesiology workforce have proved controversial.[2] It is therefore useful to employ different methodologies, as we do, to assess shortage or surplus,

[1] See, for instance, MCCG (undated).

[2] For instance, Schubert, Eckhout, Cooperider, and Kuhel (2001) question the assumptions made by the American Society of Anesthesiologists (ASA) (1994) to arrive at the conclusion that the labor market for anesthesiology was at surplus.

and evaluate the reasons for convergence or divergence across these methodologies. Given that ANs, CRNAs, surgeons, and facilities are joint inputs used to provide anesthesia services, studying them together would allow us to understand how the interactions among the characteristics of these various inputs influence the labor markets. This will not be possible if these markets are studied separately.

The research questions that guide our study are as follows:

- What are characteristics of the AN and CRNA labor markets—their demographics, employment arrangements, compensation, and usage of time?
- How do these characteristics differ by geography and facility?
- What are their perceptions of and preferences for anesthesia technologies, and how do these depend on the above characteristics?
- Are these labor markets characterized by shortage or surplus?

The Practice of Anesthesiology

ANs are physicians who are trained extensively in the delivery of anesthesia, and a large percentage of them are certified by the American Board of Anesthesiology or the American Osteopathic Board of Anesthesiology as capable of managing complicated medical and surgical situations. After completing a medical degree, prospective ANs must complete four years of an intensive residency before qualifying for board certification. After initial certification, ANs are required to be recertified every ten years. The primary professional association for ANs is the ASA.

CRNAs and AAs are licensed professionals with a master's degree and the training necessary to participate in the delivery of anesthesia. CRNAs are far more prevalent in the United States than AAs, with more than 39,000 licensed and student CRNAs (compared to fewer than 1,000 AAs) (AANA, undated). CRNAs have been delivering anesthesia for more than 125 years, and yet the profession has expanded significantly only since the late 1970s (Bankert, 1989). CRNAs must be recertified every two years by the National Board on Certification and Recertification of Nurse Anesthetists. The professional association representing CRNAs is the American Association for Nurse Anesthetists (AANA). More than 90 percent of the nation's CRNAs are members of AANA. Although relatively similar in training and scope of practice, AAs differ from CRNAs in several ways. They are licensed by a separate board, the National Commission for Certification of Anesthesiologist Assistants. The training programs are also slightly different, and AAs are trained only to work under the direction of Anesthesiologists. Yet, CRNAs and AAs are both listed in the Code of Federal Regulations (42 C.F.R. 482.52) as being eligible to administer anesthesia.

There is significant variation across states in how CRNAs are used in the provision of anesthesia. In 2001, the U.S. Department of Health and Human Services Centers for Medicare and Medicaid Services decided that states could opt out of the requirement that CRNAs be supervised by a physician (CMS, 2001). Fifteen states have opted out of the physician-supervision

Miller and Lanier (2001, p. 969) note that the response to that study was dramatic and widespread: "Applications to US anesthesiology training programs declined dramatically, and many trainees already in anesthesiology training programs changed specialties."

regulation—from earliest to latest, Iowa, Nebraska, Idaho, Minnesota, New Hampshire, New Mexico, Kansas, North Dakota, Washington, Alaska, Oregon, South Dakota, Wisconsin, Montana, and California. There is a significant amount of debate over the appropriate scope of practice for CRNAs (ASA, 2004; AANA, 2007). The arguments over the mix of professionals focus on both cost and safety considerations (Abenstein et al., 2004; Cromwell, 1999; Pearson, 2002). The debate about the division of labor between CRNAs and ANs appears to be driven by the notion that these labor sources act as direct substitutes for one another (Cromwell, 1999). Yet, to the best of our knowledge, there are no significant studies that examine whether CRNAs and ANs are primarily substitutes (either provider can provide anesthesia care) or complements (both providers are needed to provide anesthesia care).[3]

Wide variation in who actually provides anesthesia is seen throughout the United States (Cromwell and Snyder, 2000). CRNAs can work directly with ANs, or ANs can supervise CRNAs who are working in several different rooms. Often, physician supervision can mean simply having an AN "on call" rather than directly supervising CRNAs. In addition, CRNAs and ANs can both provide anesthesia independently. CRNAs have become a particularly important labor source in rural areas, where they often provide anesthesia independently. However, in some other areas, such as California, CRNAs are rarely used (Seibert et al., 2004). Finally, some forms of anesthesia—particularly conscious (moderate) anesthesia—can be provided without any anesthesia provider at all. ASA has published a document to describe the appropriate practices for anesthesia provision by non–anesthesia providers (ASA, 2002).

While this report focuses on the labor markets for CRNAs and ANs, it is important to keep in mind that surgeons, nurses, and other medical professionals also play important roles in providing anesthesia for many procedures. The data collected through our surveys allow us to examine the variation in provider mix and time usage and to get a partial glimpse at the role these other providers play.

Current Literature

The State of Anesthesiology Labor Markets

The discussion over the appropriate provider mix has been overshadowed by an even larger debate on whether there is a shortage of anesthesia providers in the United States. The conclusions from one study (ASA, 1994) led to fears of an oversupply of ANs and actions across the country to reduce the number of new ANs being trained and certified. Since then, a series of reports has been produced that have questioned some of the assumptions made in the 1994 study (about, e.g., utilization of operating rooms, the growth of surgical procedures) and argue that cuts made in AN training have resulted in a shortage of ANs that will become even more acute in the near future (Eckhout and Schubert, 2001; Schubert, Eckhout, Cooperider, and Kuhel, 2001; Schubert, Eckhout, and Tremper, 2003). A simultaneous discussion has been taking place regarding a shortage of CRNAs. All of these reports argue that CRNAs, like most nurses, are facing a shortage as well (Cromwell et al., 1991; Mastropietro et al., 2001; Merwin, Stern, and Jordan, 2006).

The literature on medical labor shortage provides a number of reasons that the AN and CRNA labor markets may be facing shortages. A common explanation for nursing shortages

[3] It was beyond the scope of this study to examine the extent to which CRNAs and ANs are substitutes versus complements.

is that hospitals have monopsony power (bargaining power in hiring situations). Because there are relatively few highly differentiated facilities available as employers in an area, these facilities may have significant market power to set wages below the level that would be seen in a more competitive market (Robinson, 1988; Sullivan, 1989). However, more-recent studies have challenged this explanation for nursing shortages (Hirsch and Schumacher, 2005; Staiger, Spetz, and Phibbs, 1999). Another argument made is that significant demographic changes and rapid economic growth over a short period of time will not allow time for supply to catch up with the increasing demand (Cooper et al., 2002). Yet another explanation is that there has been insufficient investment in training facilities for these providers of anesthesia (Tremper, Shanks, and Morris, 2006).

Methodologies Used in Labor-Market Assessment

There are a variety of methods used in the literature to determine whether there is a shortage of medical providers. Demand-based analysis (DBA) is perhaps the most widely used approach (and, for this reason, it is one of the methods we also employ in this study). This method is often termed *noneconomic*, since it does not typically take wages into account. It is based on quantities alone. Supply is calculated from hypothetical full-time equivalent (FTE) medical providers from primary surveys or secondary data sources. Demand is calculated from indicators or proxies of patient usage of medical services—that is, from a different data source. For instance, one set of noneconomic analyses uses ratios of medical providers to a number of proxies for demand, such as population over 65 and the number of surgeries (HHS, 2006; Lane and Gohmann, 1995; Fallacaro, 1997). The idea is that, if the ratio is low, falls below some predetermined level, or is projected to decrease, shortage is more likely. Another set of noneconomic analyses attempts to proxy for demand using such measures as inpatient days and chart times and compares this to labor hours supplied by medical providers (Lee, Jackson, and Relles, 1998; Schmitz, Lantin, and White, 1999; HHS, 2006). The U.S. Department of Health and Human Services focuses primarily on these noneconomic methods to count and compare demand and supply in recent documents it has published on workforce-assessment methodologies (HHS, 2006, 2007). As we describe in Chapter Two, our analysis uses data from the same primary surveys for supply and demand calculations, under different assumptions for "identifying" (that is, distinguishing) each.

A less commonly used method of identifying shortage is economic models (Fair and Jaffee, 1972). Lane and Gohmann (1995) argue that it is unwise and unrealistic to examine these labor markets without considering wages. When there is an upward pressure on demand and, therefore, on wages, workers may choose, in response, to increase their hours worked above what is normally considered as full time. Hence, wages paid, along with hours worked, tell us a great deal about the tightness of labor markets. DBA uses only quantities (hours supplied and demanded) and not prices (wages); economic analysis uses both.

In fact, Lane and Gohmann (1995) show that economic and noneconomic analyses generate results that agree only 60 percent of the time. They argue that economic models are preferable because they offer policymakers a wider range of solutions rather than simply increasing supply, presumably because they seek to use all the information available on prices (wages) and quantities. Economic models of labor markets can therefore be a good complement to other approaches in order to assess the state of the CRNA and AN labor markets and those in the health-care segment in general.

The contributions of our study to the existing literature are as follows:

- We use primary data collected through multiple surveys of the various professional groups involved in providing anesthesia care. These surveys help us to provide a rich, descriptive picture of the labor market for anesthesiology, including practice patterns, wages, and preference for technology. In addition, these surveys, which recognize that the different groups jointly provide anesthesia services, allow us to ask pointed questions about working patterns that aid in the comprehensive assessment of the anesthesiology labor markets.
- While workforce studies have been done separately for the AN and CRNA labor markets, to the best of our knowledge, no study has jointly examined these markets. For instance, our econometric analysis treats the AN and CRNA markets jointly and allows for wages in one market to influence demand in the other. Without such a combined analysis, it would be difficult to exploit any complementarities that exist in anesthesia-care provision to provide a more accurate assessment of the two labor markets.
- By employing three different methodologies in the assessment of the AN and CRNA labor markets, we are able to provide a multifaceted perspective on the condition of these markets. When the approaches differ, we are able to shed light on the reasons for the differences, thereby contributing to the debate on the efficacy of the different methods. Our contribution is therefore as much on the methodological front as it is on the substantive front.
- Unlike most existing studies, and as is explained in detail in Chapter Two, our study exploits variation across states on such dimensions as education and licensing and, therefore, estimates shortage or surplus by state rather than a national figure alone. Given the high degree of heterogeneity we observe across states in labor-market characteristics, the statewide estimation is a significant addition to existing studies.

The rest of this report proceeds as follows. In Chapter Two, we describe our research methodology in greater detail. In Chapter Three, we summarize the findings from our surveys, focusing on the geographical and urban/rural variation that exists in the AN and CRNA labor markets. Chapter Four is devoted to a discussion of our analysis on the shortage and surplus in these markets. In Chapter Five, we present a few simple scenarios to study how supply and demand in the two labor markets might evolve up to the year 2020. In Chapter Six, we conclude with a synthesis of our findings and a list of possibilities for future research.

CHAPTER TWO

Research Methodology

This chapter discusses the surveys that were used to collect data for the studies and the methods that were used in the workforce estimates. In consideration of the broad scope of our research questions and the level of data it takes to answer these questions, we concluded that the public data were not sufficient. We therefore created surveys for four different groups that are associated with the labor market for anesthesia: ANs, CRNAs, directors of anesthesiology (ANDIRs), and surgeons.

Survey Design

Anesthesiologist Survey

The AN survey gathers information on demographics, general employment information (including compensation), time usage, preference for technology, and future plans.[1] It was developed collaboratively with ASA, which also endorsed the survey and shared member information with us so that we could email the link to the online survey to its members. The Web-based survey was hosted and administered by Multimode Interviewing Capability (MMIC), a RAND-based unit with expertise in the design and administration of Internet surveys.

We had access to ASA's entire membership file. This consisted of 23,667 records. Of those, we selected all ANs who had provided their email addresses to ASA. This resulted in a target sample of 19,941 ANs. Each accessible member was sent an initial mailing, followed by two reminders if there was no record of response. We had 4,554 responses, which amounted to a response rate of 22.8 percent. To construct population weights, we had to deal with three different groups of ANs. First, not all ANs are members of ASA. Hence, they could not be surveyed. We relied on the Area Resource File (ARF) to adjust counts of ANs by states. The ARF provides a count of all ANs in each state for 2006. The total AN population was estimated to be 39,698.[2] The second group did not have email addresses available in the ASA file.[3] We

[1] The questionnaire used for the AN survey can be found in Appendix A.

[2] As long as excluded or included groups do not vary by the strata (mentioned below) used in the calculation of probability weights, what matters for the analysis are percentages rather than actual counts of ANs and CRNAs. Results are likewise delivered in percentages and can be applied to a given total number of ANs or CRNAs. As we will see, the only absolute level that matters for the analysis is the definition of FTE.

[3] A probit regression of the likelihood of not having an email on gender, age, and region—the information that we have available—showed that, while those without emails are slightly more likely to be female and older, there were not significant regional differences.

grouped them with other nonrespondents—the third group—and created probability weights based on state, gender, and age.[4]

Certified Registered Nurse Anesthetist Survey

The CRNA survey also gathers information on demographics, general employment information (including compensation), time usage, preference for technology, and future plans. The survey consists of nearly 50 questions. To facilitate comparisons between the two groups, we designed the CRNA survey to be as similar to the AN survey as possible. The survey was developed collaboratively with AANA, which also endorsed the survey and emailed the link to the online survey to its members. This Web-based survey was also hosted and administered by MMIC.[5]

The AANA membership file consisted of 27,889 records. We had email access to 22,791 of its members. Each accessible member was sent an initial mailing, followed by two reminders if there was no record of response. We had 5,441 responses, which amounted to a response rate of close to 24 percent. To account for those CRNAs who opted out of receiving email, we had to weight our responses appropriately.[6] An additional problem for part of the analysis was that no ZIP Code information was available for approximately 18 percent of respondents; it was not possible to identify the state of residence for these respondents.[7] For most analyses, we simply kept those responses. For any analysis involving classification by state, we did not include them. Weights of remaining respondents were adjusted accordingly, and the aggregate counts are unaffected. The total size of the CRNA population is not known from the ARF. However, AANA estimates the population (including nonmembers) to be 33,914. We scaled weights so that they aggregated up to population size.[8]

Director of Anesthesiology Survey

ANDIRs are in charge of the allocation of ANs and CRNAs and hence have a good overall view of labor-market conditions, as well as other general information, such as remuneration level, total number of procedures per day, number of ANs, CRNA required per day, and waiting times. We therefore included a survey of ANDIRs in our study. Information from this survey is used to supplement the analysis; we do not rely on it exclusively to draw our conclusions. The survey consists of more than 30 questions, some with subquestions.[9]

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[4] To construct probability weights, we first calculate the predicted probability, based on a regression of those who responded, as a function of state, gender, and age. Denote by p the predicted probability based on this probit regression. Then the probability weight is $w = 1/p$. We adjusted w so that the sum aggregates to the total population as estimated from the ARF.

[5] This method of surveying runs the risk of selection bias if members and nonmembers systematically differ. The questionnaire used for the CRNA survey can be found in Appendix B. The questions used in the AN and CRNA surveys were very similar. We had to take into consideration input from ASA in developing the AN survey and AANA for the CRNA survey, which is the source of the few differences.

[6] We constructed probability weights in the same way as for the AN survey, using gender, state, and age and calculating the weight as the inverse of predicted probability.

[7] A probit regression of the likelihood of missing a ZIP Code on explanatory variables, such as gender, age, and experience, indicated that males, older CRNAs, and CRNAs with more experience were less likely to be missing ZIP Codes. CRNAs with missing ZIP Codes do not seem to work more or fewer hours or work for different employers.

[8] The assumption made here is that missingness of ZIP Codes is not systematically related to states.

[9] The questionnaire used for the ANDIR survey can be found in Appendix C.

ANDIRs are not part of a separate, large professional association, so we were not able to rely on a membership list for a sampling frame. We instead acquired a list of nearly 4,000 ANDIRs across the country from SK&A Information Services, a provider of contact lists that is located in Southern California. In addition to names and addresses, the list also provided the number of beds in each establishment. While this survey was Web based, like the AN and CRNA surveys, the directors in the sample had to be contacted by regular mail, and follow-up had to be done by phone. Due to cost considerations, we chose to target a random stratified sample of 1,313 directors from a population of 3,676.

We drew a stratified sample based on different characteristics of potential respondents. In particular, we stratified based on

1. census region: Northeast, Midwest, South, and West
2. rural versus urban county, as classified by the U.S. Department of Agriculture
3. facility size (measured by the number of beds in the establishment: small hospitals have 0–125 beds, medium hospitals 126–250 beds, and large hospitals 250 or more beds).

We sampled from each stratum in order to ensure adequate representation of different types of establishments in different geographical settings for our statistical analysis. Hence, a higher fraction of records in those cells with lower population representation was selected as part of the sample, and vice versa for those cells with higher population representation. Table 2.1 shows the sample selection by stratum.

We had 679 responses, which amounts to a response rate of 51.7 percent. We use weights throughout to calculate population estimates.[10] These weights correct for both sampling and differential nonresponse across the dimensions used for stratification of the sample.

Survey of Surgeons

We primarily rely on these three surveys (ANs, CRNAs, and ANDIRs) for our analysis. But we also surveyed surgeons in selected specialties. Our questions were added to a survey that

Table 2.1
Directors of Anesthesiology: Stratified Sample Design

	Northeast		Midwest		South		West	
Beds	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**	**Rural**	**Urban**
Frame (3,676)								
<125	78	91	383	146	311	204	169	130
125–250	32	146	64	131	117	254	16	187
>250	10	246	19	286	28	416	1	211
Sample (1,313)								
<125	53	57	68	61	84	65	62	58
125–250	32	69	58	64	64	52	16	67
>250	10	105	19	109	28	96	1	111

[10] The weights were computed for each cell using this formula: weight = (no. in population)/(no. in sample).

was conducted for another RAND project. We received responses from 816 surgeons and other specialists in general surgery, orthopedic surgery, plastic surgery, urology, obstetrics/gynecology, cardiology, and gastroenterology. Appendix D presents the portion of the survey that is relevant to this project. Since the sample selection was not done randomly across all surgical specialties (enough surgeons were surveyed in these specialties to get roughly equal numbers of responses in each specialty), we refer to findings from this survey where appropriate in our text but do not use them for formal analysis.

Labor-Market Assessment Methodologies

Our first step is to provide a thorough description of the AN and CRNA labor markets. We examine the demographics of ANs and CRNAs, the makeup of employers and facilities where they are employed, time use, earnings, and technology preference. We primarily rely on results from the AN and CRNA surveys and use the results from the ANDIR and surgeons surveys to support or weaken these findings.

We use probit/regression analysis to identify variation in the various elements of the labor market. All of these analyses control for the census region in which the respondent resides and whether the respondent (or facility) is located in an urban or rural county. Many of our analyses also control for facility size (number of beds for ANDIR; number of surgeons in the primary facility for AN and CRNA surveys), and some control for additional variables, such as employer type. We also attempt to link some of our labor-market features through probit and regression analysis to examine whether the regional patterns we find are representative of larger institutional differences in these regions. Both our probit and regression analyses and the estimates presented in our tables are weighted with our sample weights (described earlier) to ensure that the estimates are representative of the entire population (as we have defined it). We focus on regional and rural/urban differences and identify those differences that are significant ($p < 0.05$).

We then use three methods to assess the labor-market conditions. Throughout this report, we use *shortage* and *excess demand* interchangeably, as we do *surplus* and *excess supply*. We present the technical details in Appendixes E and F and results based on the various methods in Chapter Four.

Survey-Based Analysis

We included questions in the surveys to directly gauge potential shortages. In the AN and CRNA surveys, we include questions on job openings, employer need for more anesthesia professionals to meet current demand as well as to handle more cases, the recent history of changes to hours worked, the willingness to increase hours worked, and the extra compensation that would be needed if so willing. In the ANDIR survey, we included questions on the time it takes to fill open AN and CRNA positions, an indication of whether procedures had to be postponed due to a lack of anesthesia professionals, and whether the facilities needed more ANs and CRNAs to meet current demand. We examine the heterogeneity in the responses to these questions by region and facility size and study how they correlate to other responses.

Despite our use of statistical techniques to validate responses and address confounding factors, the survey-based approach can provide, at best, corroborating evidence to other methods to assess the state of the labor market. Shortage or surplus is an aggregate phenomenon,

and individual responses go only so far in capturing the multiple dimensions of labor markets. To more completely explore the question of whether the labor markets for ANs and CRNAs are experiencing shortage, we must employ techniques that identify and aggregate supply and demand in these markets.

Demand-Based Analysis

We next conduct a DBA, the procedure most commonly followed in workforce analyses of physicians and nurses. The basic idea behind DBA is to sum up FTE workers in a particular region and to calculate the demand for services in terms of FTE providers, using information on average provider time required per unit of service. When demand equals supply, there is equilibrium; if demand exceeds supply, there is a shortage; if demand is less than supply, there is a surplus.

A key challenge in an analysis of labor markets is distinguishing supply from demand—the so-called *identification problem*. As mentioned earlier, most DBA studies have solved this problem by calculating supply and demand from different sources. For instance, Lee, Jackson, and Relles (1998) used membership files from the American Academy of Orthopaedic Surgeons and the U.S. Department of Health and Human Services' Health Resources and Services Administration's ARF to calculate supply. They estimated demand from levels of utilization of orthopedic services from several national data sets generated by the National Center for Health Statistics and, to convert utilization data into work times, conducted a survey of practicing orthopedic surgeons.

Our analysis uses data from the same primary surveys for supply and demand calculations. We sum up the supply of full-time equivalent (FTE) workers present in a particular state using national averages of clinical hours worked gathered from our surveys (49 hours per week for ANs and 37 for CRNAs).[11] We then calculate the demand using the actual volume of services provided and time taken per unit of service (e.g., procedures, patient)—again based on national averages—which is then reexpressed in terms of FTE. While, nationally, supply and demand would have to be equal, within a state, they need not.[12]

That leaves us with the task of identifying supply and demand within a state. It is important to realize that the quantity of labor, q, that we observe could be *either* demand or supply. This is represented graphically in Figure 2.1, where q^d denotes demand and q^s denotes supply. The 45-degree line denotes points at which supply equals demand (that is, the market is in equilibrium). The horizontal lines denote points at which supply exceeds demand (surplus), and the vertical line denotes points at which demand exceeds supply (shortage). For instance, where $q_0^{\,d}$ intersects the vertical line in Figure 2.1, there is a shortage of $q_0^{\,d} - q_0$.

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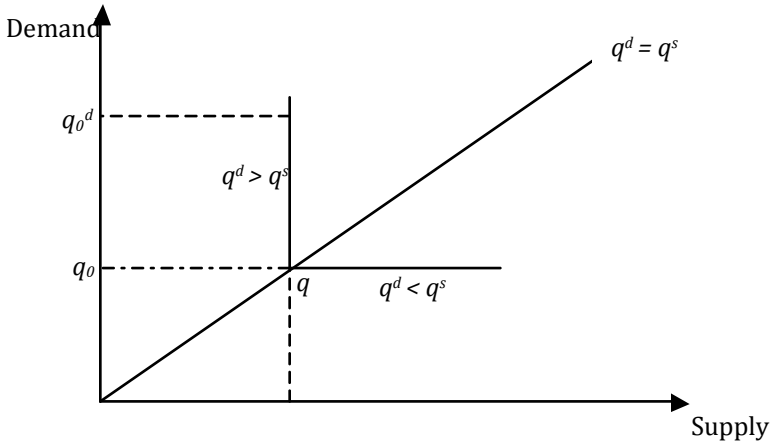
[11] We retain states that have more than five survey responses. For ANs, we retain 49 states (we drop Alaska and Wyoming and include the District of Columbia as a state), and, for CRNAs, we retain 47 states (we drop Alaska, Montana, Vermont, and Wyoming and include the District of Columbia as a state).

[12] Our method, therefore, identifies relative shortages and surpluses across states. We also assess the labor markets with a predefined figure for FTE as done in previous workforce studies, instead of using the hours from our surveys. For instance, Engen et al. (2005) use a 40-hour FTE definition in their study of the Canadian anesthesia workforce; Reinier et al. (2005) use a 40-hour FTE in their study of the U.S. nursing workforce; and Pisetsky et al. (1998) use a 40-hour FTE for physician assistants and advanced practice nurses in assessing the value of work performed by anesthesiology residents. Any fixed definition for the workweek, such as 40 hours, would yield shortage/supply at the national level, but, as shown in Appendix H, the results are highly sensitive to hours assumed for the clinical workweek.

Figure 2.1
Excess Demand and Supply in Demand-Based Analysis



Since we calculate shortage or surplus across states, by considering some of the components of either supply or demand as invariant across states, we can exploit the heterogeneity in the data observed (for instance, average hours worked per week) for identification of demand and supply at the state level. Implicit in this procedure is the strong assumption that preferences, technology, compensation, and productivity are identical across states. Appendix E provides the technical details of the calculations for DBA.

We proceed stepwise to the final shortage/surplus values that we seek. First, if the desired number of working hours is considered invariant across the country (counterfactual supply), then differences in hours of work across states can be attributed to differences in demand. States where providers work more than the desired level are in excess demand and, where they work less, in excess supply.

Second, if instead the amount of time to do a particular procedure is considered invariant across states (counterfactual demand), then it can be shown that states where procedures are done faster have a larger shortage. We can use such chart times (gathered, in our case, from our surveys) to calculate counterfactual demand and compare with the actually observed supply. The intuition is that, if there is a shortage of supply and the number of procedures demanded is the same (a situation of excess demand), then procedures *have* to be done faster. This, of course, makes the rather strong assumptions mentioned earlier, that differences in procedure times are entirely attributable to a shortage or a surplus and that such factors as differences in productivity do not play any role.

These two procedures attribute all variation across states to differences in either hours worked or time per procedure. If we instead combine both considerations (that both desired working time and per-procedure time are given), we can show that the variation in the *number* of procedures can be exploited to distinguish demand from supply. States that perform more procedures than average have a larger shortage. This third step can be thought of as capturing the total variation observed, which is then "decomposed" into the two components described in the earlier two steps. While we focus on the outcomes of the third step in our discussion, it

is useful to present the outcomes of the first two steps as well, to examine where most of the variation lies—hours worked or time per procedure.

For calculations involving demand, we disaggregate by type of procedure. Respondents were asked the percentage of their clinical time spent doing general anesthesia, monitored anesthesia care (MAC), obstetrical anesthesia, and regional and spinal anesthesia. We use their report on the total number of clinical hours to convert these percentages to hours. We also obtain the number of procedures done per week. We appropriately weight these to aggregate them to the state level. To minimize the effect of outliers and measurement errors, we compute the time per procedure using the aggregated responses at the state level rather than individual responses.

Identifying demand and supply from the same data source, instead of different data sources, aids consistency. Questions on hours worked and time spent per procedure when answered by an individual in the same survey are likely to be more accurate than when deduced from different data sources and surveys. However, the problem of identifying supply from demand is trickier when the same data source is used and involves the use of counterfactuals as described earlier. Using different data sources for DBA permits calculation of national shortage or surplus. While our approach yields equality of supply and demand at the national level, it identifies shortage/supply at the state level. Previous studies have not conducted state-level assessments of anesthesiology labor markets. The equality at the national level we obtain can also give a point of reference against which future workforce estimates can be compared.

Irrespective of whether the same data set is used or how supply and demand are identified, the key limitation of DBA is that it does not use any price (wage) data—an important part of the supply/demand calculus. For example, higher compensation in a particular state could be responsible for a higher quantity of labor supplied there. Characterizing this phenomenon as a shortage, as would be done with one of the assumptions mentioned earlier, is not accurate. What the DBA assumes is that the supply curve is totally *inelastic*. That is, labor supply is unresponsive to wages. DBA also does not use information on differences in regulation and institutions, relying purely on observed quantities of labor. While wage and other considerations are implicit in the observed quantities, DBA does not consider a structural relationship between these quantities and wages. We next turn to describing the econometric (economic) approach, which does use wage data and institutional differences across states and is therefore our preferred method of assessing the labor markets for anesthesiology.

Econometric Analysis

The econometric approach involves estimating a demand and supply relationship under different assumptions about what may be causing excess demand or supply. Such models take account of behavioral responses that cannot be modeled with the DBA discussed in the previous section.

There is substantial variation in outcomes across states. Furthermore, the unit of variation in regulations regarding residency, education, licensing, and reimbursement mechanisms is the state. We therefore conduct our analysis at the state level, which appears to be the appropriate market. It is not possible to disaggregate at the county level because too few respondents per

county are present. We keep information on states with more than five survey responses.[13] Our final sample consists of 48 states with this information.[14]

We use sampling weights to aggregate responses up to the state level. As with the DBA discussed in the previous section, we use national averages of clinical hours worked, gathered from our surveys (49 hours per week for ANs and 37 for CRNAs) to convert labor quantities to FTEs. In addition to the quantity of labor, from our surveys, we use data on hourly wages (annual earnings divided by annual hours of work), average number of procedures per week as a measure of output, and, as a measure of preference for technology, the percentage of respondents in a state who report that their primary employer is too slow at adopting technology.

We also use a number of state-level variables from sources other than our surveys in order to characterize the states and associate them with supply or demand. First, we use the ARF to get information on the total population and the population 65 or older. We also use a measure of population density and median income. As a proxy for competition, we use the health maintenance organization (HMO) penetration rate for 2004. As a measure of capacity, we also use the total number of hospital beds available in the states.

For ANs, we use information on AN residency positions available for the year 2004. For CRNAs, we obtained information on the number of accredited nurse-anesthetist education programs in the state.

We specify the labor supply for each group of anesthesia providers (ANs and CRNAs) at the state level as dependent on wages and other variables likely to influence supply. Likewise, we assume the existence of a demand function at the facility level that is aggregated up to the state level. The quantity demanded also depends on wages (capturing the potential simultaneity of the supply/demand system) as well as on output (procedures) and other variables likely to influence supply. If the labor market is in equilibrium, supply equals demand, and these quantities and the wages are determined simultaneously. However, as discussed in Chapter One, existing literature seems to suggest that there are institutional constraints that prevent the market for anesthesia providers from maintaining equilibrium. Therefore, a disequilibrium model might be the more relevant one.

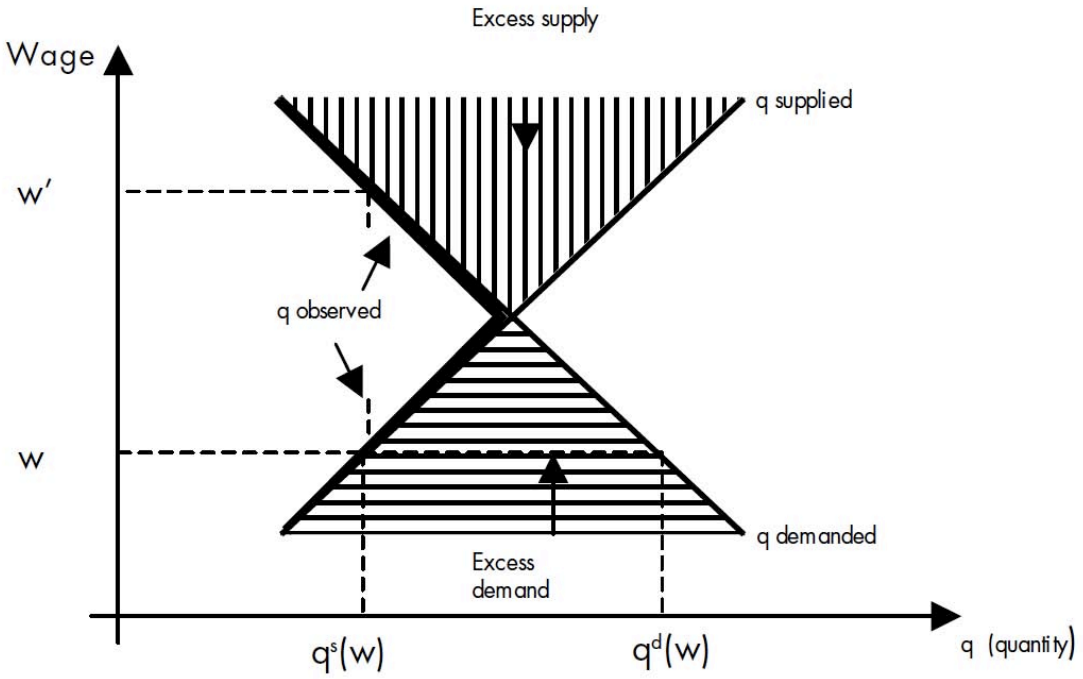
The common approach to modeling disequilibrium is to assume that prices or wages are exogenous (that is, that they do not adjust to equate quantities demanded and supplied). In that case, the minimum of the quantity demanded and supplied is observed. When the observed quantity is the supply, we are in a situation of excess demand. When the opposite occurs, there is excess supply.

Figure 2.2 illustrates this point. Hypothetical demand and supply are plotted against wage. If the market is in equilibrium, the quantity observed will be at the intersection of demand and supply. If we start from a wage different from the equilibrium wage, there will be excess demand or excess supply. For instance, at wage w, demand is higher than supply. If wages can adjust freely, the employers will bid up the wage. However, if prices cannot adjust (for instance, due to a fixed rate of reimbursement by programs, such as Medicare), the disequi-

[13] There is a trade-off here: If we had insisted on a higher threshold, data from a few of the smaller states would have been discarded. For the estimation of the parameters, we weight state-level likelihood contributions by the square root of the number of underlying respondents in the cell. Under random sampling with equal population variance across cells, the sampling variance is inversely proportional to the square root of the sample size within the cell. Hence, we down-weight cells with few observations and give more weight to cells with more observations.

[14] When we use the word *national* to refer to a shortage or surplus, we refer to the aggregation of those states we analyzed.

Figure 2.2
An Illustration of Disequilibrium



librium at wage w persists. There is unmet demand in the market as only $q^s(w)$ workers work. If the price is set above the equilibrium wage, a situation of excess supply will arise. The heavier line denotes the minimum of demand and supply that will be observed under disequilibrium.

This figure can also be used to illustrate the shortcoming of DBA discussed in the previous section. If the wage were w', the *same* observed quantity $q^s(w)$ would be indicative of a surplus rather than a shortage. Classifying a situation as a shortage or surplus on the basis of quantity of labor alone is therefore not appropriate.

Empirically, the exclusion restrictions that distinguish supply from demand and allow estimation of the equilibrium model are well understood. In our context, we need one determinant that appears only in the supply equation (but not the demand equation) and one that appears only in the demand equation; residency openings are included only in the AN labor supply equation, and the HMO penetration rate is included only in the AN labor demand equation. We also exclude the wage and output of CRNAs from the AN supply equation. For CRNAs, we follow a similar strategy with the number of accredited nurse-anesthetist education programs in the state used in the supply equation. The equilibrium model is easily estimated by the two-stage least-squares method.

The disequilibrium model with fixed wages does not require exclusion restrictions. However, we impose the same restrictions as in the equilibrium model because these seem natural and may sharpen the estimation.

The surveys we conducted elicited a response that helps identify the wage *elasticity* of labor supply—that is, the percentage by which the number of hours worked increases for a 1-percent increase in the wage rate. We asked respondents whether they would increase hours by 10 percent. If they said yes, they were asked how much income they would require. They

were given the choice of 5 percent, 10 percent, 20 percent, 25 percent, or more than 25 percent. If the respondent did not want to increase hours, we assigned that respondent an elasticity of 0. Therefore, in the disequilibrium model, where the wage is considered fixed and the dependence of supply on the wage is not econometrically determined, we fix the coefficient on wage in the model equal to the average state-level elasticity gathered from the survey.

The disequilibrium model is estimated via the method of maximum likelihood, following Maddala and Nelson (1974). The model delivers the probabilities that the situation is one of excess demand or of excess supply. Following Gourieroux (2000), we can also estimate how far wages are from the equilibrium wages. This is done by equalizing predicted demand and supply and solving for the equilibrium wage. This quantity is then compared with the actual wage.

CHAPTER THREE

Survey Findings

The surveys we conducted are a rich source of information on the labor markets for anesthesiology. By collecting information from the major participants in the anesthesia labor market (ANs, CRNAs, ANDIRs, and surgeons), we are able to capture the institutional intricacies and the variety of practice methods in anesthesiology. Exploring the labor market and its variation across different regions and facilities is a necessary step in understanding any shortage or surplus that we find in the labor markets. In this chapter, we summarize the key findings of the surveys.[1]

It is important to note that not all findings presented in this chapter are used in the shortage/surplus analysis conducted later. The data actually used are presented in each of the methods employed to analyze shortage/surplus. Our aim in this chapter is primarily to summarize the responses to our questionnaires in order to capture the intricacies of the labor markets for anesthesiology.

We first analyze some basic demographic characteristics of the AN and CRNA populations. We will then relate these characteristics to their labor-market participation and technology preferences.

Demographic Patterns

CRNAs are more likely than ANs to work in rural areas (Figure 3.1). ANs are much more likely than CRNAs to work in the Northeast and the West. The ANDIR survey shows similar distributions of CRNAs and ANs across regions and rural/urban areas.

Overall, ANs are more likely to be male and CRNAs are more likely to be female (Figure 3.2). Yet, gender composition differs markedly depending on whether we are looking at urban or rural CRNAs. In rural areas, more CRNAs are male (62 percent, versus 38 percent female).

The average age for both CRNAs and ANs is 49, and the average years of experience are 16 for ANs and 17 for CRNAs. A higher proportion of ANs are between the ages of 40 and 55, while CRNAs are more evenly spread across all ages (Figure 3.3). More than one-quarter

[1] The survey instruments are presented in Appendixes A through D. A familiarity with the questions asked in the surveys would facilitate a correct interpretation of the descriptions that follow. The analysis we present is based on survey responses rather the sampling frames, which did not have all the details. The results reported in the text are significant at the $p < 0.05$ level in probit and linear regressions that control for region and urban/rural county (as well as facility size, for the ANDIR results). To avoid clutter, we do not show complete regression results and all details we discuss in the text in the tables. These can be obtained from the authors upon request.

Figure 3.1
Locations of Certified Registered Nurse Anesthetists and Anesthesiologists

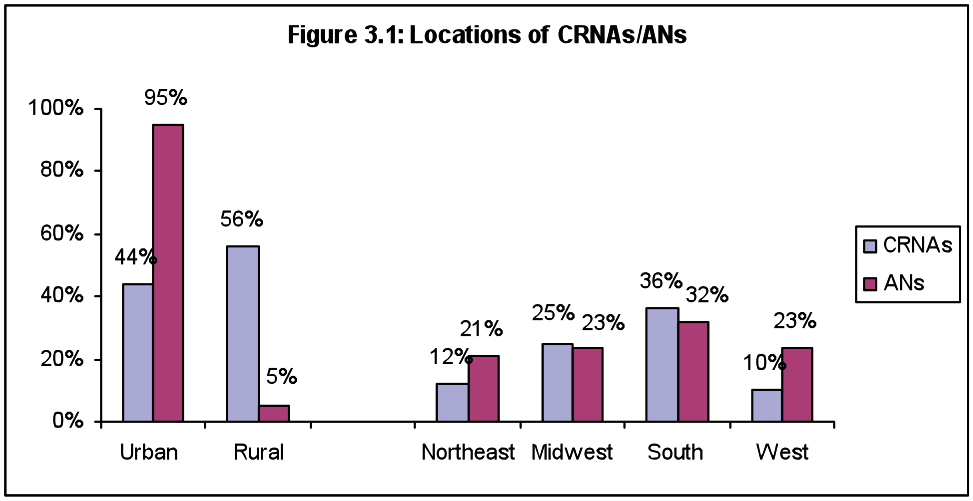
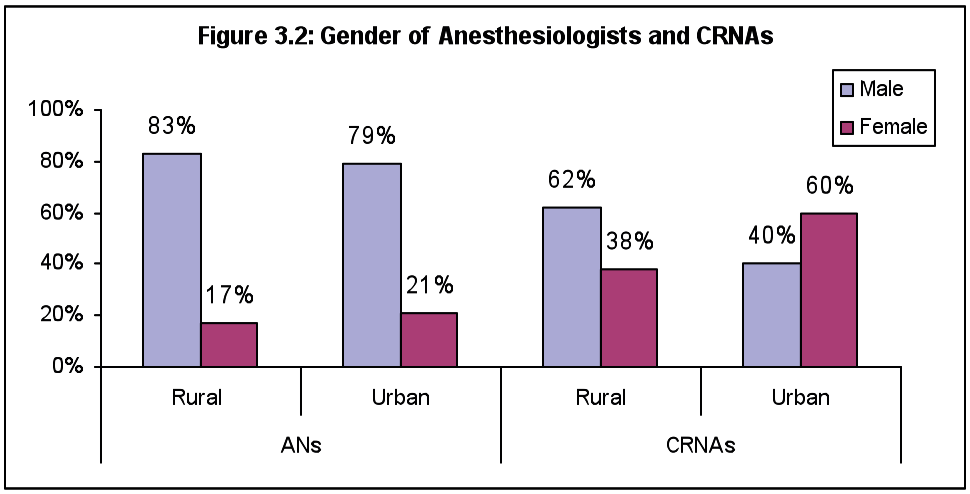


Figure 3.2
Gender of Anesthesiologists and Certified Registered Nurse Anesthetists

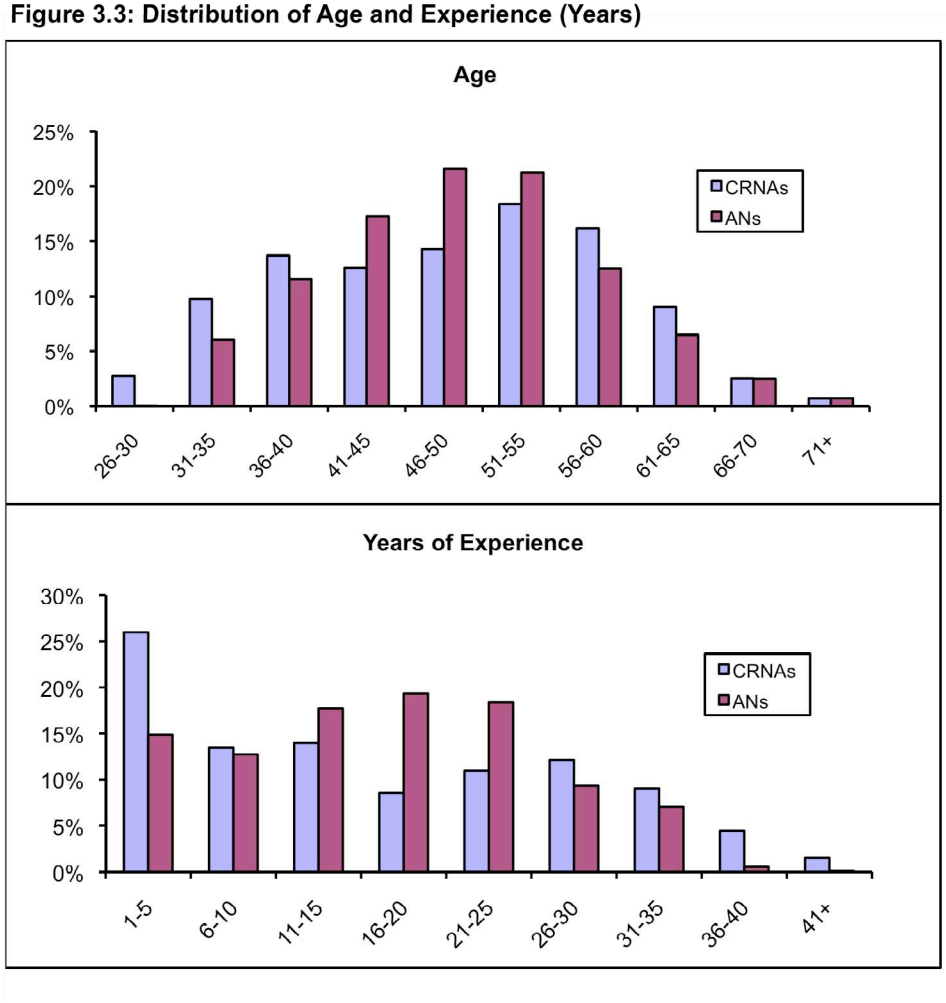


of all CRNAs have only one to five years of experience. In contrast, fewer than 15 percent of ANs are in this lowest experience category.

Employment Arrangements

Our analyses indicate that there is significant regional and rural/urban variation in labor-market patterns. In this section, we focus on differences in employment arrangements for ANs and CRNAs, and we compare their characteristics with those from the ANDIR survey. We focus on differences in these patterns across our main demographic dimensions: region, rural/urban, and gender.

Figure 3.3
Distribution of Age and Experience (years)



Employers

ANs and CRNAs were queried about their primary employment arrangement. Nearly 80 percent of ANs and CRNAs report their primary employment to be with one group or one facility (Figure 3.4). ANs are more likely than CRNAs to work for one group or in multiple facilities and less likely to work for one facility.

Table 3.1 looks at regional differences in type of employer for CRNAs and ANs. The following findings are statistically significant even after controlling for age, experience, and gender, which might be responsible for these differences on their own:

- The urban/rural differences are the same for ANs and CRNAs, with both groups more likely to work for one facility in rural areas.
- Regional differences run in opposite directions for ANs and CRNAs. Controlling for urban/rural differences, ANs in the Northeast are most likely to work for one facility, while CRNAs in the Northeast are less likely to be working for one facility (and more

Figure 3.4
Primary Employment Arrangement

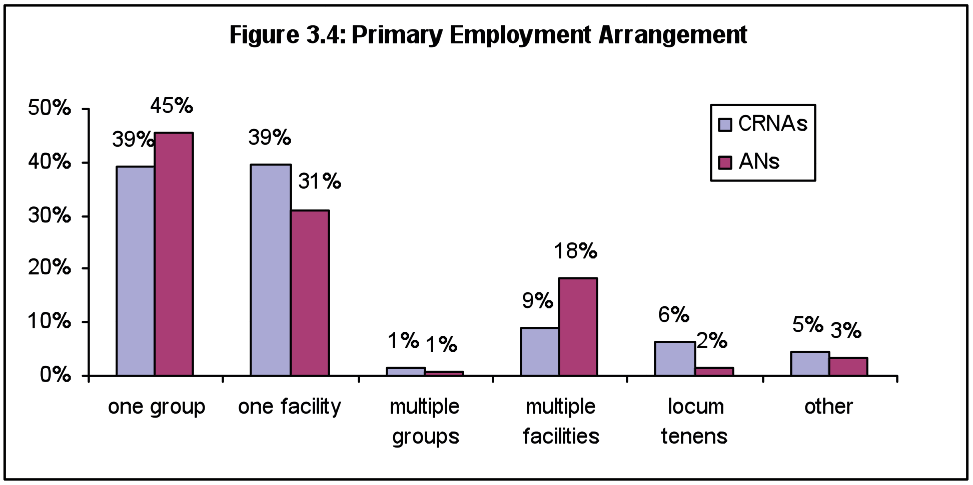


Table 3.1
Differences in Type of Primary Employer (%)

	CRNAs			ANs		
Location	**One Group**	**One Facility**	**Other**	**One Group**	**One Facility**	**Other**
Northeast	43.6	35.9	20.6	39.9	37.5	22.6
Midwest	37.6	43.4	19.1	47.0	32.3	20.7
South	40.0	35.5	24.5	44.5	31.2	24.3
West	29.9	44.0	26.1	50.3	22.4	27.4
Rural	33.6	43.9	22.5	36.7	45.5	17.9
Urban	40.1	37.4	22.5	45.9	29.9	24.2

likely to be working for a group) than CRNAs in the Midwest and West. The West appears to have to most differences in type of employment arrangement.

ANs tend to have longer tenure in their current primary employment arrangement. More than 50 percent of the CRNAs have five years or less with their current primary employer, while only 37 percent of ANs have five years or less (Figure 3.5). The average number of years of tenure with the primary employer is around 8.5 years for CRNAs and 10.3 years for ANs.

ANs tend to work for larger employers of ANs. Forty-five percent of the CRNAs work with fewer than ten other CRNAs in their primary employment arrangement, while less than 30 percent of ANs work for employers with fewer than ten ANs (Figure 3.6). The mean number of CRNAs in the primary employment arrangement is 22.3, while the mean number of ANs in the primary employment arrangement is 33.9.

These primary employment arrangement characteristics may be related to both the need for anesthesia professionals and employers' ability to hire them when needed. Therefore, these

Figure 3.5
Tenure with Current Primary Employment Arrangement (years)

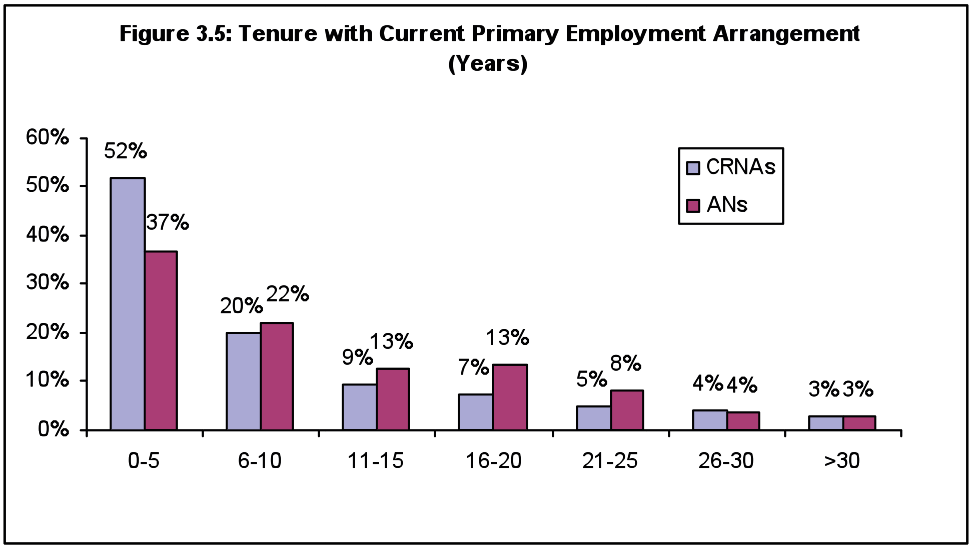
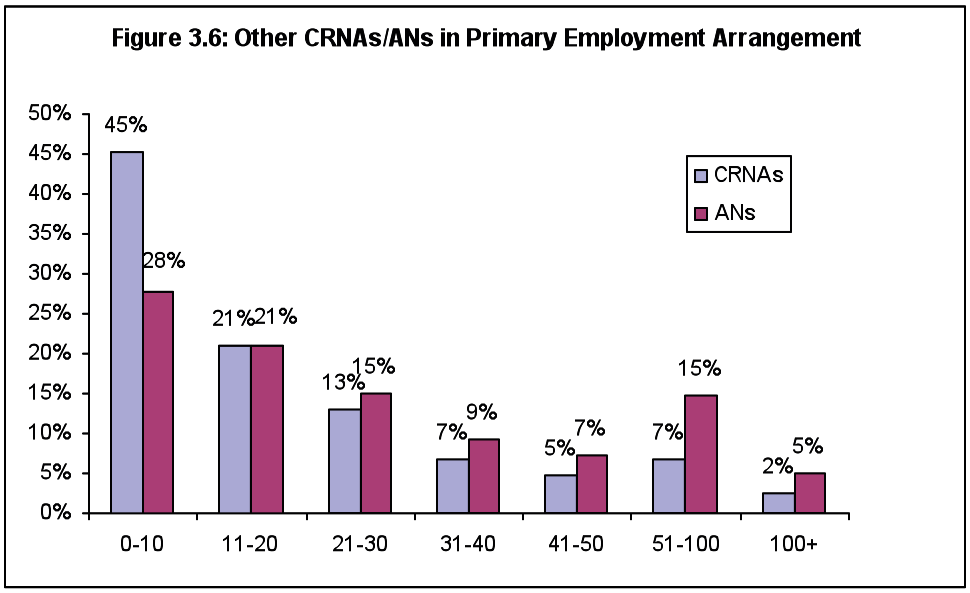


Figure 3.6
Other Certified Registered Nurse Anesthetists and Anesthesiologists in Primary Employment Arrangement



characteristics may have implications for whether there is a shortage in the labor market. We take them into consideration in our later analysis of potential shortage.

Facilities

CRNAs and ANs were asked about the primary facilities in which they provide services. Even while working for one group, these professionals may split their time across multiple facilities.

Hence, we also break down employment by whether they work primarily in one facility or in multiple facilities. We find that a little less than half of the CRNAs work in multiple facilities, while a little more than half of the ANs work in multiple facilities (Figure 3.7).

We find that a lower proportion of CRNAs in the South and in the West work in multiple facilities than their counterparts in the Northeast. By contrast, ANs in these regions are more likely than those elsewhere to work in multiple facilities. Urban ANs are more likely to work in multiple facilities (see Table 3.2). These results are consistent with those reported in Table 3.1: The ANs and CRNAs who are most likely to be employed in a single group are the ones most likely to work in multiple facilities.

Employing or having access to CRNAs does not mean that their services will be used on a daily basis. The ANDIR survey found that facilities in the Midwest and South are more likely than facilities elsewhere to use CRNAs daily and that facilities in the West are the least likely to use CRNAs daily (Table 3.3). We also find that Northeastern facilities are most likely

Figure 3.7
Primary Place of Employment

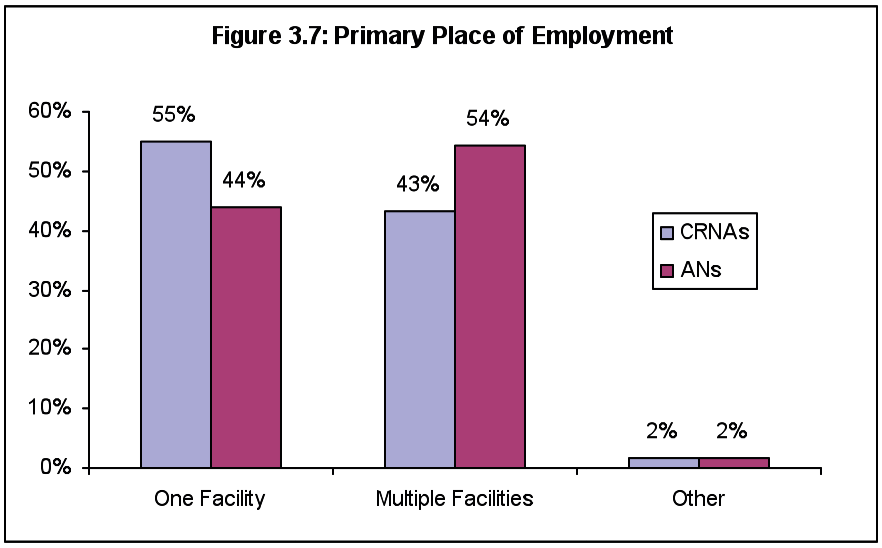


Table 3.2
Regional Differences in Facilities

	CRNAs		ANs	
Location	**Single Facility**	**Multiple Facilities**	**Single Facility**	**Multiple Facilities**
Northeast	52.1	46.5	49.6	47.7
Midwest	55.1	44.0	46.7	51.9
South	56.5	41.7	44.7	53.8
West	59.0	38.2	34.6	64.0
Rural	66.8	32.3	66.5	31.7
Urban	53.3	45.0	42.5	55.8

Table 3.3
Facilities Not Using Any Certified Registered Nurse Anesthetists or Anesthesiologists Daily (%)

Location	No CRNAs	No ANs
Northeast	20	5
Midwest	11	28
South	9	18
West	55	18
Rural	9	45
Urban	26	5

to use ANs daily, and these differences remain significant when we control for facility size and whether the facility is located in an urban/rural county. The ANDIR survey also found that urban facilities were more likely than rural ones to use ANs daily, while rural facilities were more likely to use CRNAs daily.

Our ANDIR and CRNA analyses show similar regional results for direct hiring. The ANDIR survey found that Southern facilities are less likely to directly hire ANs and CRNAs than to obtain services through independent providers. In the CRNA survey, we find that Southern and Northeastern CRNAs are more likely to be employed by a group than a facility (and less likely, therefore, to be directly hired). However, in the ANDIR survey, we do not find too many regional differences for ANs, except that the Northeastern facilities are more likely to use ANs. The AN survey also indicates that Southern ANs are less likely than those in other regions to be hired by one facility but more likely to be hired by one group.

We asked CRNAs and ANs about how many other CRNAs, ANs, and surgeons work in their primary facility. Table 3.4 reports the mean and median number of each type of employee. CRNAs appear to work with more CRNAs and with fewer ANs and surgeons in their facilities than ANs do.[2]

There are clear regional differences in the number of fellow health-care providers CRNAs and ANs report in the facilities. Table 3.5 reports the median number of CRNAs, ANs, and surgeons in various regions. As reported by both CRNAs and ANs in the Northeast, there is

Table 3.4
Health-Care Providers in Primary Facility

Providers		CRNAs	ANs	Surgeons
CRNAs	Mean	17.7	10.6	22.5
	Median	10	6	15
ANs	Mean	13.9	23.9	56.5
	Median	7	16	32

[2] One cannot calculate the average ratio of surgeons to ANs or CRNAs directly from this table, since the ratio of averages differs from the average of ratios. Based on individual responses, the average ratio of surgeons to ANs is 4.5, and of surgeons to CRNAs is 6.5.

Table 3.5
Differences in Median Number of Other Health-Care Providers in Facility, by Location

	CRNAs			ANs		
Locations	**CRNAs**	**ANs**	**Surgeons**	**CRNAs**	**ANs**	**Surgeons**
Northeast	10	7	20	9	20	35
Midwest	10	5	14	9	15	30
South	9	5	15	10	14	30
West	6	3	10	0	19	40
Rural	4	1	10	4	5	15
Urban	12	7	17	7	18	40

typically a combination of both types of providers in the facilities, though the ratio of CRNAs to ANs and the number of surgeons differs depending on who is reporting. CRNAs in the Midwest, South, and West report a 2-to-1 CRNA-to-AN ratio, while ANs report working with fewer CRNAs. The difference is particularly pronounced in the West, where the average AN reports working with no CRNAs. This is in line with our findings in Table 3.3, which indicated that 55 percent of Western facilities do not use any CRNAs. ANs also appear to work in larger (and different) facilities in terms of number of surgeons. As expected, we also find that urban facilities employ more of all labor sources. Urban facilities have a lower CRNA-to-AN ratio, in line with our finding that the majority of ANs are working in urban areas.

Earnings

We now turn to analyzing how CRNAs and ANs are compensated for their services. A relatively small percentage of the respondents—11.25 percent of CRNAs and 20.22 percent of ANs—chose not to answer our questions on wages but did respond to the more general question on sources of income. Respondents were given the flexibility to provide their earnings as dollar figures or within ranges.[3]

The data indicate that most income comes from fixed contracts, though there is wide variation in the percentage of income coming from other sources (Table 3.6). There are large regional differences in the percentage of income from fixed contracts, particularly for ANs. Western ANs and CRNAs receive a much larger portion of their earnings from fee-for-service work. The urban/rural difference in source of earnings is significant only for ANs, with urban ANs earning less of their wages from fixed contracts than rural ANs do. The greater fixed-contract earnings for CRNAs in urban areas are driven by census-region effects.

Figure 3.8 presents the sources of income for ANs by type of employer. It is clear that those who are employed by a single facility or considered locum tenens earn, on average, a greater portion of their income from fixed salary or contract. Those who are employed by groups and multiple facilities receive more fee-for-service income.

[3] For those respondents that provided us with earnings in a range, we imputed exact income amounts by assuming that the distribution of earnings within each range was the same as that for respondents who provided us exact dollar amounts within that range.

Table 3.6
Percentage of Income from Various Sources

	CRNAs			ANs		
Location	Fixed Contract	Fee-for-Service	Other	Fixed Contract	Fee-for-Service	Other
Northeast	92.2	3.7	4.1	70.5	23.7	5.8
Midwest	89.3	7.3	3.4	60.3	34.6	5.1
South	87.9	9.3	2.7	63.0	32.6	4.4
West	76.8	20.7	2.5	38.9	56.6	4.5
Rural	81.3	15.8	2.9	64.1	33.0	2.9
Urban	89.4	7.5	3.1	58.1	36.9	5.0

Figure 3.8
Mean Percentage of Anesthesiologists' Income from Various Sources

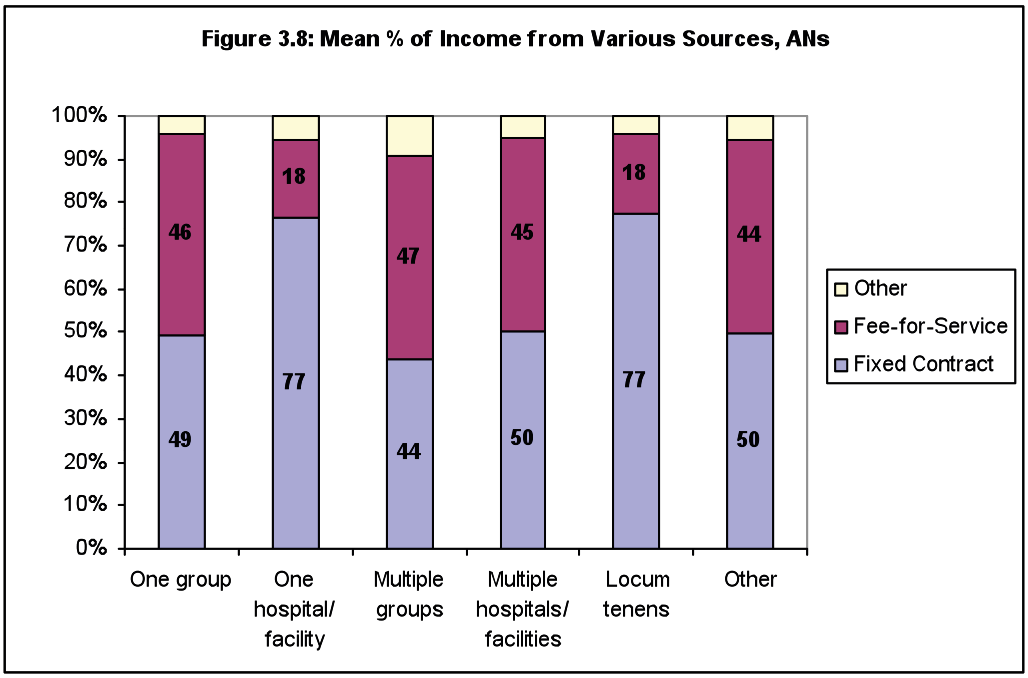
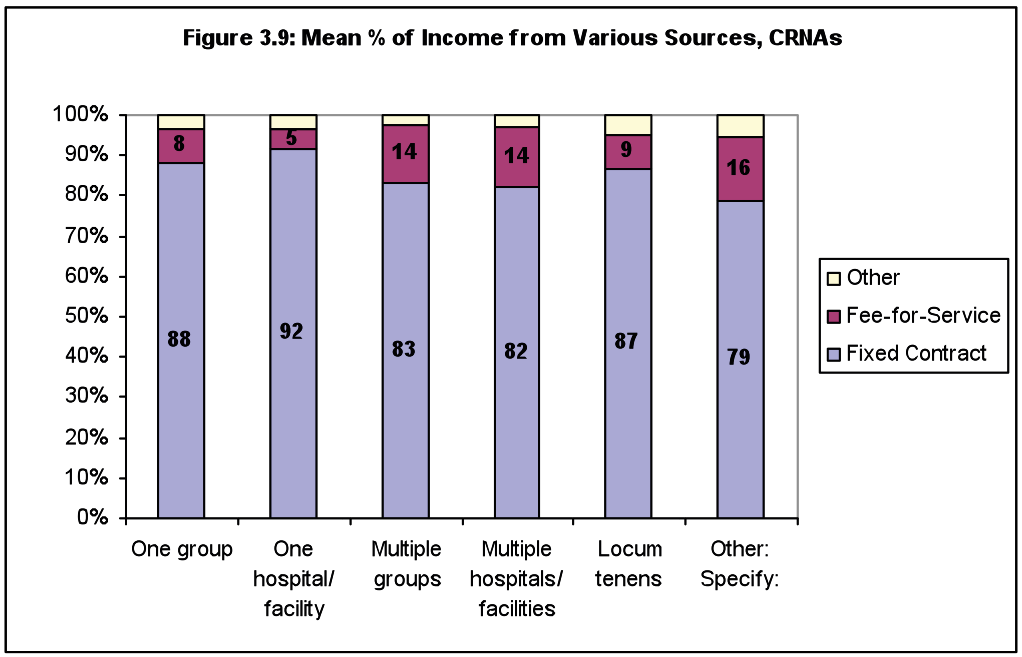


Figure 3.9 presents analogous results on the percentage of income that CRNAs receive from various sources. It is clear that, on average, CRNAs receive a much greater percentage of their incomes from fixed salary or contract. There is much less variation across types of employers, though we find that CRNAs working for multiple groups or facilities are slightly more likely to receive fee-for-service income.

The average annual income for ANs is $337,551, and, for CRNAs, it is $151,380. The medians are similar to the respective averages—an indication that the earnings distributions are not too skewed. These findings confirm our findings on compensation from our ANDIR survey. ANDIRs report average annual salaries for ANs and CRNAs of $303,000 and $149,000, respectively.

Figure 3.9
Mean Percentage of Certified Registered Nurse Anesthetists' Income from Various Sources



CRNAs earn significantly less in the Northeast than their counterparts in other regions, and the ones in the West earn the most (Table 3.7). However, the higher annual wages for Western CRNAs are driven by the greater number of hours worked by these CRNAs, because the difference relative to the Midwest and South is no longer significant when we use the hourly wage. Average annual AN earnings were highest in the Midwest and South and lowest in the West. However, regional differences in hourly AN wages are not statistically significant, with the results primarily driven by differences in hours and urban/rural location.

CRNAs in urban regions earn less than their rural counterparts, while ANs in urban regions earn more. However, this is true only for annual earnings. When annual earnings are converted to hourly earnings using the data provided on average weekly hours, urban CRNAs

Table 3.7
Regional Differences in Earnings ($)

	CRNA Survey		AN Survey	
Location	**Annual**	**Hourly**	**Annual**	**Hourly**
Mean	151,380	76.08	337,551	127.98
Northeast	139,768	71.51	328,220	122.74
Midwest	155,941	79.55	350,313	138.30
South	158,724	79.09	348,934	131.13
West	169,655	82.95	316,614	117.87
Rural	177,505	85.48	329,908	160.51
Urban	151,280	76.80	338,080	125.73

and ANs are both paid less. As in the CRNA survey, in the ANDIR survey, CRNAs in rural areas earn more. By contrast, the ANDIR survey did not find any regional or rural/urban differences in pay for ANs.

It is possible that the lower wage incomes paid to CRNAs and ANs are compensated with better benefits. To shed light on this possibility, we examined the data we collected on employer contribution for a variety of benefits, including health insurance, disability, dental, vision, retirement, and long-term care, as well as employer provision of education or training funds. On average, employers cover 70.76 percent of health-insurance costs and an average of 60.47 percent of disability insurance for CRNAs but only 59.46 percent of health-insurance costs and 35.19 percent of disability for ANs. Employers cover somewhat more on average for all benefit categories, except retirement, for CRNAs than for ANs (see Table 3.8).[4]

Even after controlling for income differences, CRNAs and ANs in the South have significantly lower health-insurance coverage amounts. We also find that ANs in the Midwest and West have lower benefits than those elsewhere. Urban CRNAs receive more health-insurance coverage than their rural counterparts, which might help explain some of the income differences we see for these areas. There are also significant differences by gender. Not only do men receive higher salaries; they also receive more benefits. These regional, urban/rural, and gender differences remain even when we control for the number of hours worked.

Time Usage

In gathering information on time usage or procedures done, our questions generally ask for the percentage of time or procedures spent on a particular type of activity. The surveys did not explicitly ask whether the respondent actually *administered* a particular type of anesthesia, *supervised* another professional, or *was supervised by* another professional. The data on hours worked and time usage allow us to explore possible differences in productivity across regions,

Table 3.8
Percentage of Benefits Paid by Employer

Benefit	CRNAs	ANs
Health care	70.8	59.5
Disability	60.5	35.2
Dental	51.5	37.3
Vision	37.1	23.7
Retirement	32.7	40.4
Long-term care	12.0	7.3

[4] The higher levels of compensation through benefits for CRNAs might be associated with the fact that they receive more income from arrangements with fixed salaries or contracts. In additional analyses, we find that CRNAs and ANs with more income from fixed salary or contracts receive more benefits. We also find a small negative relationship between wages and health-insurance benefits, suggesting that employers substitute higher benefits for wages.

as well as potential shortage for anesthesia professionals in facilities by region and urban/rural areas, a theme we further explore in Chapter Four.

On average, CRNAs work 44 hours per week, with the majority of these hours spent doing clinical work (Table 3.9). ANs work substantially more hours, and most of these additional hours are clinical. The regional and urban/rural differences are more pronounced for CRNAs. As expected, it appears that there is a positive relationship between earnings and hours worked for both CRNAs and ANs. Western CRNAs work more and earn more than those in other regions, while Western ANs work less and earn less than those in other regions. Southern CRNAs and ANs both earn more and work more than their Northeastern counterparts. Urban CRNAs make less and work less than rural CRNAs.

There are very few differences in where ANs and the CRNAs spend their clinical hours. Most of the clinical time is spent in the hospital (82 percent), although CRNAs have more outpatient clinical hours than ANs (59 percent versus 51 percent) (Table 3.10).

Urban CRNAs and ANs spend more time than their rural counterparts in out-of-hospital–based care (likely because urban areas are more likely to have nonhospital facilities),

Table 3.9
Regional Differences in Average Weekly Hours

	CRNAs		ANs	
Location	Total Hours	Clinical Hours	Total Hours	Clinical Hours
Mean	43.9	36.9	63.7	48.6
Northeast	42.1	35.7	64.6	47.0
Midwest	44.5	35.7	62.9	49.4
South	43.8	37.2	64.5	50.0
West	46.2	36.9	62.3	47.5
Rural	50.1	37.5	62.7	49.8
Urban	42.6	36.3	63.7	48.6

Table 3.10
Percentage of Clinical Hours Spent in Various Locations

	CRNAs		ANs	
Location	Mean	Standard Deviation	Mean	Standard Deviation
Hospital	81.7	34.0	81.8	28.8
Inpatient	41.5	26.1	49.4	26.1
Outpatient	58.5	26.1	50.6	26.1
Freestanding ambulatory center	15.1	30.8	14.9	25.6
Office based	1.9	11.6	2.8	12.2
Dental office	0.5	4.9	0.1	2.0
Other	0.8	8.5	0.4	5.2

but there are few regional differences in how CRNAs spend clinical time. Western ANs spend less time in hospital-based care than those in other regions do.

However, results from our surgeons' survey are indicative of a possible future shift in the location of surgical procedures. While 29 percent of procedures are currently conducted in surgeons' offices, surgeons anticipate conducting 32 percent of procedures there in five years; procedures in freestanding ambulatory centers are expected to increase from 15 percent to more than 21 percent. At the same time, hospital procedures are expected to decrease from 54 percent to 44 percent. In other words, a shift of procedures from hospitals to ambulatory centers and surgeons' offices is likely. This would likely entail a shift of anesthesia providers to these facilities as well.

Overall, CRNAs report that they spend nearly 75 percent of their clinical time doing procedures or intraoperative tasks (see Table 3.11). ANs also spend the majority of their time in procedures (nearly 66 percent), though somewhat less than CRNAs do.

Northeast ANs and CRNAs reported spending a larger percentage of their time performing procedures than their counterparts in the Midwest and South do. However, the results for Western ANs and CRNAs run in opposite directions. Western CRNAs spend the smallest percentage of time of all CRNAs in procedures, while Western ANs spend the greatest percentage of time in procedures (Table 3.12). Urban ANs and CRNAs also spend more time

Table 3.11
Percentage of Clinic Hours Spent on Various Tasks

	CRNAs		ANs	
Task	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Preoperative	8.4	7.8	10.9	11.2
Intraoperative	75.0	20.1	65.9	23.1
Postoperative	5.4	5.2	7.3	6.5
Critical care	2.0	3.8	2.0	9.6
Pain management	1.0	4.5	2.9	5.9
Labor/delivery	6.9	14.5	7.5	11.9
Other	1.2	9.0	0.6	5.7

Table 3.12
Differences in Time Usage, by Location (%)

	CRNAs		ANs	
Location	**Intra-Operative**	**Labor/Delivery**	**Intra-Operative**	**Labor/Delivery**
Northeast	79.5	2.8	67.0	7.7
Midwest	74.4	6.6	62.7	7.2
South	75.3	7.0	63.4	7.7
West	66.9	13.8	71.7	7.4
Rural	70.4	9.1	59.6	8.2
Urban	75.9	6.4	66.3	7.5

in procedures. Hence, though the number of hours worked is smaller in the Northeast and urban areas, more time is potentially spent on performing procedures. We also found that rural CRNAs and Western CRNAs spend a lower proportion of their time on procedures than their counterparts elsewhere, as do rural ANs and Southern and Midwestern ANs.

Overall, the less time CRNAs spend in performing procedures, the more time they spend in labor and delivery (Table 3.12). CRNAs in the West spend a relatively large percentage of time in labor/delivery anesthesia. There are no regional or urban/rural differences for percentage of AN time spent in labor/delivery anesthesia.

Monitored Anesthesia Care

In this section, we continue to look at CRNA and AN time usage, but with a focus on MAC. Surveys questioned CRNAs and ANs about the percentage of clinical time and the number of procedures they undertake in each of the following anesthesia techniques: MAC, general anesthesia, regional/block/spinal anesthesia, and obstetrical anesthesia.[5] Data collected from these questions play an instrumental role in the shortage analysis we conduct later, by helping us deduce the time required per procedure for the different types of anesthesia, given data on total clinical time and the number of procedures.

CRNAs and ANs spend the majority of their time in general anesthesia. However, ANs spend somewhat more time in general anesthesia, while CRNAs spend more time in monitored anesthesia. Table 3.13 suggests that general anesthesia procedures are more time-intensive than other procedures. General anesthesia procedures appear to be particularly long for ANs, as these procedures take up more than two-thirds of ANs' time but make up less than one-third of their total number of procedures. These results indicate that CRNAs and ANs spending more time on non–general anesthesia will appear more productive in terms of the number of procedures performed for a given amount of time, due to the differing mix of procedures they perform.

The distribution of time spent on regional anesthesia by CRNAs is highly skewed. The median percentage of time is 5 percent. In results not shown in order to avoid clutter, 25 per-

Table 3.13
Percentage of Time Spent on Various Types of Anesthesia

	CRNAs				ANs			
	% of Time		% of Procedures		% of Time		% of Procedures	
Anesthesia	Mean	Median	Mean	Median	Mean	Median	Mean	Median
MAC	24.5	20	28.7	24	15.5	10	26.8	25
General	58.5	60	51.1	50	67.0	70	31.5	25
Regional/ spinal	10.3	5	12.6	10	11.2	8	24.2	25
Obstetrical	6.7	0	7.7	1	6.4	2	17.6	25

[5] We did not explicitly ask whether the respondent actually *administered* a particular type of anesthesia, *supervised* another professional, or *was supervised by* another professional.

cent of CRNAs spend no time at all on these procedures. CRNAs in rural areas spend more time on these procedures than do those in urban areas (a median of 5 percent for urban CRNAs and a median of 10 percent for rural CRNAs).

Table 3.14 displays the regional and rural/urban differences for CRNA and AN time usage in the various types of anesthesia. The biggest regional differences are for MAC, with CRNAs and ANs in the Northeast spending significantly more time on this type of anesthesia than those in other regions. CRNAs are also used more often for regional/spinal and obstetrical anesthesia in the West than elsewhere. Western ANs, on the other hand, seem to be used heavily in general procedures. It appears not only that are CRNAs less prevalent in Western facilities but also that they may play a more specialized role rather than being used alongside ANs. CRNAs in urban areas spend significantly more time on general anesthesia and less on all other types of anesthesia than CRNAs in rural areas.

The ANDIR survey yielded findings similar to the CRNA and AN surveys. ANDIRs in the Northeast report that CRNAs and ANs spend a much greater percentage of time on MAC than on other procedures. The fact that Northeastern and rural facilities use *both* ANs and CRNAs more often for MAC than other facilities do suggests that the regional and rural/urban differences cannot be explained by the substitution of CRNAs for ANs or vice versa and suggests that there are other factors associated with the greater use of all anesthesia providers for MAC. This could be attributed to patient differences, facility preferences, or, possibly, regional norms.

Given this proclivity toward MAC, CRNAs and ANs in Northeastern facilities spend a greater percentage of their time performing these types of procedures than they do other procedures. Procedures requiring MAC are significantly shorter (on average) than procedures requiring general anesthesia. The Northeastern CRNAs and ANs are therefore able to complete many more procedures in a day. This can help to explain why, in the ANDIR survey, we found that anesthesia providers in Northeastern facilities were completing many more procedures than those in other areas of the country. Later, we explore whether this greater productivity among Northeastern CRNAs and ANs is mirrored by greater evidence of shortage, to see whether they are "worked harder." The ANDIR results were also in line with our findings that ANs spend a much greater percentage of time than CRNAs do on general anesthesia and less on MAC.

Table 3.14
Regional Differences in Mean Time Spent on Various Types of Anesthesiology

	CRNAs				ANs			
Location	MAC	General	Regional/ Spinal	Obstetrical	MAC	General	Regional/ Spinal	Obstetrical
Northeast	32.9	54.0	10.3	2.9	20.6	61.0	12.0	6.4
Midwest	24.2	56.9	12.2	6.8	14.4	66.7	12.9	6.1
South	23.9	60.7	8.7	6.7	14.6	68.7	10.0	6.7
West	21.6	51.5	14.3	12.6	13.0	70.5	10.3	6.2
Rural	27.9	47.8	15.4	9.0	17.0	59.8	15.9	7.2
Urban	24.7	59.7	9.4	6.1	15.4	67.4	10.9	6.3

Evidence from the surgeons' survey is consistent with the results reported in Table 3.13. More surgeons reported that CRNAs play an important role in the provision of monitored anesthesia than said the same of regional/spinal anesthesia (25.44 percent versus 9.88 percent). Surgeons also reported that ANs provide more procedures in general anesthesia (64.53 percent) than in the other types of anesthesia—36.78 percent in MAC procedures and 21.06 percent in regional/spinal anesthesia procedures.

It is important to understand why percentage of time spent on MAC varies across regions and between urban and rural areas, because this variation has implications for the potential substitutability of non–anesthesia providers for these procedures, which may affect future workforce requirements. One possible explanation is that facilities can choose whether they use anesthesia providers or non–anesthesia providers to sedate the patient for certain procedures. We gathered information on MAC provided by anesthesia (ANs and CRNAs) and conscious sedation provided by non–anesthesia providers.[6] There is also a considerable amount of heterogeneity across procedures (see Table 3.15). The percentages reported by CRNAs and ANs are relatively similar. There are larger discrepancies for non–anesthesia-provider percentages, resulting possibly from the fact that CRNAs and ANs are less likely to know about all of the procedures in which non–anesthesia providers take responsibility for conscious sedation. The small differences that do exist are likely due to the differing areas and types of facilities in which they work.

We found wide regional variation in the type of providers used to deliver MAC and conscious sedation as reported by CRNAs and ANs (Table 3.16). According to CRNAs and ANs, the Northeast uses anesthesia providers significantly more often than facilities elsewhere. While the table presents results for only two types of procedures, this regional pattern holds

Table 3.15
Providers of Conscious Sedation or Monitored Anesthesia Care for Various Procedures (%)

	Non–Anesthesia Providers		Anesthesia Providers	
Procedure	**CRNA Survey**	**AN Survey**	**CRNA Survey**	**AN Survey**
Cataracts	4.60	6.78	74.45	73.01
Adult radiology	42.87	58.02	20.39	16.72
Colonoscopy/ endoscopy	48.10	57.69	43.22	33.41
Pediatric radiology	16.17	29.69	31.33	33.72
EPS lab	25.70	39.44	20.87	27.50
Catheter lab	45.38	65.21	11.02	10.45
TEE lab	34.31	58.90	19.61	16.29
Bronchoscopy suite	39.14	64.91	26.23	15.85

NOTE: Due to "I don't know" responses, percentages for each survey may not sum to 100. EPS = electrophysiology study. TEE = transesophageal echocardiography.

[6] See, for instance, ASA (2004 [2009]), for the distinction between conscious (moderate) sedation and MAC. While MAC might include sedatives or analgesics used in conscious sedation, "the provider of MAC must be prepared and qualified to convert to general anesthesia when necessary" (p. 1).

Table 3.16
Providers of Anesthesia for Selected Procedures (percentage of procedures for each)

	CRNAs				ANs			
	Colonoscopy		TEE Lab		Colonoscopy		TEE Lab	
Location	CRNAs/ANs	Non–Anesthesia Provider	CRNAs/ANs	Non–Anesthesia Provider	CRNAs/ANs	Non–Anesthesia Provider	CRNAs/ANs	Non–Anesthesia Provider
Northeast	49.2	24.2	26.3	48.2	57.1	38.1	30.2	32.7
Midwest	24.1	35.9	12.4	67.8	38.5	55.6	14.2	37.6
South	38.0	28.6	15.9	57.5	43.4	44.4	17.1	32.0
West	20.0	29.0	10.5	60.1	29.7	55.7	10.3	24.1
Rural	30.8	36.7	7.5	50.8	47.9	49.3	11.7	21.5
Urban	33.2	28.9	16.7	59.1	40.7	47.8	19.2	36.3

across all procedures. The South and West use anesthesia providers for significantly fewer procedures than other regions do. The procedures with the largest regional variation are colonoscopies and endoscopies, EPS labs, and TEE labs.

The urban/rural differences are less clear, with patterns in the use of anesthesia providers varying across procedures. Urban facilities are more likely than rural ones to use anesthesia providers for EPS, catheter, and TEE labs and less likely to use them in all other procedures. These regional and rural/urban differences remain after controlling for the anesthesia provider's percentage of time in MAC, indicating that the percentages reported for cases facility-wide are not confounded by the amount of time an individual spends on that type of care. It is unlikely that these differences can be fully explained by differences in the patient population receiving these procedures. The results provide evidence for possible regional norms of practice regarding who provides a particular type of service.

Tables 3.15 and 3.16 suggest that non–anesthesia providers may be an important labor source of anesthesia provision.

Overall, there are few differences in the types of patients seen by ANs and CRNAs, so differences in patient characteristics are unlikely to explain the differences in time spent on MAC across these two types of anesthesia providers. However, there are significant regional and urban/rural differences in patient characteristics, so these differences may be partially responsible for regional and urban/rural variations in provision of MAC within each type of provider. Nearly 10 percent of patients treated by respondents to the CRNA survey and 12 percent of respondents to the AN survey were in the highest ASA categories—statuses IV and V (patients who have been classified as extremely ill and near death) (Table 3.17). Nearly 30 percent of the patients cared for by ANs were elderly, nearly the same as the 30.8 percent of patients seen by CRNAs. On average, about one-fifth of the cases are considered urgent or emergent rather than elective for both ANs and CRNAs. The results indicate regional and urban/rural differences in patient age and severity of condition, but not in the percentage of cases that are elective.[7] Patients seen by Northeastern CRNAs are more likely than those in the West to be older and in the higher ASA categories. These differences are particularly large

[7] Regional variation in establishing physical-status scores may also play a role.

Table 3.17
Regional Patient Characteristics (%)

	ASA Status IV or V		Elderly		Nonelective	
Location	CRNA	AN	CRNA	AN	CRNA	AN
Mean	9.3	12.1	30.8	29.6	20.1	20.9
Northeast	10.5	12.2	34.3	30.8	19.7	19.9
Midwest	8.2	12.1	30.9	30.3	19.1	19.6
South	9.7	15.4	30.3	29.2	19.0	21.5
West	6.0	11.2	27.3	28.3	20.6	21.6
Rural	10.6	7.3	32.8	33.7	20.6	18.9
Urban	13.1	9.3	29.4	29.9	20.7	19.4

for CRNAs. Patients seen by urban CRNAs are younger than those seen by rural CRNAs but are slightly more likely to be in the higher ASA categories. On the other hand, there are no regional or urban/rural differences in the percentage of cases that are nonelective.

Working Patterns

Table 3.18 examines joint working patterns of CRNAs and ANs. CRNAs were asked how many anesthesia providers they work with on a typical procedure.[8] We find that CRNAs typically work with one or two ANs on each procedure, although 20 percent of CRNAs report

Table 3.18
Joint Working Patterns of Anesthesiologists and Certified Registered Nurse Anesthetists

	CRNAs		ANs			
	No. of ANs Typically Working With		% Time Spent Supervising CRNAs		% Time Personally Delivering Anesthesia	
Location	Mean	Median	Mean	Median	Mean	Median
Total	1.6	1	35.7	23	47.1	30
Northeast	1.8	2	35.2	25	38.0	20
Midwest	1.4	1	41.3	30	39.5	20
South	1.5	1	47.9	50	38.2	20
West	0.9	1	11.6	0	76.1	100
Rural	0.8	0	38.5	0	57.0	0
Urban	1.6	2	35.2	2	40.6	2

[8] The question asked was this: "In your primary facility, how many Anesthesiologists do you typically work with on a procedure?" Note that the survey findings presented in Table 3.18 are not used in the demand-based or economic analyses of the labor markets.

working with no ANs. The following findings are significant when we control for region and urban/rural county:

- CRNAs who spend a greater percentage of time delivering monitored anesthesia also work with fewer ANs (and are more likely to work alone).
- Even controlling for the percentage of time spent on MAC, CRNAs in the Northeast and urban areas work with more ANs than CRNAs in other regions do.
- CRNAs in the West work with fewer ANs than CRNAs in other regions do.

ANs were asked a slightly different question to get at this issue: In what percentage of cases do they (1) supervise or medically direct AAs or CRNAs and (2) personally deliver anesthesia (see Table 3.18).

- On average, ANs spend nearly half of their time personally providing anesthesia and a little more than one-third of their time supervising CRNAs. More than 30 percent of ANs never supervise CRNAs (31 percent). More than half of ANs in the West never supervise CRNAs, and more than half spend all of their time personally delivering anesthesia.
- In general, the regional differences are quite large. ANs in the Midwest and South spend the most time supervising CRNAs, while ANs in the West spend the least time supervising CRNAs. We saw in Table 3.4 that these regional differences are similar for the number of CRNAs a facility has. This might suggest that a lack of CRNA usage in the facility is driving part of the differences in supervision time. But we found that, even when controlling for the number of CRNAs employed by the facility, the regional and urban/rural differences remained, indicating not only that Western facilities are less likely to use CRNAs but also that ANs and CRNAs in the same facility are less likely to work together.

Preference for Technology

We now examine the preference for technology among CRNAs, ANs, ANDIRs, and surgeons and how these preferences relate to the labor-market characteristics of these groups. We also look at the technology preference of surgeons and ANDIRs. Table 3.19 shows the results for these statements: "Professionally, overall I would describe myself as being pro-technology" and "My primary facility does not adopt new technology fast enough." Overall, most respondents (91 percent) call themselves pro-technology. However, 34.1 percent of CRNAs and nearly 30 percent of ANs feel that their facilities are not adopting technology frequently enough, while a lower proportion of surgeons feel this way (23 percent).

There is very little regional and rural/urban variation in responses to these general technology-preference questions. The only statistically significant difference is in the Midwest, where CRNAs and ANs are both less likely than their Northeastern counterparts are to state that their facilities are not adopting technology frequently enough. When we add other controls—total hours and tenure with facility or group—we find that having longer hours increases technology preference and that having longer tenure lessens the likelihood of responding that the primary facility does not adopt technology frequently enough. This may

Table 3.19
General Technology Preference (%)

	I Am Pro-Technology		My Facility Doesn't Adopt Technology Quickly Enough	
Location	CRNAs	ANs	CRNAs	ANs
Mean	90.8	90.9	34.1	29.1
Northeast	90.9	90.6	37.3	29.9
Midwest	89.3	91.2	28.1	24.5
South	90.3	91.6	36.1	32.9
West	91.7	89.6	34.2	27.9
Rural	91.5	37.5	33.0	25.5
Urban	90.0	36.5	34.0	29.4

be driven by changes in the individual's technology preference or by increased familiarity with the technology adoption of his or her primary facility.

In the general technology questions, we find only one regional difference in the CRNA, AN, and ANDIR surveys. We find that ANDIRs in the Midwest are more likely to say that "increasing technology will improve quality of care." However, the ANDIR survey also found that Midwestern directors were less likely to report that additional MAC technology would lead to cost savings. In combination, these surveys present a picture of Midwestern facilities as preferring technology and being quick adopters of technology that is needed for anesthesia in these facilities, because Midwestern directors show a higher preference for increasing technology to improve quality of care, and ANs and CRNAs in the Midwest believe that their facilities are adopting technology frequently. Other than this Midwestern difference in technology preference, there also were very few regional or rural/urban differences in the ANDIR survey technology findings.

Other questions attempted to get at technology preference by more specifically asking about technology in different areas. They ask whether access to better technology is needed for (1) anesthesia machines, (2) patient monitoring, (3) drug delivery, (4) respirators and ventila-

Table 3.20
Certified Registered Nurse Anesthetists Stating a Preference for More Technology in Various Areas (%)

Location	Anesthesia Machines	Patient Monitoring	Drug Delivery	Respirators/ Ventilators	Information Technology
Mean	49.3	62.0	55.8	42.5	50.6
Northeast	55.1	62.7	62.2	48.0	58.0
Midwest	42.8	56.0	53.1	37.5	46.6
South	49.0	62.8	53.9	39.5	47.8
West	51.4	62.0	56.8	43.7	53.1
Rural	44.0	56.8	53.6	37.5	46.3
Urban	49.4	61.6	55.7	41.4	50.4

Table 3.21
Anesthesiologists Stating a Preference for More Technology in Various Areas (%)

Location	Anesthesia Machines	Patient Monitoring	Drug Delivery	Respirators/ Ventilators	Information Technology
Mean	43.6	61.9	61.2	32.5	69.7
Northeast	43.9	65.9	66.5	33.9	72.9
Midwest	40.5	58.6	57.5	29.5	68.9
South	46.9	63.4	61.8	35.0	70.4
West	41.6	58.8	59.1	30.6	66.1
Rural	36.9	55.7	57.2	29.1	67.2
Urban	44.0	62.3	61.5	32.7	69.8

tors, and (5) information technology. Table 3.20 reports the results from the CRNA survey, and Table 3.21 reports the results from the AN survey.

For CRNAs, the most-desired technology is in the area of patient monitoring, with 62 percent stating that they would like to have better technology in this area. This is followed by better drug-delivery technology, which is preferred by 56 percent of CRNAs. The least-desired technology is respirators and ventilators.

The proportions of ANs preferring better technology in these areas are relatively similar to those of CRNAs (see Table 3.21). ANs prefer additional patient monitoring and drug delivery technology to additional technology for anesthesia machines and respirators or ventilators. ANs are much more likely to want better information technology (70 percent, versus 50 percent of CRNAs).

There are significant regional differences across all five areas of technology for CRNAs. Respondents from the Midwest were less likely than those from the Northeast to want better technology. This is consistent with results reported in Table 3.19, which indicate that Midwestern CRNAs are more satisfied with the speed of the technology adoption in their facilities. The South and the West are also less likely to state a preference for more technology in most of the technology categories. Northeastern CRNAs are consistently the most likely to want more technology. Urban CRNAs are more likely to prefer better technology for anesthesia machines and patient monitoring. These regional differences remain even after controlling for percentage of time spent in MAC, indicating that differences in time usage do not account for all differences in technology preference. However, it is unclear whether CRNAs want more technology in the Northeast (and in some cases, in urban areas) because their facilities are not providing as much as those in other parts of the country or because people in these regions have a higher overall preference for technology.

The regional and rural/urban differences for specific technology preferences are similar for ANs and CRNAs. Midwestern and Western ANs are less likely than their counterparts elsewhere to prefer better technology in all areas of technology except anesthesia machines. Urban ANs are more likely than rural ones to prefer better technology for patient monitoring. In addition, ANs who work more hours and spend a greater percentage of time in MAC are more likely than other ANs to prefer access to better anesthesia technology. This suggests that better anesthesia technology may be a complement to AN labor rather than a substitute.

Table 3.22
Preference for More Technology in Various Types of Anesthesia (%)

	CRNAs			ANs		
Location	Monitored	General	Reg./Spinal	Monitored	General	Reg./Spinal
Mean	46.9	60.5	49.3	36.2	60.8	63.8
Northeast	49.5	63.4	48.5	40.2	63.7	65.3
Midwest	41.1	56.1	46.0	33.5	57.7	64.1
South	48.8	60.0	47.6	37.9	63.3	64.3
West	43.4	61.1	56.9	32.6	57.6	61.1
Rural	42.8	56.1	52.9	33.7	55.5	66.2
Urban	47.0	60.3	47.2	36.4	61.2	63.6

Table 3.22 examines differences in preferences for technology in the three major categories of anesthesia: (1) general anesthesia, (2) regional/spinal anesthesia, and (3) monitored anesthesia. Overall, CRNAs and ANs are least likely to prefer more technology in MAC than in other categories. Part of this difference may be due to the greater amount of time that CRNAs and ANs spend providing general anesthesia (see Table 3.13).

Relative to those in the Northeast, CRNAs in the Midwest are less likely to prefer better technology in all areas of anesthesia, and ANs in the Midwest are less likely to prefer better general-anesthesia technology. This supports our interpretation from previous results that Midwestern CRNAs have a lower preference for additional technology. One possible explanation is that Midwestern facilities are quicker to adopt technology, while another is that Midwestern facilities need less technology because the facilities are more likely to be smaller, rural facilities and less likely to see the most–seriously ill patients. Western CRNAs and ANs are also less likely than those in other regions to prefer better MAC technology. Western CRNAs, who have been shown to spend more time in regional/spinal anesthesia, also have the highest preference of all CRNAs for technology in this area. In general, the more time a CRNA or AN spends in a type of anesthesiology, the more he or she prefers better technology for that type of anesthesia. The only urban/rural difference is for monitored anesthesia. CRNAs in urban areas prefer better technology for monitored anesthesia.

The overall preference for technology across types of anesthesia is also much higher among CRNAs and ANs than among ANDIRs. Only 12 percent of ANDIRs wanted more MAC technology, and only 23 percent wanted more general-anesthesia technology, while 47 percent of CRNAs (and 36 percent of ANs) want more MAC technology, and 61 percent of CRNAs (and 64 percent of ANs) want more general-anesthesia technology. These differences in preferences may reflect the greater potential control ANDIRs have over the technology that is adopted in the facility and their being more accountable for cost-benefit justifications. From the viewpoint of surgeons, it appears that technology is most important because it improves quality of care, allows for additional functionality, and provides an interesting work environment. These results do seem to indicate, however, that the preference for technology among CRNAs and ANs is not lessened because they view technology as a substitute for their labor.

CHAPTER FOUR

Analysis of the Labor Markets

In this chapter, we present results from our workforce analyses. As discussed in Chapter Two, we use three different methodologies: a survey-based approach, DBA, and economic analysis.

Survey-Based Analysis

As part of our surveys, we asked questions that would specifically help us to understand whether the labor markets for ANs and CRNAs exhibit shortages. We examine data gathered on job openings, changes in hours worked, and responses to whether the employer needed more CRNAs and ANs to meet current and potential demand. Although those are not direct measures of surplus or shortage, they are suggestive.

The reported percentages of CRNAs and ANs with open positions available in their primary employment arrangement are 58 percent and 68 percent, respectively (Table 4.1). We find large differences in the percentage of CRNAs and ANs reporting open positions across regional and rural/urban areas. CRNAs and ANs in the Northeast are significantly more likely to report open positions, particularly relative to those in the West, and CRNAs and ANs in urban areas are also significantly more likely to report open positions than are their rural counterparts. Controlling for the size of the primary employer does significantly reduce urban/rural differences in open positions but does not completely eliminate the significance of this difference. Larger employers are more likely to have open positions, and these tend to be concentrated in more-populated areas.

The average number of open AN positions reported for these employers is 2.8, and the average number of open CRNA positions reported is 3.4.[1] There are more CRNA positions reported open than AN positions, whether we look at the absolute number of open positions or the percentage of total positions open. The employers for whom Western CRNAs work were less likely to have open CRNA positions and also any open positions. CRNAs and ANs who work for a single facility report more open AN positions than did those who work for a single group. Larger employers also have more open positions.

The AN and CRNA surveys also included a question on whether the respondent's employer (facility or group) needs more CRNAs or ANs to meet current demand. Responses varied across the three surveys. CRNAs are much more likely to state that their employer needs

[1] One should be cautious in interpreting these numbers because a significant fraction of respondents could not answer this question. Of those respondents reporting any open position (58 percent for CRNAs and 68 percent for ANs), two-thirds knew the number of open CRNA or AN positions for their profession in their primary employment arrangement, while lower proportions knew the number of open positions for other types of anesthesia providers.

Table 4.1
Open Positions for Certified Registered Nurse Anesthetists and Anesthesiologists

	CRNA Survey		AN Survey	
Location	% with Any Positions Open	Open Positions for CRNAs	% with Any Positions Open	Open Positions for ANs
Total	58.24	3.36	68.23	2.82
Northeast	71.91	3.44	77.54	2.91
Midwest	54.35	3.06	65.24	2.53
South	55.92	3.56	72.85	2.47
West	44.38	2.31	55.46	3.78
Rural	39.92	2.02	47.32	1.69
Urban	60.50	3.53	69.51	2.88

more CRNAs (78.5 percent) than to state that their employer needs more ANs (32.2 percent). Nearly 36 percent of ANs state that their primary employer needs more CRNAs, while 47.4 percent of ANs state that their employer needs more ANs. In the ANDIR survey, 22 percent of directors believe that they need more ANs to meet current demand, while nearly 30 percent of directors believe that they need more CRNAs to meet current demand.[2] It is possible that ANs and CRNAs are more knowledgeable of the needs for their own group and that ANDIRs are the most knowledgeable of all, having a better perspective on their facility's overall staffing requirements.

CRNAs in the Northeast are significantly more likely than those in any other region to report a need for both more CRNAs and more ANs (Table 4.2). In the Northeast, ANs also note this greater need for labor, particularly relative to the West. These responses suggest that the West in particular is not facing a shortage of anesthesia providers compared with other

Table 4.2
Percentage Reporting That Employer or Facility Needs More Certified Registered Nurse Anesthetists or Anesthesiologists to Meet Current Demand

	CRNA Survey		AN Survey	
Location	Need More CRNAs	Need More ANs	Need More CRNAs	Need More ANs
Total	79.07	32.80	35.72	47.44
Northeast	86.58	40.32	46.45	50.27
Midwest	76.39	26.60	36.63	48.20
South	77.21	30.87	43.20	50.94
West	68.52	27.08	14.12	39.10
Rural	63.16	13.32	31.96	38.53
Urban	80.78	34.89	35.95	48.00

[2] In the interest of brevity, we do not present detailed tables of findings from our ANDIR survey. We give primacy to the AN and CRNA surveys and use the ANDIR survey to supplement findings from those two surveys.

regions. Urban CRNAs and ANs both report a greater need than their rural counterparts do for labor (particularly ANs) to meet current demand.

Although there is disagreement on the levels, the regional differences found for the CRNAs stating, "My primary employer needs more CRNAs to meet demand," closely mirror our findings for the same question on the ANDIR survey. The Northeast is much more likely than all other regions to "need more CRNAs," particularly relative to the West (though the difference with the South is only marginally significant, $p = 0.09$, when we control for rural/urban, facility size, and the number of CRNAs used daily). The rural/urban differences are not significant for ANs or CRNAs when controlling for facility size. There were also no significant regional differences in measures of AN shortage in the ANDIR survey. In the AN survey, we found several measures that indicate that AN shortages are less likely in Western facilities than elsewhere. Western ANs are less likely than ANs elsewhere to say that their employer "needs more ANs to meet current demand" and are less likely to report open positions with their employer.

We then attempt to gauge excess capacity in the workforces of CRNAs and ANs rather than lack of capacity, by asking, "Does your primary employment arrangement need more CRNAs/ANs to handle more cases?"[3]

As seen in Table 4.3, a greater percentage of CRNAs report the need for greater numbers of CRNAs to handle more cases (83 percent) than do ANs report needing ANs (35.3 percent). Approximately one-third of ANs who did report that their employer did not need additional staff to handle additional cases respond that additional CRNAs or ANs are "not the bottleneck to expansion," implying that, even if their employer added more staff, they still would not be able to handle additional cases. As with the question on staffing needs to meet current demand,

Table 4.3
Percentage Reporting That Employer or Facility Needs More Certified Registered Nurse Anesthetists or Anesthesiologists to Handle More Cases

	CRNAs		ANs	
Location	Need More CRNAs	Need More ANs	Need More CRNAs	Need More ANs
Total	82.97	41.81	31.54	35.25
Northeast	87.37	53.27	41.85	39.23
Midwest	80.15	35.29	30.29	31.73
South	80.62	37.92	37.25	38.03
West	78.50	36.40	14.70	31.06
Rural	70.69	18.93	22.78	25.09
Urban	83.68	44.16	32.11	35.90

[3] In the AN survey, the answer "no" was followed by "(additional staff is not the bottleneck to expansion)." In the CRNA survey, the answer "no" could mean that the employer could handle more cases without employing more CRNAs or ANs (excess labor capacity). However, in the AN survey, the answer "no" could mean (1) that their employer could handle more cases without employing more CRNAs or ANs or (2) that, even if their employer increased the number of CRNAs or ANs, they would not be able to handle more cases. A "no" answer by ANs can therefore be interpreted as an indication of additional labor capacity or a lack of nonlabor capacity, such as hospital facilities. The results for this question should therefore be interpreted with caution.

urban respondents were more likely than rural ones to report that their employer would need more professionals to handle additional patient volume. Northeastern CRNAs and ANs and those with larger employers are more likely to report that their employer needs more professionals to handle more cases.[4]

We do find that there is a statistically significant (and large) relationship between a CRNA or AN reporting that his or her employer has open positions and stating, "employer needs more CRNAs (ANs) to meet current demand." This is useful validation of responses to different but related questions.

We asked in our surveys whether respondents had increased hours worked since 2004 (Table 4.4).

CRNAs in urban areas and ANs in the West are less likely than those elsewhere to have increased hours. This is interesting because our measures of shortage in the form of open positions and perception of need for labor find greater evidence of shortage in these areas. It may reveal the preferences of these groups to work fewer hours. Or, it might be that these CRNAs and ANs are otherwise constrained in the hours they are able to work. It is not that these urban CRNAs and Western ANs are working very long hours, because they are actually working the same or fewer hours than their counterparts in other regions (see Table 3.9 in Chapter Three).[5] But the differences could be due to regulations or because urban CRNAs are actually facing longer workdays than rural CRNAs if commute time is included.

In both the AN and CRNA surveys, we found significantly greater evidence of shortage in urban areas.[6] Urban employers have more open positions and are more likely to need more ANs and CRNAs to meet current demand, yet controlling for facility size diminishes or

Table 4.4
Percentage with Increase in Hours, 2004–2009

Location	CRNAs	ANs
Total	41.78	54.77
Northeast	40.18	56.40
Midwest	42.81	57.37
South	43.61	58.79
West	41.78	44.80
Rural	49.19	56.67
Urban	41.27	54.66

[4] Finally, there are significant differences for male CRNAs and ANs with more experience, which remain even when the employer characteristics are controlled for. Experienced workers could be more aware of the right level of capacity in the workforce as they become more knowledgeable about their employer and more involved in higher levels of administration. Or, it may be that seniority affords these workers a more desirable work schedule that leads these CRNAs and ANs to feel less overworked.

[5] We also looked at the possibility that ANs in the West spent more of their total hours on call (and had therefore reached a limit on call availability), but we did not find this to be the case.

[6] Another interesting result is the statistically significant gender effect that remains even when all controls are added. This indicates that male CRNAs see labor-market conditions differently given open positions in the employment arrangement. One possible explanation is that male CRNAs are more eager to increase hours.

eliminates the significance of some of these findings, indicating that facility size is the primary driver of these rural/urban differences. Using data from the ANDIR survey (and controlling for facility size), we find that postponements of procedures due to a lack of CRNAs were greater in urban areas, but there were few other urban/rural differences in shortage.

Another difference in findings between the ANDIR and CRNA surveys is the relationship between direct hiring and shortage. Analysis of the ANDIR survey found that facilities that directly hire were more likely to postpone procedures due to shortage. The AN survey had similar results, with ANs working for one facility more likely to report that their employer "needs more ANs/CRNAs to meet current demand." However, the CRNA survey finds that group employers, rather than facility (direct) employers, have the greatest likelihood of shortage. Facilities that do not directly employ can use multiple employer groups to staff their facility, so that, when one group may not have enough staff, another group can be used. This flexibility is a likely cause of the results found in the ANDIR survey. Yet, group employers of CRNAs may be more likely to have open positions (and "need more ANs/CRNAs") because the size of a group employer may be more flexible than a facility employer and more capable of expansion.

Finally, the surgeon survey provides further evidence that there is a shortage of ANs and CRNAs. Surgeons state whether the availability of ANs and CRNAs is adequate for elective procedures. More than three-quarters of surgeons responded that the availability of ANs and CRNAs is inadequate for monitored and general anesthesia (Table 4.5). Those surgeons reporting supply to be inadequate report that approximately 17 percent of elective monitored and regional/spinal anesthesia procedures and 33.4 percent of elective general-anesthesia procedures are rescheduled due to this shortage of anesthesia providers.

All our surveys therefore suggest potential shortages in the AN and CRNA labor markets. The number of open positions, preference for more ANs or CRNAs to meet current demand, and rescheduling or postponement of procedures all point in the direction of shortages. We turn to the next level of our labor-market analysis, in which we do a DBA by tallying up supply of and demand for the two groups of anesthesia providers.

Demand-Based Analysis

As discussed in Chapter Two, our analysis uses data from the same primary surveys for supply and demand calculations. We use national averages of clinical hours worked gathered from our surveys (49 hours per week for ANs and 37 for CRNAs) to sum up the supply of workers present in a particular state, in FTEs. We then calculate the demand using the actual volume of services provided and time taken per unit of service (e.g., procedures, patient), again based

Table 4.5
Surgeon Reports of Anesthesia-Provider Shortage (%)

Type of Anesthesia	% Reporting AN/CRNA Supply Inadequate	% Reporting Some Procedures Rescheduled	% Reporting Some Procedures Delayed
MAC	77.48	16.26	54.62
General	77.46	33.40	69.20
Regional/spinal	64.62	17.13	50.73

on national averages, which is then reexpressed in terms of FTEs. While, nationally, supply and demand would have to be equal (i.e., the "average" state will be in equilibrium), within a given state, they need not.[7]

To briefly summarize the DBA discussion from Chapter Two, if the number of working hours is considered invariant across the states (counterfactual supply), then differences in hours of work across states can be attributed to differences in demand. States where providers work more than the desired level are in excess demand and, where they work less, in excess supply (step 1). If instead the time to do a particular procedure is considered invariant across states (counterfactual demand), then states where procedures are done faster have a larger shortage (step 2). If we combine both considerations, we can show that the variation in the number of procedures can be exploited to distinguish demand from supply (step 3). The primary focus will be on this final step, as it combines observed variations in work hours and procedure times.

In Tables 4.6 and 4.7, we report estimated excess demand (negative if there is excess supply) using DBA.[8] Quantities are reported in terms of FTEs, using 49 hours per week for ANs and 37 hours per week for CRNAs. In Appendix G, we present the summary statistics on the clinical workweek and number of procedures per week used in the DBA calculations.[9]

In the first step, in which average hours worked are constant across states, we find that 27 out of the 49 states examined face excess demand of ANs and 24 out of 47 of CRNAs. In the second step, in which time per procedure is held constant across states, we find that 25 states for ANs and 17 states for CRNAs are in shortage. When we combine the two considerations (step 3), 25 states for ANs and 19 for CRNAs are in shortage. For ANs, the estimates range from a 36-percent surplus in the District of Columbia to a shortage of 82 percent in Alabama. In absolute numbers, Florida, Alabama, and North Carolina exhibit the most shortage, and California, New York, and Massachusetts the most surplus. For CRNAs, the estimates range from a 38-percent surplus in South Dakota to a shortage of nearly the same percentage in Iowa. In terms of absolute numbers, Pennsylvania, Michigan, and Florida exhibit the most shortage, and Minnesota, North Carolina, and California the most surplus.[10]

Figure 4.1 shows a map of the United States for step 3, in which different shades indicate whether we estimate ANs and CRNAs to be in surplus or shortage. We leave unshaded those states that we do not include in our analysis due to an inadequate number of observations.

As mentioned in Chapter Two, many workforce studies have adopted a fixed workweek—typically, 40 hours. Therefore, we also analyze the labor markets with a 40-hour FTE for both

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[7] Algebraically, equilibrium at the national level will be approximate due to computational considerations and because averages of ratios (say, while calculating per-procedure times) will not equal ratios of averages.

[8] As mentioned in Chapter Two, we retain states with more than five responses. For ANs, we have 49 states, and, for CRNAs, we have 47 states. We do not include Wyoming in the analysis of CRNAs, since all nine survey responses we have are from rural areas—the only state where this occurred.

[9] The first column of each summary statistics table (Tables 4.6 and 4.7) shows the number of survey responses that have state identifiers and can therefore be included in the DBA; they are lower than the total responses mentioned in Chapter Two. Not all states presented in Appendix G have enough responses to qualify for the DBA.

[10] For ANs, the correlation between clinical hours per week and the excess demand (from Appendix G and Table 4.6) is 0.27, and the correlation between the number of procedures performed per week and the excess demand is 0.55. The correlations are similar for CRNAs. These correlations indicate that the variation in procedures across states contributes substantially more to the excess-demand calculations than the variation in hours worked. This can also be seen in Tables 4.6 and 4.7, in which step 2 (variation in procedures) excess-demand numbers are much closer to the step 3 numbers than are step 1 (variation in hours) numbers.

Table 4.6
Demand-Based Analysis Results for Anesthesiologists with Full-Time Equivalence of 49 Hours per Week

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
Alabama	48.578	0.104	332.617	0.711	382.561	0.818
Arizona	19.139	0.024	–182.587	–0.229	–164.922	–0.207
Arkansas	–23.369	–0.099	5.533	0.023	–10.345	–0.044
California	–239.744	–0.053	–1,300.715	–0.288	–1,569.42	–0.347
Colorado	–17.117	–0.029	–74.591	–0.127	–82.26	–0.14
Connecticut	27.341	0.052	103.006	0.198	136.879	0.263
Delaware	5.492	0.074	1.167	0.016	6.454	0.087
D.C.	–17.105	–0.15	–28.899	–0.254	–41.07	–0.361
Florida	142.874	0.055	616.64	0.237	765.161	0.294
Georgia	1.751	0.002	111.927	0.129	129.193	0.149
Hawaii	–0.685	–0.007	–29.76	–0.287	–28.23	–0.272
Idaho	–11.827	–0.206	8.754	0.152	–3.072	–0.053
Illinois	51.599	0.029	–54.47	–0.03	19.059	0.011
Indiana	–43.36	–0.053	–164.931	–0.203	–200.209	–0.246
Iowa	–20.769	–0.072	–64.465	–0.225	–84.42	–0.294
Kansas	–30.403	–0.112	93.107	0.344	61.037	0.225
Kentucky	10.836	0.022	–28.372	–0.057	–14.884	–0.03
Louisiana	–29.238	–0.064	210.593	0.462	177.054	0.389
Maine	–4.89	–0.044	15.608	0.14	8.042	0.072
Maryland	–67.421	–0.074	–136.761	–0.149	–183.299	–0.2
Massachusetts	–160.45	–0.133	–91.869	–0.076	–258.632	–0.214
Michigan	11.589	0.014	228.152	0.273	230.964	0.276
Minnesota	21.21	0.041	200.412	0.385	210.585	0.404
Mississippi	15.044	0.106	–37.787	–0.266	–22.665	–0.16
Missouri	25.307	0.04	4.574	0.007	6.262	0.01
Montana	8.564	0.1	–30.136	–0.35	–22.683	–0.264
Nebraska	8.766	0.039	–6.048	–0.027	0.233	0.001
Nevada	55.578	0.142	–154.979	–0.395	–98.94	–0.252
New Hampshire	7.738	0.086	23.322	0.258	32.765	0.363
New Jersey	–27.173	–0.019	77.435	0.055	14.918	0.011
New Mexico	2.86	0.015	–59.935	–0.318	–51.837	–0.275

Table 4.6—Continued

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
New York	–124.825	–0.04	–586.776	–0.186	–673.43	–0.214
North Carolina	9.476	0.012	266.578	0.332	298.551	0.372
North Dakota	–1.504	–0.035	10.289	0.238	8.786	0.203
Ohio	21.954	0.015	230.457	0.155	262.339	0.177
Oklahoma	–3.299	–0.012	–38.853	–0.138	–44.113	–0.157
Oregon	13.058	0.029	–46.847	–0.105	–55.854	–0.125
Pennsylvania	–58.531	–0.039	250.605	0.167	193.653	0.129
Rhode Island	–3.006	–0.026	17.841	0.156	17.886	0.157
South Carolina	15.625	0.035	140.776	0.317	161.858	0.364
South Dakota	9.463	0.179	22.819	0.432	32.282	0.612
Tennessee	–28.435	–0.04	233.723	0.33	221.497	0.312
Texas	14.655	0.005	–270.726	–0.092	–250.223	–0.085
Utah	0.212	0.001	–32.297	–0.095	–34.639	–0.101
Vermont	–5.787	–0.114	–8.062	–0.158	–13.157	–0.259
Virginia	15.935	0.017	105.138	0.114	114.149	0.124
Washington	–47.873	–0.057	–116.197	–0.138	–170.676	–0.202
West Virginia	6.297	0.04	6.988	0.044	15.046	0.095
Wisconsin	11.55	0.015	–41.398	–0.055	–39.45	–0.052

NOTE: Step 1 holds desired clinical working hours constant across states, 2 assumes constant procedure times across states, and 3 combines the two.

Table 4.7
Demand-Based Analysis Results for Certified Registered Nurse Anesthetists with Full-Time Equivalence of 37 Hours per Week

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
Alabama	1.176	0.001	–69.042	–0.067	–45.015	–0.044
Arizona	10.145	0.054	–24.531	–0.131	–6.439	–0.034
Arkansas	39.83	0.136	–10.463	–0.036	31.23	0.106
California	–36.601	–0.038	–126.908	–0.13	–154.917	–0.159
Colorado	–6.364	–0.036	–10.998	–0.062	–32.751	–0.185
Connecticut	–59.395	–0.208	–0.565	–0.002	–55.147	–0.193
Delaware	2.983	0.018	3.433	0.021	6.896	0.042
D.C.	21.082	0.277	–26.382	–0.346	–18.627	–0.244

Table 4.7—Continued

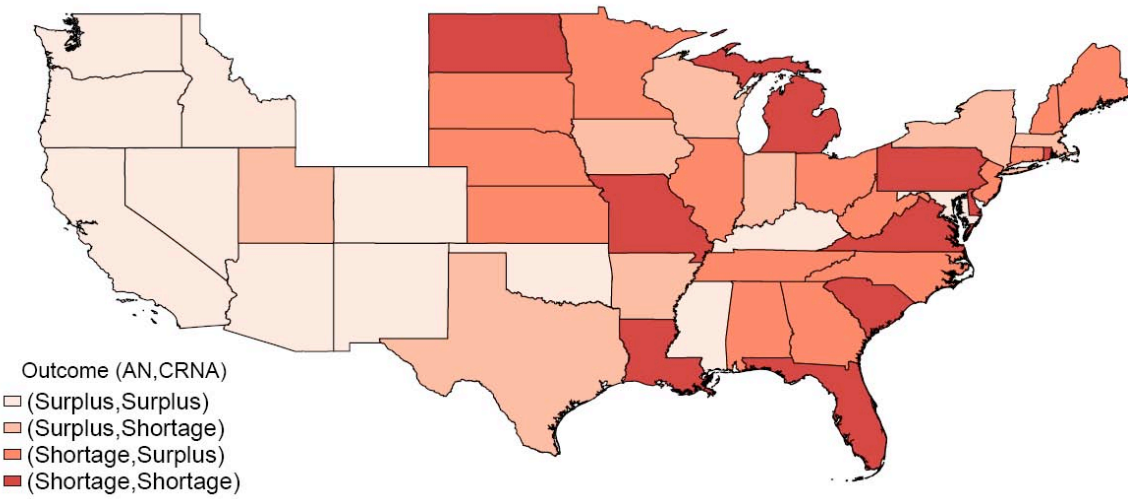
	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
Florida	24.06	0.011	216.316	0.096	248.868	0.111
Georgia	–28.163	–0.038	–28.315	–0.039	–47.1	–0.064
Hawaii	0.996	0.01	–1.341	–0.014	1.14	0.012
Idaho	–4.401	–0.026	–4.571	–0.027	–8.357	–0.049
Illinois	–48.394	–0.058	–98.074	–0.118	–149.828	–0.181
Indiana	–1.252	–0.006	21.426	0.111	16.058	0.083
Iowa	9.59	0.059	52.114	0.321	62.075	0.382
Kansas	–18.527	–0.052	3.948	0.011	–14.552	–0.041
Kentucky	33.025	0.067	–55.257	–0.112	–22.768	–0.046
Louisiana	27.617	0.036	–24.611	–0.032	5.665	0.007
Maine	–17.77	–0.104	–19.356	–0.113	–34.088	–0.199
Maryland	1.925	0.005	–41.91	–0.108	–43.903	–0.113
Massachusetts	–1.029	–0.002	13.085	0.022	10.83	0.019
Michigan	–3.418	–0.002	237.214	0.157	179.656	0.119
Minnesota	–148.079	–0.151	–80.166	–0.082	–241.023	–0.246
Mississippi	–21.722	–0.08	11.227	0.041	–2.133	–0.008
Missouri	53.982	0.061	5.371	0.006	45.298	0.051
Montana						
Nebraska	3.814	0.026	–21.584	–0.145	–22.417	–0.151
Nevada	4.816	0.079	–25.311	–0.417	–20.495	–0.338
New Hampshire	4.995	0.081	–14.319	–0.231	–8.585	–0.138
New Jersey	–28.471	–0.061	25.716	0.055	–5.046	–0.011
New Mexico	–15.225	–0.187	–4.418	–0.054	–17.473	–0.214
New York	–17.075	–0.022	79.139	0.103	61.1	0.079
North Carolina	–99.801	–0.066	–54.007	–0.036	–166.023	–0.11
North Dakota	–8.683	–0.052	34.837	0.211	28.521	0.172
Ohio	–43.511	–0.031	12.225	0.009	–4.732	–0.003
Oklahoma	27.401	0.113	–45.885	–0.19	–12.579	–0.052
Oregon	31.634	0.17	–27.425	–0.147	–6.463	–0.035
Pennsylvania	–5.583	–0.002	124.186	0.053	114.84	0.049
Rhode Island	2.151	0.02	4.055	0.037	1.878	0.017
South Carolina	–4.489	–0.007	52.154	0.079	46.886	0.071

Table 4.7—Continued

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
South Dakota	–28.204	–0.172	–29.629	–0.181	–62.259	–0.379
Tennessee	28.284	0.025	–13.17	–0.011	–3.089	–0.003
Texas	60.92	0.029	–24.099	–0.012	9.058	0.004
Utah	12.883	0.1	–5.956	–0.046	7.881	0.061
Vermont						
Virginia	26.453	0.029	63.486	0.07	96.049	0.106
Washington	–6.913	–0.02	–44.15	–0.13	–51.773	–0.153
West Virginia	22.528	0.073	–37.198	–0.12	–46.087	–0.149
Wisconsin	15.688	0.036	–5.549	–0.013	16.747	0.039

NOTE: Step 1 holds desired clinical working hours constant across states, 2 assumes constant procedure times across states, and 3 combines the two.

Figure 4.1
Classification of States by Shortage/Surplus, Demand-Based Analysis



NOTE: States that are not shaded are those that we do not include in our analysis due to an inadequate number of observations.

groups.[11] The analogues of Tables 4.6 and 4.7 for this case are presented and discussed in Appendix H.

We next present results from the economic analysis, which, unlike DBA, does take into account wages and other institutional factors that vary by state.

[11] Previous studies have typically examined either the physician or the nurse market. The assumption of 40-hour FTE for both markets, where the average numbers of hours worked per week are clearly different, is less innocuous.

Economic Analysis

Two market models were estimated: one assuming equilibrium and another not. In the equilibrium model, wages are assumed to adjust, while, in the second, institutional rigidities prevent wages from adjusting fully. We present results for both models in this section.

Since the economic analysis uses wages and other state-level information to estimate supply and demand relationships, it is not bound by the restrictions discussed for DBA, in which using the same data on the quantity of labor for demand and supply meant that the national labor market was in equilibrium (and we identified shortage/surplus at the state level). In the disequilibrium model presented in this section, we can provide estimates of shortage/surplus not only at the state level but also at the national level.

Equilibrium Model

In Chapter Two, we discussed the estimation strategy for the equilibrium model in detail. Appendix F describes the technical details of the equilibrium model. In essence, we used the state as the unit of analysis and estimated the demand for a given labor group (ANs or CRNAs) as dependent on wages of both groups, output (procedures), and a set of controls. Supply was estimated as dependent on wages of own group and a set of controls. The controls used were the percentage of respondents in a state who reported that their primary employer is too slow at adopting technology (as a measure of technology or lack thereof), information on the total population and population 65 and older, population density, median income, HMO penetration rate for 2004, number of beds available in the state, AN residency positions available for 2004, and the number of CRNA accredited nurse-anesthetist education programs in the state.

Distinguishing supply from demand requires that we exclude at least one (different) control each in the supply and demand estimations. We did this by excluding residency openings from the AN labor demand equation and the HMO penetration rate from the AN labor supply equation. We also excluded the wages of CRNA and output from the AN supply equation. For CRNAs, we enforced similar exclusions, although we used the number of accredited nurse-anesthetist education programs in the state as the exclusion restriction in the supply equation.

Estimates from the equilibrium model reveal extremely large demand elasticity: –2.015 for ANs and –1.772 for CRNAs. (The demand elasticity signifies the percentage change—a decrease—in demand for a 1-percent increase in the wage rate.) However, they are not statistically significant. The estimates of cross-elasticity (the percentage by which AN demand increases when CRNA wage increases by 1 percent and vice versa) are also not significant. The magnitude and the imprecision of these estimates might be a signal that equilibrium models might not be appropriate for the situation at hand. Lane and Gohmann (1995) report similar results. Therefore, we discuss the disequilibrium model, which is much more likely to be relevant to these markets, in greater detail in the next section.

Disequilibrium Model

The estimation of the disequilibrium model was also discussed in detail in Chapter Two; technical details are given in Appendix F. In this model, wages do not adjust so as to equate demand and supply; they are assumed fixed. Instead of estimating labor supply and demand elasticity simultaneously as in the equilibrium model, we use data from our surveys to fix supply elasticity. The questions we asked allowed us to calculate that a 1-percent increase in wage would increase AN labor supply by 0.34 percent and CRNA labor supply by 0.41 per-

cent. We fix these and estimate the rest of the disequilibrium model via the method of maximum likelihood.

This model implies that a 1-percent increase in AN wages would decrease their demand by 0.187 percent and a 1-percent increase in CRNA wages would decrease their demand by 0.527 percent. These estimates are statistically significant at the 5-percent level. Therefore, assuming disequilibrium in the labor markets dramatically reduces the estimates for demand elasticity and increases its statistical significance. Output (measured in procedures) is strongly positively related to CRNA demand but not to AN demand. This may be related to the fact that average time per procedure is lower for CRNAs than for ANs (see Tables 3.13 and 3.14 in Chapter Three).

Using the estimates from the disequilibrium model, we compute estimates of the probability of shortage, the expected demand and supply of each state, and the percentage change in the current wages of both labor inputs required to "restore" equilibrium.[12] These are reported in Table 4.8 for ANs and Table 4.9 for CRNAs.[13] Following Gourieroux (2000), we classify states as experiencing shortage if the likelihood of shortage is greater than 50 percent. We

Table 4.8
Market Disequilibrium Estimates for Anesthesiologists

State	Probability of Excess Demand	Excess Demand	% Excess Demand	Required Wage Change (%)
Alabama	0.397	–19	–0.027	–0.043
Arizona	0.454	–4	–0.004	0.462
Arkansas	0.643	7	0.017	0.179
California	1.000	1,025	0.150	0.191
Colorado	0.649	22	0.024	0.116
Connecticut	0.029	–93	–0.128	–0.300
Delaware	0.000	–32	–0.261	–0.395
Florida	0.999	273	0.083	0.041
Georgia	0.919	246	0.185	0.267
Hawaii	0.000	–27	–0.133	0.070
Idaho	1.000	64	0.465	0.765
Illinois	0.380	–38	–0.014	–0.059
Indiana	0.990	88	0.077	0.224
Iowa	0.925	31	0.075	0.357

[12] As evident in Table 4.8, there is no simple connection between the change in wage required to restore equilibrium and whether a state is experiencing shortage or surplus. That is, it is not always the case that a shortage state will require higher wages to restore equilibrium. This is because we jointly estimate demand for the two groups (given the dependence of demand for one group on the wages of the other) and variables other than wages also affect the demand of both groups.

[13] In the disequilibrium economic analysis, the predicted supply in the United States will not sum up to the actual observed FTEs. This arises in part because some states are predicted to be in excess supply. Hence, the observed supply is demand constrained.

Table 4.8—Continued

State	Probability of Excess Demand	Excess Demand	% Excess Demand	Required Wage Change (%)
Kansas	0.977	91	0.210	0.320
Kentucky	0.132	–15	–0.020	–0.022
Louisiana	0.925	60	0.091	0.118
Maine	0.162	–9	–0.036	0.103
Maryland	0.545	7	0.005	–0.104
Massachusetts	0.998	215	0.109	0.158
Michigan	1.000	450	0.322	0.567
Minnesota	1.000	94	0.122	0.192
Mississippi	0.889	17	0.048	0.062
Missouri	0.149	–97	–0.109	–0.257
Montana	0.291	–4	–0.029	0.094
Nebraska	0.448	–1	–0.005	0.195
Nevada	0.330	–6	–0.012	0.282
New Hampshire	0.484	0	0.000	0.084
New Jersey	0.521	5	0.002	–0.092
New Mexico	0.003	–21	–0.068	–0.146
New York	1.000	444	0.095	0.007
North Carolina	0.997	109	0.082	0.043
North Dakota	0.453	0	–0.001	–0.015
Ohio	0.865	166	0.079	0.045
Oklahoma	0.371	–14	–0.029	–0.003
Oregon	0.474	0	–0.001	0.094
Pennsylvania	1.000	287	0.128	0.181
Rhode Island	0.000	–16	–0.111	–0.306
South Carolina	0.438	–6	–0.010	0.004
South Dakota	0.089	–9	–0.081	–0.115
Tennessee	0.733	29	0.026	0.006
Texas	1.000	364	0.090	0.106
Utah	0.828	22	0.049	0.664
Vermont	0.062	–9	–0.070	0.459
Virginia	0.719	78	0.056	0.078
Washington	0.610	12	0.009	0.127
West Virginia	0.010	–37	–0.159	–0.308

Table 4.8—Continued

State	Probability of Excess Demand	Excess Demand	% Excess Demand	Required Wage Change (%)
Wisconsin	0.986	51	0.049	0.183
Total		3,800	0.072	

NOTE: Based on disequilibrium model estimates.

Table 4.9
Market Disequilibrium Estimates for Certified Registered Nurse Anesthetists

State	Probability of Excess Demand	Excess Demand	% Excess Demand	Required Wage Change (%)
Alabama	0.822	14	0.010	0.001
Arizona	0.000	–262	–0.722	–0.838
Arkansas	0.022	–250	–0.423	–0.400
California	0.999	179	0.134	0.198
Colorado	0.000	–66	–0.168	–0.149
Connecticut	0.999	50	0.109	0.054
Delaware	0.247	–26	–0.120	–0.254
Florida	1.000	594	0.210	0.226
Georgia	0.986	98	0.089	0.141
Hawaii	0.000	–71	–0.492	–0.626
Idaho	0.666	–1	–0.004	0.172
Illinois	1.000	109	0.086	0.076
Indiana	0.000	–152	–0.404	–0.336
Iowa	0.000	–249	–0.498	–0.389
Kansas	0.729	5	0.007	0.079
Kentucky	0.641	–26	–0.027	–0.034
Louisiana	0.868	48	0.044	0.065
Maine	0.000	–101	–0.309	–0.327
Maryland	1.000	86	0.181	0.192
Massachusetts	0.994	41	0.063	0.139
Michigan	1.000	137	0.061	0.205
Minnesota	0.856	79	0.042	0.088
Mississippi	0.531	–16	–0.025	–0.011
Missouri	1.000	149	0.115	0.059
Montana	0.000	–62	–0.379	–0.376
Nebraska	0.000	–165	–0.375	–0.348

Table 4.9—Continued

State	Probability of Excess Demand	Excess Demand	% Excess Demand	Required Wage Change (%)
Nevada	0.000	–65	–0.533	–0.503
New Hampshire	0.000	–34	–0.172	–0.167
New Jersey	0.998	135	0.227	0.244
New Mexico	0.919	7	0.035	0.006
New York	1.000	324	0.279	0.343
North Carolina	1.000	475	0.185	0.229
North Dakota	0.805	7	0.027	0.020
Ohio	1.000	339	0.181	0.208
Oklahoma	0.465	–53	–0.103	–0.102
Oregon	0.274	–74	–0.183	–0.157
Pennsylvania	1.000	322	0.100	0.145
Rhode Island	1.000	33	0.213	0.214
South Carolina	0.562	–51	–0.047	–0.045
South Dakota	0.308	–41	–0.098	–0.126
Tennessee	1.000	142	0.083	0.087
Texas	1.000	238	0.080	0.109
Utah	0.013	–216	–0.713	–0.540
Vermont	0.000	–47	–0.752	–0.693
Virginia	0.847	31	0.026	0.048
Washington	0.253	–122	–0.198	–0.206
Wisconsin	0.680	–12	–0.019	–0.089
West Virginia	0.000	–203	–0.233	–0.191
Total		1,282	0.030	

NOTE: Based on disequilibrium model estimates.

estimate that 54.1 percent of the states have an excess demand for ANs. For states with excess demand, the average size of the AN shortage is 10 percent. Delaware is seen to have a surplus of ANs of more than 26 percent, while Idaho has a shortage of more than 46 percent. The remaining 46 percent of the states are estimated to have an excess supply. The extent of excess supply is, however, lower—on average, 5.9 percent lower than excess demand. Overall, we estimate a shortage of 3,800 Anesthesiologists in the United States.[14]

For CRNAs, more than 60 percent of states are predicted to be in excess demand. Such states have an average gap of 8.5 percent between demand and supply. Nevada has a surplus of CRNAs exceeding 53 percent, while New York has a shortage of nearly 28 percent. Given our

[14] Schubert, Eckhout, Cooperider, and Kuhel (2001) estimate a deficit of 1,000–4,500 ANs by 2005.

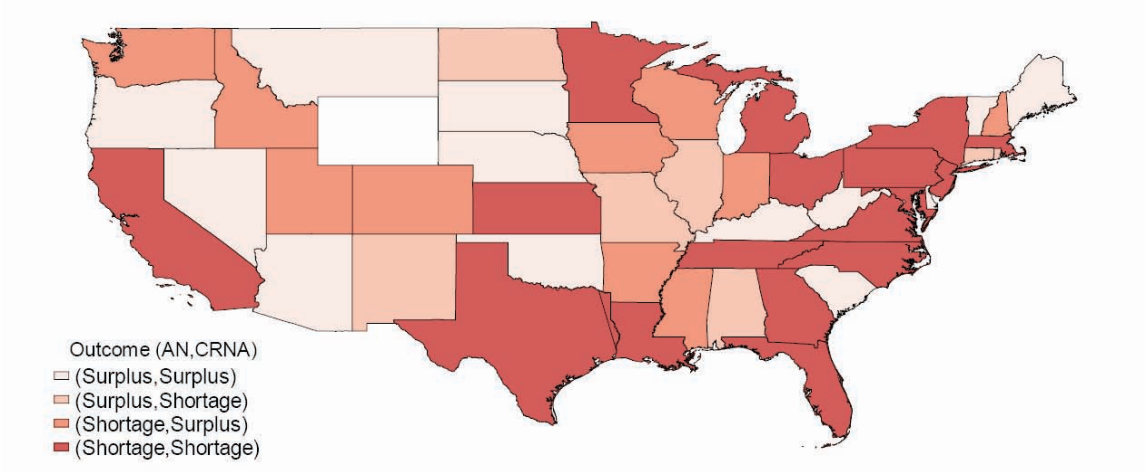
elasticity estimates, our models imply that wages would need to rise by 10.9 percent, on average, to close the gap. This is less than for ANs, reflecting the greater elasticity of both CRNA demand and supply. This implies that, for the same level of excess demand, wages are further away from their equilibrium levels for ANs. Overall, we estimate a shortage of CRNAs at the national level of 1,282.[15]

Figure 4.2 shows a map of the United States for the economic analysis (the analogue of Figure 4.1), in which different shades indicate whether we estimate ANs and CRNAs to be in surplus or shortage. States we do not include in our analysis (Alaska and Wyoming) due to an inadequate number of observations are not shaded.

Regional Analysis

We had presented the survey results by region to capture important regional differences. The region, as opposed to the state, was also a more tractable unit of analysis for this purpose. We then presented the DBA and economic analysis by state to capture the labor-market situation at a finer level of detail and because variations that exist at the state level made it a natural unit of analysis. For completeness and comparability with the survey analysis, we briefly discuss the results from the DBA and economic analysis at the regional level. Table 4.10 presents shortage/surplus by region, which can be compared to the survey results presented in Tables 4.1 and 4.2, which were indicative of a potential shortage. A positive figure indicates excess demand (shortage) in percentage FTE units, while a negative figure excess supply (surplus).

Figure 4.2
Classification of States by Shortage/Surplus, Economic Analysis



NOTE: States that are not shaded are those that we do not include in our analysis due to an inadequate number of observations.

[15] The shortage estimates of 3,800 for ANs and 1,282 for CRNAs are calculated using FTE definitions of 49 hours per week and 37 hours per week, respectively, as gathered from our surveys. If a 40-hour-per-week FTE definition is used, the shortage estimates are 4,655 for ANs and 1,186 for CRNAs.

Table 4.10
Demand-Based Analysis and Economic Analysis Results, by Region (%)

	CRNAs		ANs	
Location	DBA	Economic Analysis	DBA	Economic Analysis
Northeast	1.80	10.02	–6.68	6.45
Midwest	–1.98	1.74	6.63	8.26
South	0.28	5.31	14.02	5.19
West	–12.06	–18.48	–27.27	8.33

The regional DBA and economic analysis results for CRNAs are consistent with those we found from the survey. Evidence of a shortage is strongest for the Northeast in all three of our methods. On the opposite end, there is very little evidence of a shortage in the West, and the DBA and economic analysis both show evidence that there is, in fact, a large surplus of CRNAs in that area. Facilities in the West are less likely to use any CRNAs (Table 3.3 in Chapter Three); it is therefore possible that this lower demand leads to a surplus. Both analyses point to a small shortage in the South, more so than in the Midwest (where only the economic analysis points to a small shortage). These are in line with the findings from our surveys, which also find the facilities and employers in the South to be slightly more likely to be facing a shortage than the Midwest, but with both falling somewhere in between the Northeast and the West.

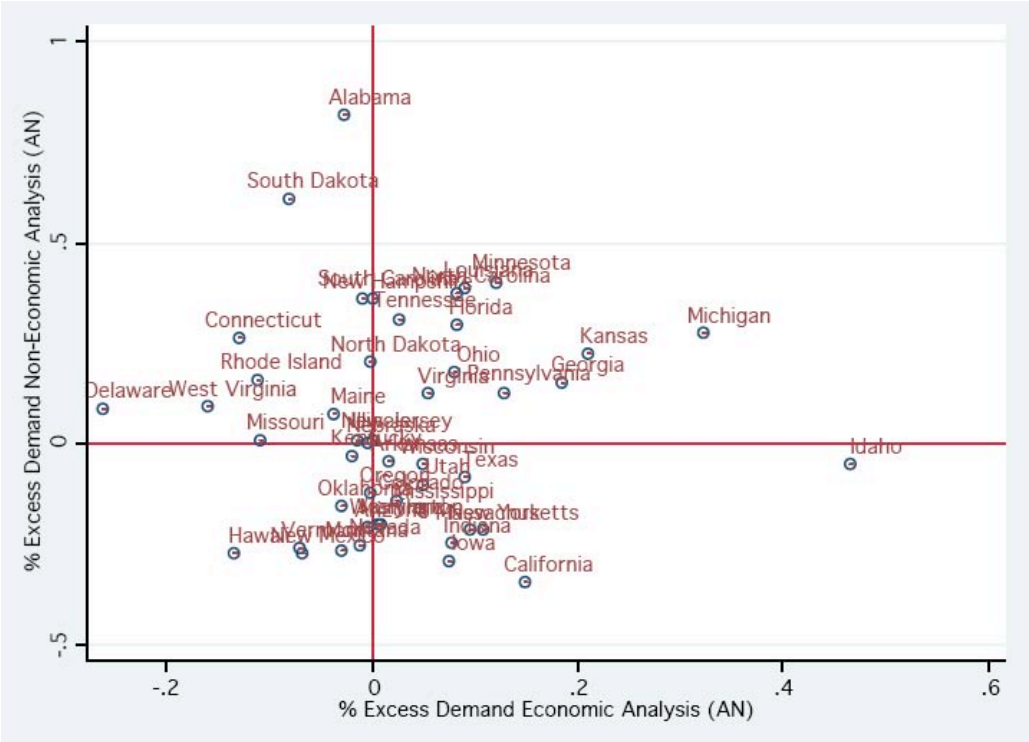
The regional DBA and economic analysis results for ANs are less consistent with each other and with the surveys. The DBA results indicate a large surplus in the West and a smaller surplus in the Northeast, with a shortage in the Midwest and an even larger shortage in the South. The economic analysis, on the other hand, shows moderate shortages in all regions, with the Midwest and West having somewhat larger shortages than the Northeast and South. The DBA results partially correspond to those of the surveys, which found that facilities in the Northeast and South were most likely to have open positions for ANs, while facilities in the West were the least likely (Table 4.1). In summary, the DBA findings indicate large regional differences in AN shortage, while the economic and survey analyses point to little regional variation, with moderate shortage across all regions.

Comparing the Demand-Based Analysis and Econometric Methods

Given that the DBA (noneconomic) method ignores an important component of the labor markets—namely, wages—as well as other factors that could potentially influence demand and supply, it is not surprising that they paint different pictures of shortage and surplus. We now delve a bit deeper into these differences and explore the potential causes for such differences.

We first plot, in Figures 4.3 and 4.4, the percentage of excess demand arising from the disequilibrium and DBA analysis. If there is perfect agreement between both methods for a state, the point should lie on the 45-degree line through the origin. However, one can see that the overall fit between the two measures is poor. Only in 44 percent of the cases do both approaches agree for ANs, and in 52 percent of the states for CRNAs.

Figure 4.3
Comparison of Excess Demand: Economic and Noneconomic Analysis for Anesthesiologists



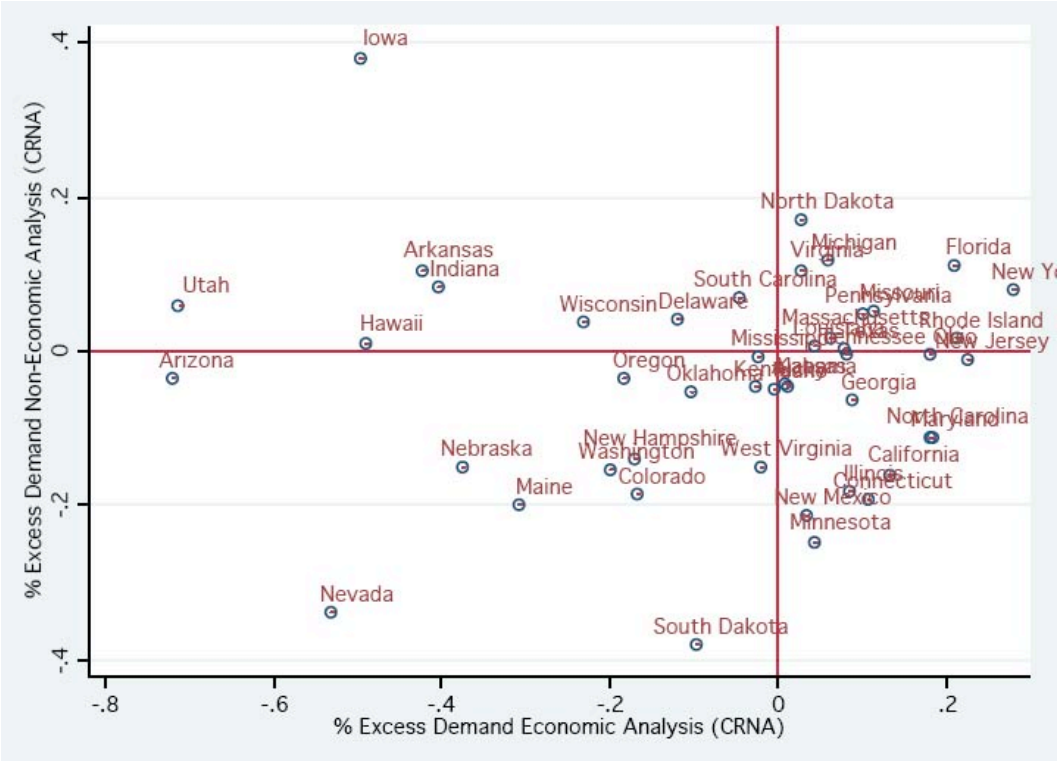
To investigate the reasons for the dissonance between the two methods, we follow Lane and Gohmann (1995) and examine the characteristics of the states based on their classification using both approaches. In Table 4.11, we present average wages, the percentage of each type of providers reporting shortage, the density of the population, median household income, and population size.

Both approaches tend to classify those states in which wages are higher as facing a shortage of ANs. The average hourly wage is $122 in those states where both methods identify a shortage, as opposed to an average hourly wage of $109 in those states where both methods reveal a surplus. In a similar vein, the average wage rate is higher ($117 per hour) when the economic approach identifies a shortage and DBA a surplus than when DBA identifies a shortage and the economic approach a surplus (when it is $106 per hour). This appears to corroborate a point we have repeatedly made, that the noneconomic approach works on the basis of partial information by ignoring wages and focusing on quantities alone.[16]

We found that, in states where median income is higher, the economic approach tends to report an excess demand for ANs. Finally, in states where a higher fraction of ANs report needing more ANs to meet current demand, both approaches are more likely to classify the

[16] This result is not inconsistent with Figure 2.2 in Chapter Two, in which a high wage is associated with high supply. That figure was drawn for a given state. Across states both the demand and supply curves could shift outward—for example, due to a higher median income of the patient population and better weather—and a higher wage could still be associated with shortage. The point we want to make here is that wages and other variables systematically differ in those states identified as being in shortage by the two types of analysis.

Figure 4.4
Comparison of Excess Demand: Economic and Noneconomic Analysis for Certified Registered Nurse Anesthetists



state as being in excess demand (44 percent of respondents reporting greater need of ANs when both methods indicate surplus and 46–51 percent reporting greater need when at least one of the methods finds excess demand). This finding points to the consistency between the survey-based approach and the economic analysis in identifying shortages.

For CRNAs, we find a similar pattern. The wage differences are smaller, but states with higher CRNA wages are nevertheless more likely to be classified by at least one approach as being in excess demand. The percentage of CRNAs reporting greater need for CRNAs is highly correlated with our classification of states. In states where both methods find excess demand, 84 percent of CRNAs report shortage, compared to 68 percent in states where both methods find excess supply.

In summary, we find that the economic and noneconomic approaches yield quite different predictions of shortage and surplus across the states, and for reasons we had expected a priori. The economic approach uses all available information, especially wages. The outcomes of the survey-based method are well correlated with those of the economic approach. Given its more complete use of information, we lean toward the outcomes of the economic approach (which are well corroborated by the survey-based approach).

Table 4.11
Characteristics of States, Based on Noneconomic and Economic Classification of Shortage

Variable	NE = 0, E = 0	NE = 1, E = 0	NE = 0, E = 1	NE = 1, E = 1	Total
ANs					
Wage (AN)	108.60	106.17	116.74	121.96	113.82
Wage (CRNA)	71.57	69.93	76.69	74.59	73.40
% AN say shortage	0.44	0.51	0.46	0.47	0.47
Density population	0.15	0.29	0.32	0.62	0.36
Household income	39,435	41,022	43,647	43,132	42,041
Population (millions)	2.816	3.142	9.142	8.172	6.131
No. of states	9	13	14	13	49
CRNAs					
Wage (AN)	110.58	112.91	119.23	112.51	113.82
Wage (CRNA)	73.14	72.50	75.49	72.19	73.40
% CRNA say shortage	0.68	0.71	0.78	0.84	0.75
Density population	0.13	0.17	0.45	0.70	0.36
Household income	39,567	41,538	45,079	42,053	42,041
Population	3.091	2.855	9.078	9.215	6.131
No. of states	14	10	13	12	49

NOTE: NE = noneconomic (0 = surplus, 1 = shortage). E = economic. Statistics reported are means.

CHAPTER FIVE

Scenarios for Certified Registered Nurse Anesthetist and Anesthesiologist Labor Markets, 2007–2020

In this chapter, we use data from our surveys and other available sources to study a few scenarios of how the CRNA and AN labor markets might evolve between 2007 and 2020.

A few caveats are in order:

- Even with very sophisticated models, projecting or forecasting is a treacherous exercise, since completely unforeseen circumstances can alter the situation drastically. This is particularly so with the "linear" projection approach that we and other workforce studies have taken. These projections give estimates of how workforce requirements will change in the future under a given set of assumptions about such things as entry and exit rates and the rate of growth in demand. Therefore, scenario planning, rather than forecasting, is the appropriate interpretation of the analysis in this chapter.
- The reliability of projections for the immediate future is likely to be higher than those for the distant future. Growth rates get "compounded" over longer horizons, and small changes in the time trend can have large effects on results for the distant future.
- The models do not account for factors that may change in the future, such as the ramifications of health-care reform for anesthesiology, changes in certifications or residency positions, potential change in U.S. demand for surgeries due to international tourism, technological change (which could increase labor demand if the technologies complement the skills of ANs and CRNAs or decrease it if they substitute for skills), drug discoveries, change in the mix of the types of anesthesia professionals for cost, technological or regulatory reasons, and increased participation of anesthesia professionals in administration or management (or in general a change in the percentage of time they spend in clinical care).
- In particular, the ongoing economic and financial crisis that followed the surveys we conducted might have long-term implications for both supply (for example, professionals who have seen their retirement savings dissipate might decide to work longer) and demand (for example, closures of some facilities for cost reasons), which the present analysis does not take into account.
- We conduct the projection exercise starting with a situation of equilibrium in both markets. Recall from Chapter Four that DBA yields equilibrium at the national level.[1] Therefore, any drawbacks of this methodology will carry over to the projections.

[1] Doing projections with the economic approach would require data over time, which we do not have. Given that the economic approach indicates shortages in both labor markets, any shortage seen when we start from a position of equilibrium should be interpreted as a lower bound.

Consistent with the scenario-planning interpretation, we conduct extensive analysis on the sensitivity of the projections to assumptions in key supply and demand parameters. Studying the range of possible outcomes under different parameter assumptions is particularly important given the above caveats.

Data, Parameters, and Initial Values

Table 5.1 documents the data sources for each parameter, the initial values of these parameters, and the ranges used in our sensitivity analysis. The key parameters used to project demand and supply labor markets are described in this section.

Demand

Recall that the DBA yields equilibrium at the national level; equilibrium in both markets is therefore our initial condition.[2] The initial values for number of procedures and time per procedure are taken from our surveys.[3]

The average times per procedure for CRNAs and ANs remain fixed in our projections, as do the proportion of all procedures covered by CRNAs or ANs. In other words, we assume that the demand for CRNAs and ANs changes at the same rate over time.

Our survey gives us a snapshot of demand in 2007, but we must use other data sources to project growth in demand. We use the ARF data from 1985 to 2004 to calculate the growth rate of total surgeries completed annually. We use this 1.61-percent annual growth rate found in the ARF data as our baseline value for the growth rate in demand.

There are reasons to believe that growth in surgical procedures will be higher in the future than it was between 1985 and 2004. The U.S. Census Bureau projects that the number of people aged 65 and over will grow at an average annual rate of 2.7 percent between 2005 and 2020. Increases in morbidity and increased access to health care are other potential explanations for higher growth rates in demand for anesthesia providers. We therefore project an alternative growth rate of 3 percent to determine whether this changes the potential for shortage in the CRNA and AN labor markets. We also consider 4- and 5-percent demand growth for CRNAs to see under what conditions shortage could result for them.

Some ANs feel that the demand for their group has seen an increase due to a rapid rise in ambulatory surgical centers. If the current economic slowdown persists for a few years, some of these facilities are likely to be shut down. Moreover, potential health-care reform could make some surgical procedures elective. These factors could decrease the demand for anesthesia services below what would be predicted based on current demand, so we also study a demand growth rate lower than 1.61 percent, of 0.75 percent for ANs.

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[2] As mentioned earlier, the national equilibrium will be approximate due to computational considerations and because averages of ratios will not equal ratios of averages.

[3] CRNAs report that they participate in 947,710 procedures weekly and spend an average of 1.22 hours on each procedure. ANs report 1,534,773 procedures and an average of 1.08 hours per procedure. The longer per-procedure time for CRNAs is not inconsistent with the discussion surrounding Table 3.13 in Chapter Three. There, we examine the *percentage* allocation of the clinical times of the two groups across the various types of procedure. The number of procedures and time per procedure given here take into account the actual clinical hours per week, which are different between the two groups. Also note that these figures are relevant for starting the scenarios out in equilibrium, but the evolution of the labor markets depend on the parameters listed in Table 5.1.

Table 5.1
Summary of Data and Parameters

Labor Market	Group	Data	Period	Baseline Values	Range of Values (%)
Demand 2007				Growth of procedures (*rd*) (%)	
	CRNAs	ARF file	1985–2004	1.61	[1.61, 5]
	ANs	ARF file	1985–2004	1.61	[0.75, 3]
				Number of procedures	
	CRNAs	CRNA survey	2007	947,710	
	ANs	AN survey	2007	1,534,773	
				Time per procedure (hours)	
	CRNAs	CRNA survey	2007	1.224756	
	ANs	AN survey	2007	1.079154	
Supply 2007				Exit rate (*rx*) (%)	
	CRNAs	AANA	1994–2007	1.40	[0.5, 3]
	ANs	ASA	1999–2007	1.15	[0.5, 3]
				Entry rate (*re*) (%)	
	CRNAs	AANA	1994–2007	4.4	[1, 5.5]
	ANs	ASA	1999–2007	1.82	[1, 5.5]

Supply

We start with the supply used in our DBA. We assume that the changes in the supply of CRNAs and ANs are driven by entries into and exits from the labor market according to the following equations:

$$S_{t+1} = S_t + E_t - X_t$$
$$\frac{S_{t+1}}{S_t} = 1 + re_t - rx_t.$$

Here, S is the "stock" of labor (i.e., the current number of professionals), and t and $t + 1$ refer to the current and next years, respectively. Entry into the labor force (e.g., through certification, completion of residency) is denoted by E, and exit from the labor force (e.g., through retirement, death) is denoted by X.[4] The rate of entry, *re*, captures new entrants as a fraction of the labor force (E/S), and the rate of exit, *rx*, captures exits as a fraction of the labor force (X/S). Since

$$\frac{S_{t+1}}{S_t}$$

[4] AN residencies typically last three to four years; therefore, we do not consider each resident as an entrant into the AN labor market until four years after entering residency.

is the gross growth rate of labor (which equals 1 + g if g denotes the growth rate of labor), we can write

$$g = re - rx.$$

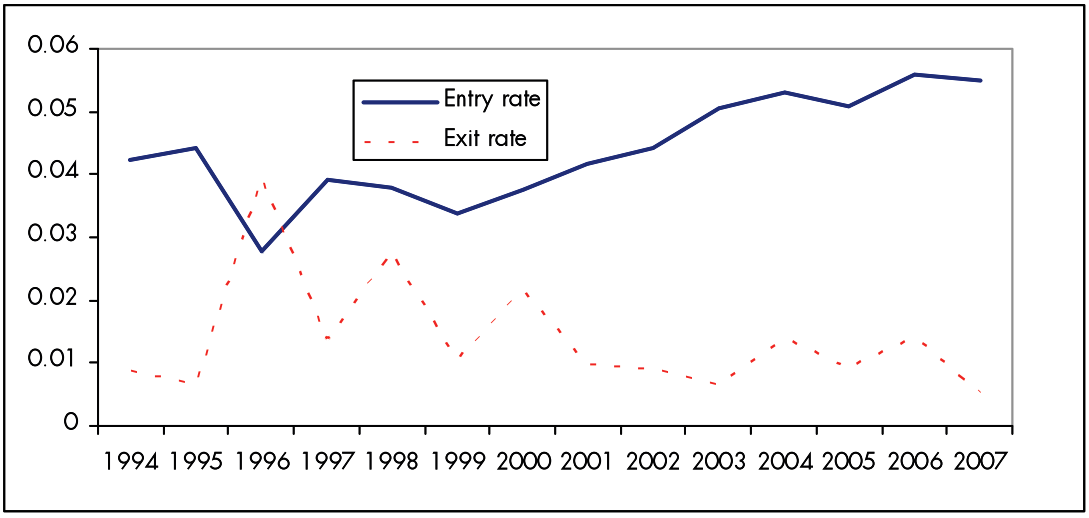
The growth rate of labor is the difference between the entry and exit rates. Therefore, for supply, our key parameters are the rates of entry (*re*) and exit (*rx*).

We assume that all newly certified CRNAs become active members of the labor force immediately. AANA provided us with data on newly certified CRNAs each year between 1994 and 2007, allowing us to calculate the entry rates for these years. Figure 5.1 illustrates the large fluctuations in entry rates through 1998. Since 1999, the pattern has been more consistent, with steady growth in the number of new entrants. Between 1999 and 2007, the entry rate as defined above increased from 3.4 percent to 5.5 percent. The baseline value we use for the CRNA entry rate is 4.39 percent, the average between 1999 and 2007. In our sensitivity analysis, we examine what would happen to the supply of CRNAs if the entry rate remained at the recently seen high of 5.5 percent, as well as what the implications would be if annual CRNA certifications were restricted to a low value of 1 percent of the labor force.

While we do not have data on the number of CRNAs leaving the labor market, AANA did provide the total number of CRNAs in the labor market (between 1994 and 2007). Combining the change in total CRNAs with our data on entries, we are able to calculate the number of CRNAs leaving the labor market using the equations shown above.[5] Our initial value for the exit rate is 1.4 percent, the average exit rate across all years of data.

We can use our survey data to determine whether an exit rate of 1.4 percent is plausible. Table 5.2 displays the retirement expectations for our survey respondents. It is likely that those who are closest to retiring are able to make the most-accurate predictions about years

Figure 5.1
Entry and Exit Rates in the Certified Registered Nurse Anesthetist Labor Market



[5] This method leads to a highly variable exit rate. It may also overestimate the entry rate and underestimate the exit rate because it assumes that all newly certified CRNAs enter the labor market.

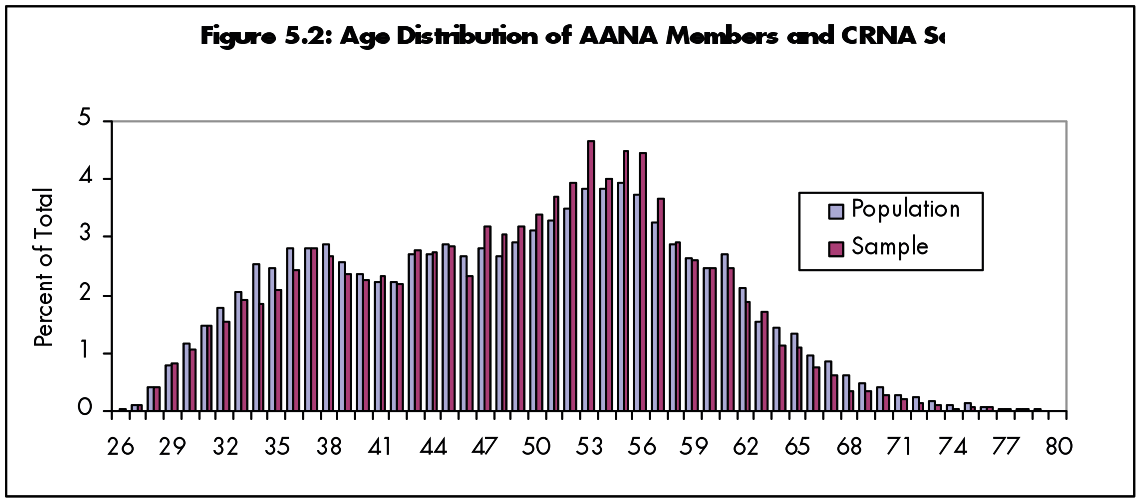
Table 5.2
Certified Registered Nurse Anesthetists and Anesthesiologists Planning to Retire (%)

Retirement Year	CRNAs	ANs
2007	0.23	0.48
2008–2010	6.64	4.46
2011–2015	20.53	19.66
2016–2020	26.05	30.16
After 2020	46.55	45.25

of retirement, so we use those who planned to retire 2008–2010 to estimate retirement rates. This method results in a CRNA exit-rate estimate of 2.2 percent, somewhat higher than the initial value we propose. The higher reports of expected retirement in our CRNA survey may be indicative of higher exit rates in the near future. The age distribution of CRNAs seen in Figure 5.2 shows a distinct hump between the ages of 52 and 60. This indicates that a large number of CRNAs will be reaching retirement age by 2020. To predict what may happen if CRNAs exit at these higher rates, our sensitivity analysis includes an exit rate of 3 percent. We also experiment with a low exit rate of 0.5 percent, to capture the low exit rate in 2007 seen in Table 5.2.

To calculate the labor-market entry rates for ANs, we used data on newly filled residencies (1990–2006) from the National Resident Matching Program (NRM) results for 2006 (Grogono, 2006). However, because residencies typically last three to four years, we do not

Figure 5.2
Age Distribution of American Association for Nurse Anesthetist Members and Certified Registered Nurse Anesthetist Sample



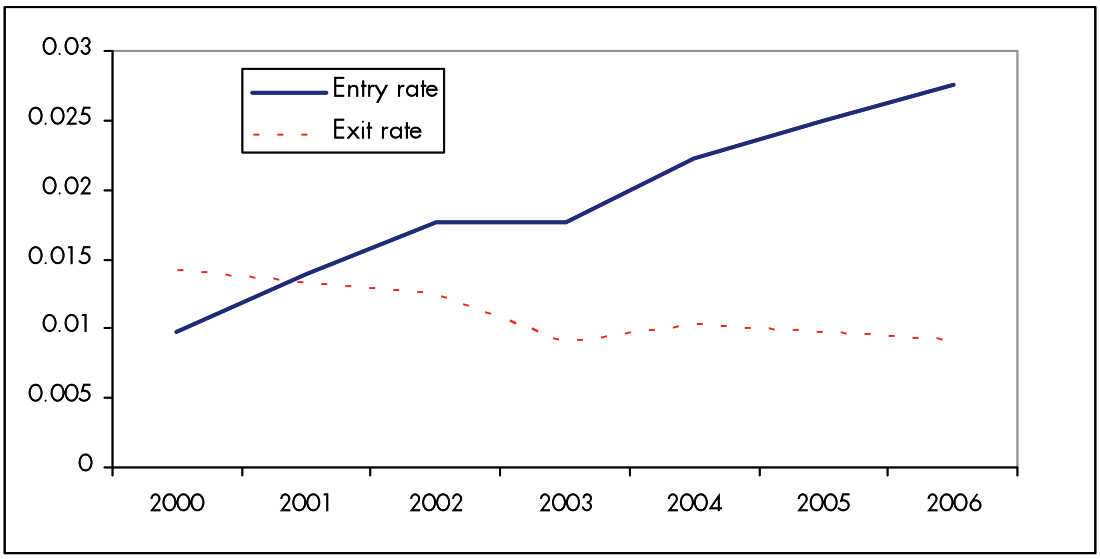
consider each resident as an entrant into the AN labor market until four years after entering residency.[6] Figure 5.3 indicates that, similar to CRNAs, there has been significant growth in the entry rate into the AN labor market in recent years. We use 1.82 percent, the average entry rate between 2000 and 2006, as the baseline entry rate for the AN market. Since the last few years have seen a significant increase in the entry rate of ANs, we also study a 2.5-percent entry rate, the average for the last three years of our data. Finally, we experiment with entry rates of 5.5 percent and 1 percent (as we do for CRNAs) in our sensitivity analysis.

We obtained data from ASA on retirements, deaths, and other exits from the labor force, so we do not need to back out these estimates as we did for CRNAs. The exit rate for ANs has remained somewhat constant since 2000, with the exception of a small decline between 2002 and 2003. We use the average exit rate of 1.15 percent as our baseline value for the exit rate.

Because exit rates in the AN labor market have declined recently, it is useful to examine what may happen if this rate were lower than 1.15 percent; our sensitivity analysis therefore tests the effect of a 0.5-percent exit rate for ANs.[7]

Our survey results suggest a somewhat higher exit rate of 1.49 percent between 2008 and 2010 (see Table 5.2). This indicates that exit rates may increase in future years. It might be

Figure 5.3
Entry and Exit Rates in the Anesthesiologist Labor Market



[6] Lee, Jackson, and Relles (1998) assume that the first-year residents = 0.35 FTEs, second- and third-year residents = 0.5 FTEs, and fourth-year residents = 0.75 FTEs. Our surveys show that, on average, 9.94 percent of anesthesiology providers with whom ANs work are residents. If we assume that one-fourth of residents fall into each year of residency, the average FTE is roughly 0.5. This means that residents make up less than 5 percent of the AN labor force in terms of FTEs. We find that nearly 65 percent of ANs report no residents in their facility. Given these facts, we do not include AN residents as part of the AN labor force, but we do take into account the lag between an increase in residency positions and its effect on the labor force.

[7] The lower exit rate is studied to also account for the possibility that members older than 55 drop their membership in ASA. If this is the case, the rate of 1.15 percent might overestimate exit. These ANs might also be working reduced hours and not fully retired.

useful to explore the possibility of higher exit rates in our sensitivity analysis for the following reasons:

- In addition to planned retirements in the survey, there are deaths and disabling diseases—the death rate for 65-year-old men is about 2 percent per year in the United States, so, even if working ANs are much healthier than average, 1 percent or more of them might die or become disabled annually.
- The planning-to-retire data, summarized in Table 5.2, shows that, between 2011 and 2015, nearly 20 percent of ANs plan to retire, which amounts to 4 percent per year. Year of retirement is likely better estimated than most future events, as people can pick an age to retire; therefore, it would be useful to consider this information.
- Even though Figure 5.4—the analogue of Figure 5.2 for ANs—does not show the same hump in the age distribution that we saw for CRNAs, there are about 4 percent each year in the 44–56 age range and 2 percent in the 57–61 range.

To account for these facts, we also study a 3-percent annual exit rate.

Labor-Market Scenarios: 2007–2020

Recall that the net growth in supply is given by the difference in entry and exit rates. If this net growth in supply exceeds the demand growth, there will be a surplus; otherwise, there will be a shortage.

Certified Registered Nurse Anesthetists

When we start from equilibrium and use our baseline values for exit and entry rates (which imply a net growth in supply of 4.4 – 1.4 = 3 percent), and the baseline growth in demand (of 1.61 percent), we find a surplus of 7,970 CRNAs by 2020 (see Figure 5.5).

Figure 5.4
Age Distribution of American Society of Anesthesiologists Members

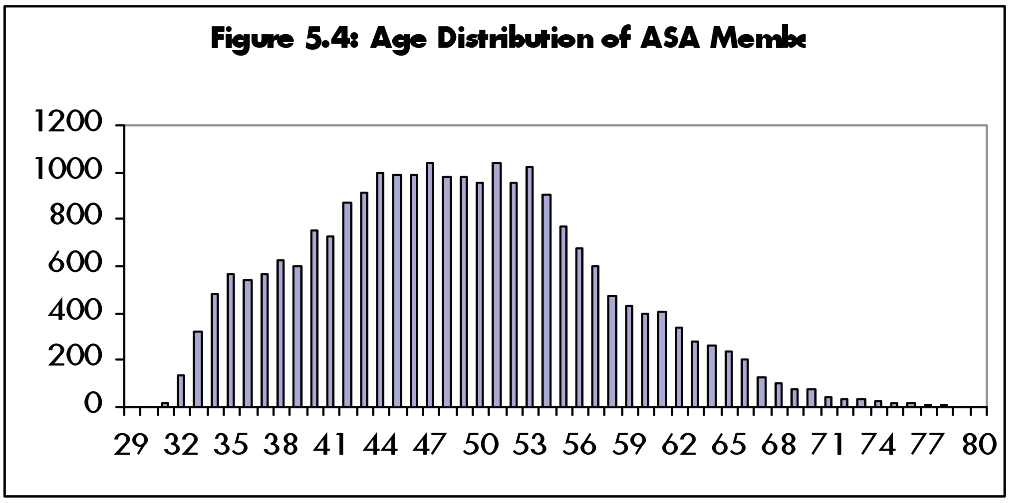


Figure 5.5
Certified Registered Nurse Anesthetist Labor Market, 2007–2020

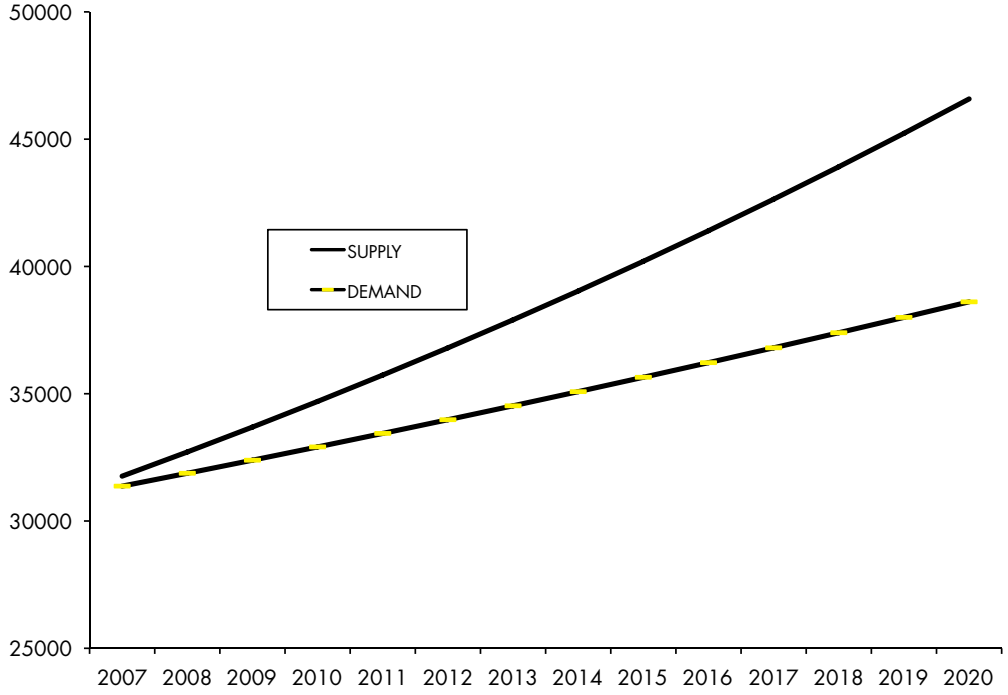


Figure 5.6 presents the sensitivity of our results to changes in the demand for CRNAs. We show the baseline demand and supply over time (as in Figure 5.5), as well as the demand under alternative scenarios. As previously mentioned, demand may be expected to increase more quickly in future years as the percentage of the population over 65 increases substantially. With an annual growth rate of 3 percent, we find that supply and demand will be in equilibrium by 2020, since supply and demand grow at the same rate over time. If growth in demand increases beyond 3 percent annually, we observe a shortage of CRNAs. With a 4-percent annual growth in demand, there is a shortage of 5,655 CRNAs by 2020, and, with 5 percent growth, a shortage of 12,574 by 2020.

The sensitivity of our analysis to changes in the supply of CRNAs is presented in Figure 5.7. We show the baseline demand and supply over time as well as the supply under alternative scenarios. We find that, if entry rates remain as high as the 2007 rate (5.5 percent of the CRNA labor force, which causes the net supply growth rate of 5.5 – 1.4 = 4.1 percent to exceed the baseline demand growth of 1.61 percent), the surplus of CRNAs will be as high as 14,942 by 2020. On the other hand, if the entry rate is limited to 1 percent of the CRNA labor force—say, by restricting certification of CRNAs, which results in the labor force *shrinking* by 0.4 percent annually (1 – 1.4), there will be a shortage of 8,460 CRNAs by 2020. Our survey data suggest that it is likely that the exit rate will increase as a large portion of the CRNA workforce reaches retirement age in the next few years. An increase in the exit rate to 3 percent would cause the supply to dip below demand slightly (since the net supply growth is

Figure 5.6
Sensitivity Analysis: Certified Registered Nurse Anesthetist Demand

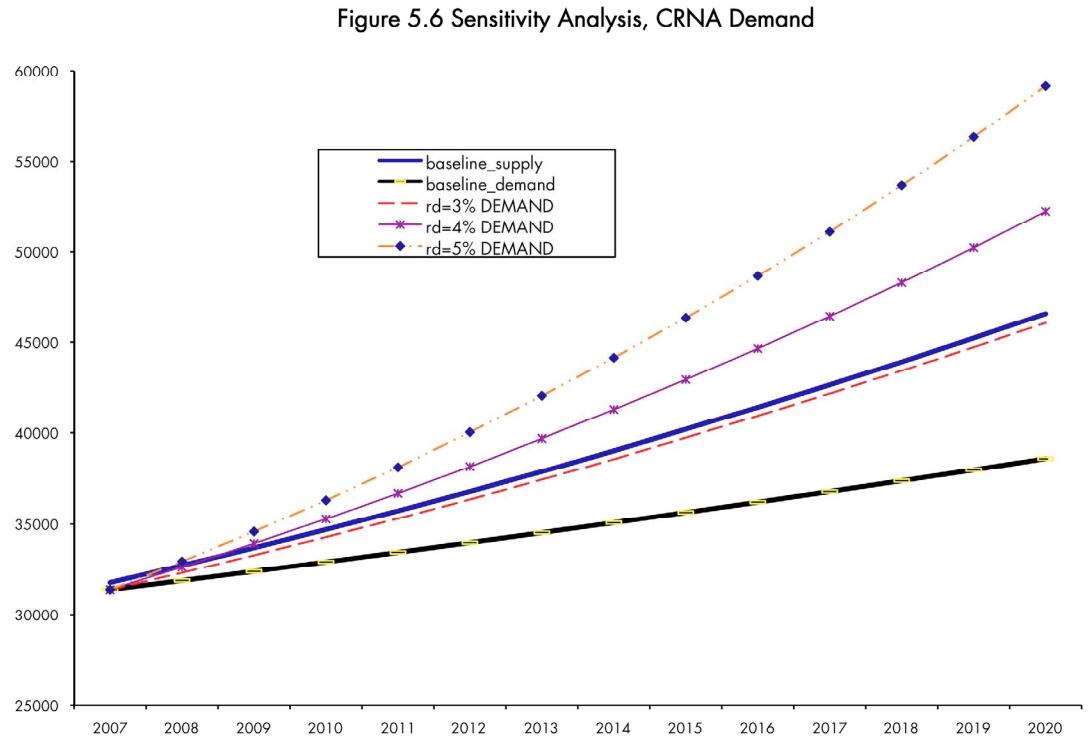
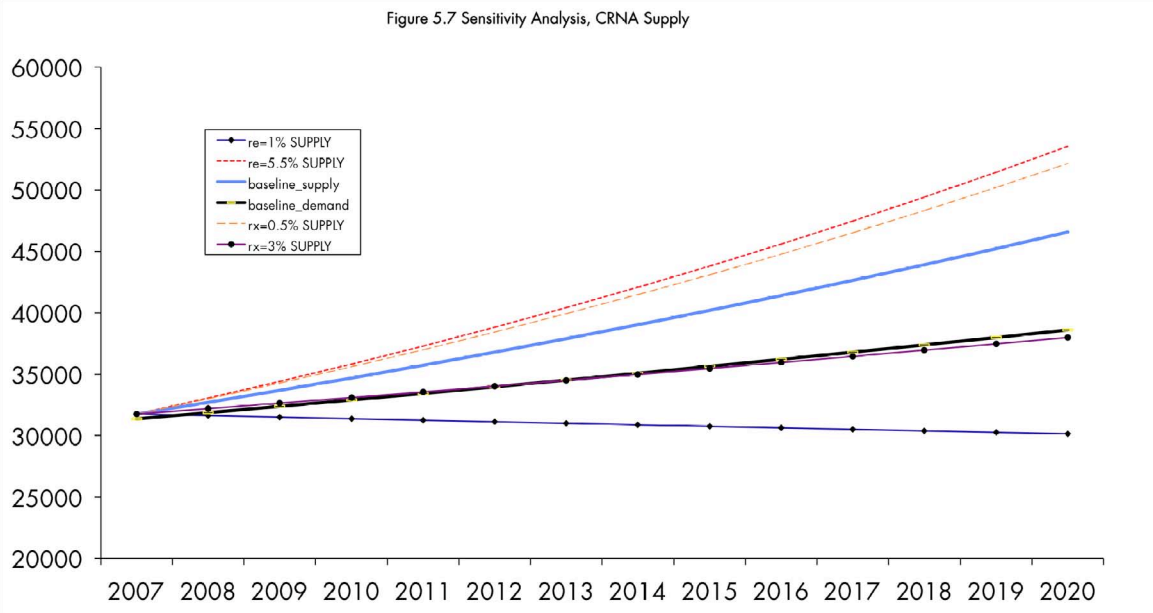


Figure 5.7
Sensitivity Analysis: Certified Registered Nurse Anesthetist Supply



4.4 – 3 = 1.4 percent), creating a shortage of 609 by 2020. A lower exit rate of 0.5 percent (net supply growth of 4.4 – 0.5 = 3.9 percent) will cause a surplus of 13,548 by 2020.

In summary, in the scenarios we have examined, a high annual growth in demand (higher than 3 percent, given baseline supply growth) and a low net growth of supply (a combination of low entry and high exit rates that cause supply growth to fall below the baseline demand growth of 1.61 percent per year) will result in shortages by 2020. In other cases, there will be a surplus.

Anesthesiologists

When we start from equilibrium and use our baseline values for exit and entry rates (which imply a net growth in supply of 1.82 – 1.15 = 0.67 percent) and the baseline growth in demand (of 1.61 percent), we find a shortage of 4,479 ANs by 2020 (see Figure 5.8).

The sensitivity analysis for changes in demand for ANs are presented in Figure 5.9. If the growth rate doubles to 3 percent with the aging of the population, the shortage of ANs will become even more severe, growing to 12,516 by 2020. A lower demand growth rate of 0.75 percent would leave the market roughly in equilibrium by 2020.

Figure 5.10 presents the sensitivity analysis for changes in AN supply. There are kinks in the supply curve, reflecting the lag between increased residencies and the four years that it takes for this increase in supply to materialize in the labor market. As mentioned earlier, we do not consider residents as part of the labor force. In the scenarios we have examined, only an increase in the entry rate to 5.5 percent (the 2007 entry rate for CRNAs, which yields a net

Figure 5.8
Anesthesiologist Projections, 2007–2020

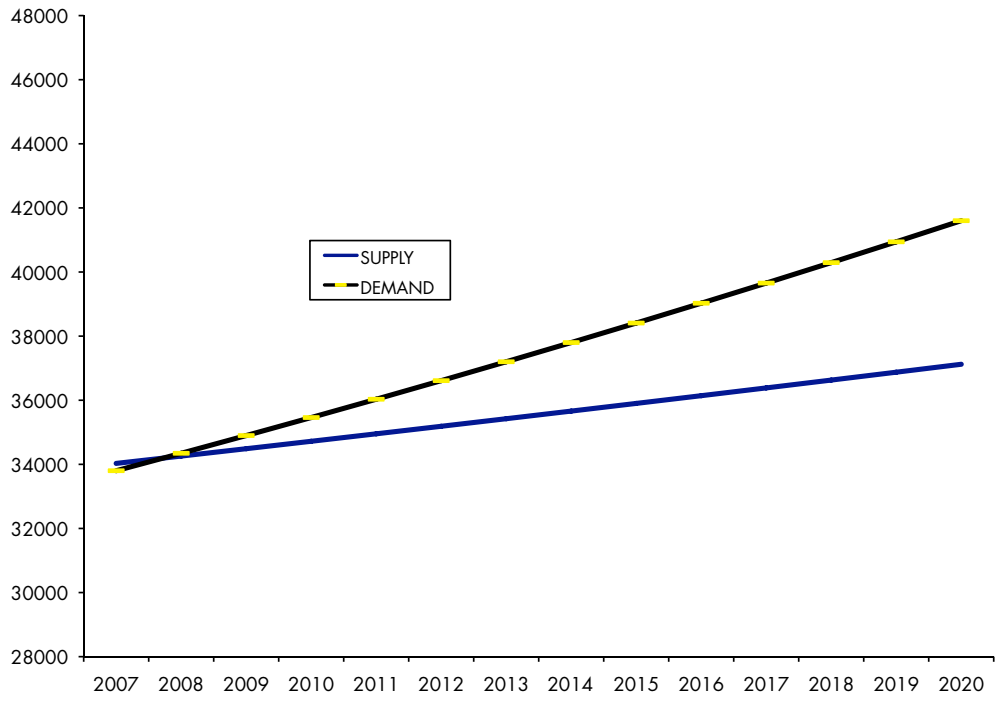
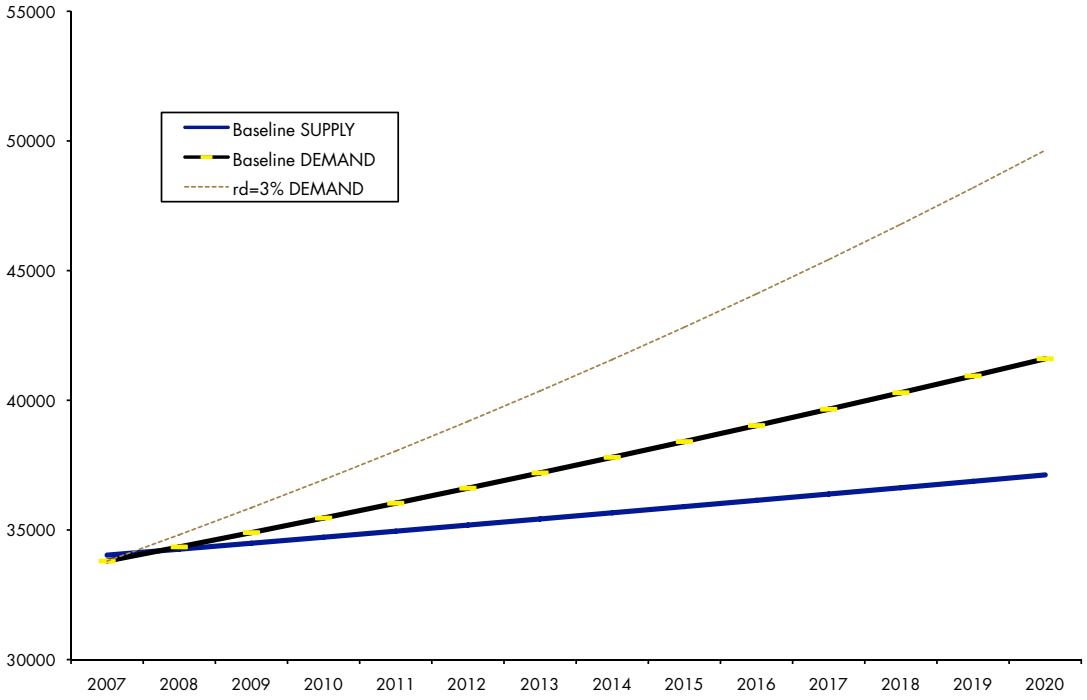


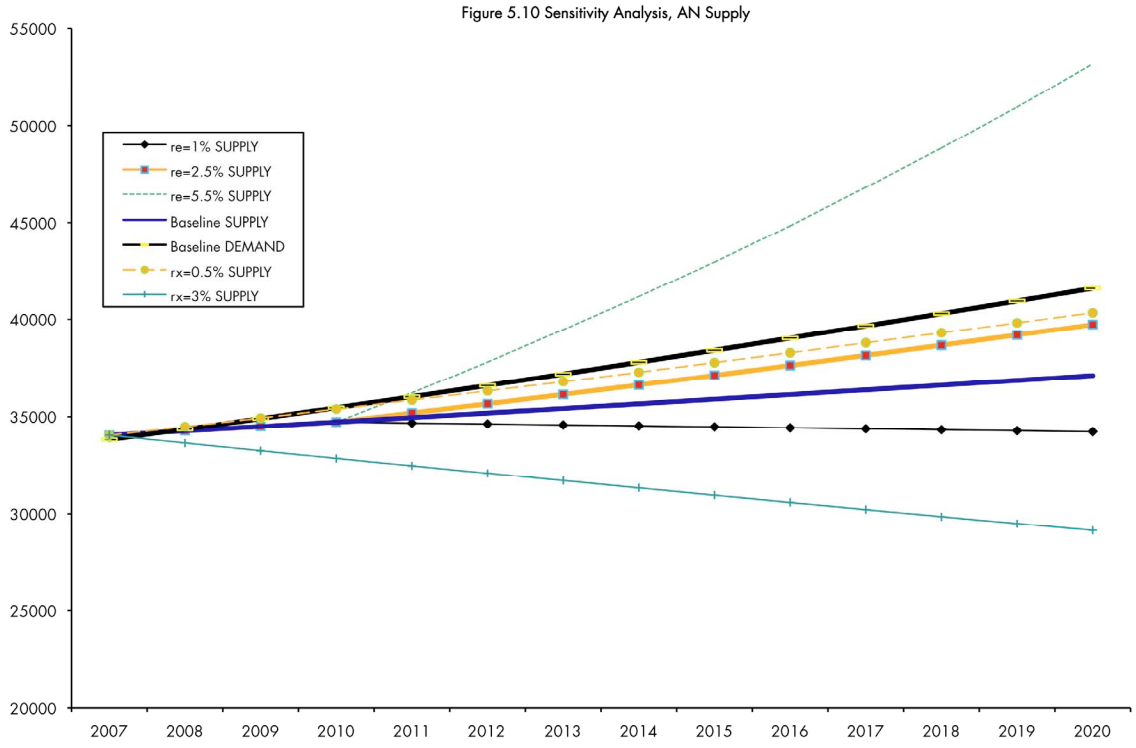
Figure 5.9
Sensitivity Analysis: Anesthesiologist Demand



supply growth rate of 5.5 – 1.15 = 4.35 percent) will lead to a surplus in 2020 of 11,571 ANs. A 2.5-percent entry rate (net supply growth of 1.35 percent) results in a shortage of 1,882 ANs by 2020, and a 1-percent entry rate (net supply *shrinkage* of 0.15 percent) in a shortage of 7,384. Relative to the benchmark exit rate of 1.15 percent, a lower exit rate of 0.5 percent (net supply growth of 1.32 percent) causes a shortage of 1,263 ANs by 2020, while a higher exit rate of 3 percent (net supply *shrinkage* of 1.18 percent) increases the shortage to 12,450 by 2020.

In summary, in the scenarios we have examined, only an entry rate of 5.5 percent will result in AN surplus by 2020. (Any entry rate over 2.76 percent will cause the net supply growth to exceed the baseline demand growth of 1.61 percent, given the baseline exit rate of 1.15 percent.) In other cases, there will be a shortage.

Figure 5.10
Sensitivity Analysis: Anesthesiologist Supply



CHAPTER SIX

Conclusions and Future Directions

In this report, we have undertaken an analysis of the labor markets for anesthesiology—in particular, for ANs and CRNAs. We conducted surveys among these groups to gather data on work patterns, wages, and demographic characteristics.

Our surveys captured many of the intricacies of these labor markets and revealed wide regional variations in the practice of anesthesiology, especially between the West (where CRNAs are less frequently used than they are elsewhere, but ANs still earn the least of any region in the country) and the Northeast (where CRNAs and ANs tend to work together more than anywhere else, MAC is provided more than anywhere else, and where growth in alternatives to MAC—moderate or deep sedation by sedation nurses or non-NAs—is likely to have the greatest impact on demand). There are also clear urban/rural differences in the labor markets for anesthesiology. Rural facilities are more likely than urban ones to employ CRNAs and less likely to employ ANs. Both ANs and CRNAs earn more in rural areas than in urban ones, and rural CRNAs also work longer hours than their urban counterparts.

We also used our surveys to gather information on the technology preferences of anesthesia providers. A majority of ANs and CRNAs across the country tend to prefer the adoption of more technology, especially in general anesthesia. ANs are less likely than CRNAs to want better technology for MAC and more likely than CRNAs to prefer better regional/spinal anesthesia technology.

Based on direct questions on potential shortages or excess supplies that we included in our surveys, as well as on a detailed econometric study, we conclude that there are shortages in the labor markets for both ANs and CRNAs at the national level. We estimate a shortage of 3,800 ANs and 1,282 CRNAs, nationally. We find that more than 54 percent of the states are experiencing a shortage of ANs, and more than 60 percent a shortage of CRNAs. There are sizable variations across states. Delaware is seen to have a surplus of ANs of more than 26 percent, while Idaho has a shortage of more than 46 percent. Nevada has a surplus of CRNAs exceeding 53 percent, while New York has a shortage of nearly 28 percent.

The noneconomic DBA we have conducted, while based on equilibrium at the national level, also provides shortage/surplus at the state level. However, the economic and noneconomic approaches agree on classifying a state as being in shortage or surplus only about half the time or less. The noneconomic analysis does not use wage and other information in its analysis, while the economic analysis does, making its findings more reliable.

We use a simple linear projection of supply and demand to examine the evolution of both labor markets until 2020, starting at equilibrium. Using the clinical-week averages from our surveys, average entry and exit rates from the recent past for both groups, and a growth rate in the demand for surgeries of around 1.6 percent between 1985 and 2004, we find a projected

shortage of ANs by 2020, and an excess supply of CRNAs. However, there are scenarios in the entire range of parameter values we examine in which these situations reverse for each group.

Our study has important implications for workforce planning. A key policy variable that is under the control of the professions' policymaking bodies is the rate of entry into the profession—residency positions for ANs and certifications for CRNAs. These could be increased in the case of shortages (such as the ones we find nationally). The scenario analysis we have done through 2020 shows how various entry rates, in conjunction with other variables, such as exit rates and demand growth rates, can result in shortage or surplus in the future. An important conclusion of our study is that the labor markets are very heterogeneous. Planning purely at the national level might not mitigate the shortage or surplus situations in particular states or regions. Understanding the degree of mobility across states and its determinants (which is beyond the scope of the current study) might be important for workforce planning in specific regions.

Our surveys have yielded a rich data set that can be used in conjunction with publicly available data to explore other research questions in the future:

- While we have explored the interaction between the labor markets and technology availability and preference for technology, more can be done. For instance, it would be useful to further explore the degree of substitutability or complementarity between technology and the two labor groups. This would shed light on how technological advances could alter the demand for labor; if technology and labor are substitutes, such an advance would decrease the demand for labor. But, if they are complements, the advance would increase the demand for labor. A particular challenge would be to disentangle regulatory features (for instance, the ability to practice independently) and intrinsic technological necessities (for instance, the combination of skills needed for certain procedures) that make factor inputs complements or substitutes.
- We have assumed that wages do not adjust in the AN and CRNA labor markets when we conduct our economic analysis. Examining specific sources of friction that prevent wages from adjusting would strengthen our conclusions. For instance, wages might reflect the level of Medicare reimbursements rather than supply and demand considerations, which are likely to be much more dynamic than adjustments to reimbursements. Or wages could reflect monopsony power (bargaining power in hiring situations) that facilities have in certain labor markets.
- Along similar lines, we have assumed in our analysis that labor markets are localized at least at the state level and that there is little mobility across states. This assumption warrants further examination. As mentioned earlier, given the high level of heterogeneity across states, labor-force planning cannot be done purely at the national level. By collecting data on patterns of mobility, it would be useful to understand the locational choice of ANs and CRNAs and assess the extent to which lack of mobility affects state-level labor-market conditions.

APPENDIX A

Anesthesiologist Survey Questionnaire

Section A: General Employment Information

A1. When did you start practice as an Anesthesiologist? [1930 . . . 2007]

Please use the following interpretation for hospital/facility:

- *Hospitals* include university hospitals and academic medical centers
- *Facilities* include ambulatory surgical centers, office suites, etc.
- *Groups* include physician group practices.

A2–A7: Questions about your main affiliation

A2. For how many years have you been in your current affiliation? [0 … 50]

A3. Which of the following best describes your current affiliation?

1. One group
2. One hospital/facility
3. Multiple groups
4. Multiple hospitals/facilities
5. Locum tenens
6. Other: Specify _____

A4. How many other Anesthesiologists practice in your primary group/practice at all facilities (not including locum tenens or other temporary additions to the group)? [0,300]

A5. How many open positions does your group/practice have for

1. Anesthesiologists
2. Anesthesiologist Assistants (AAs) / CRNAs
3. Unknown (Go to A7)

A6. To cover our current volume of cases, my group/practice would prefer to have

1. More Anesthesiologists (Yes/No/Unknown)
2. More AAs/CRNAs (Yes/No/Unknown)
3. Does Not Apply (Fully Staffed)

A7. My group/practice could handle more cases if we could hire

1. Additional Anesthesiologists (Yes/No/Unknown)
2. Additional AAs/CRNAs (Yes/No/Unknown)
3. Does Not Apply (Fully Staffed)

A8. Which of the following best describes the facility where you provide services?

1. One hospital/facility
2. Multiple hospitals/facilities
3. Other: Specify _____

For primary facility questions, please use the following interpretation:

- *Primary facility*: The facility in which you spend a majority of your time.

A9–A12: Questions about the primary facility in which you provide services

A9. How many of the following professionals practice/work in your primary facility:

1. Anesthesiologists [0–300, Do Not Know]
2. Anesthesiology residents [0–300, Do Not Know]
3. AAs/CRNAs [0–300, Do Not Know]
4. Student Registered Nurse Anesthetists (SRNAs) [0–300, Do Not Know]
5. Surgeons [0, 1,000]

A10. What is the financial structure of your primary facility:

1. Non-profit
2. For-profit
3. Governmental (e.g., VA)

A11. Is your primary facility a teaching institution (for residents, ANs, or AAs)? Yes/No

A12. Is your primary facility a free-standing ambulatory surgical center? Yes/No

A13. Who supplies your office space?

1. Hospital/facility
2. Group leases or owns office space within the hospital/facility
3. Group leases or owns office space away from the hospital/facility
4. Other: Specify _____
5. Do Not Know

The answers you provide to compensation questions allow us to better estimate the response of labor supply to different external events. We do not aim to focus on earnings in this study.

Answers to these questions, as to all other questions in this survey, will be held in the strictest confidence, and no attempt will be made to identify a specific person. However, if you feel uncomfortable answering any of the questions, you may proceed to the next question.

Please use the following interpretation for compensation for professional services:

- State the amount reported as direct compensation on a W2, 1099, or K1, plus all voluntary salary reductions (e.g., 401[k], health insurance, etc.) The amount reported should include salary, bonus, and/or incentive payments, research stipends, honoraria, and distribution of profits to employees. However, please do not include profits resulting from corporate ownership. Also, do not include benefits paid by the practice, e.g., retirement plan contributions, etc. under compensation. We ask about benefits separately.

A14. This survey and the research based on it will greatly benefit from data on compensation. Would you be willing to provide your compensation?

1. Yes, I will provide a dollar figure (GO TO A14a)
2. Yes, but I will only choose a range (GO TO A14b)
3. No, I prefer not to answer (GO TO A15)

A14a. Annual overall compensation (as defined earlier) for professional services before taxes in 2006: $_____

A14b. What was your annual overall compensation for professional services before taxes in 2006?

1. [100K–150K]
2. [150K–200K]
3. [200K–250K]
4. [250K–300K]
5. [300K–350K]
6. [350K–400K]
7. [400K–450K]
8. [450K–500K]
9. [> 500K]

A15. In 2006, what percentage of your compensation came from

1. Medicare : _____%
2. Managed care : _____%
3. Other: (Specify _____) _____%
4. Do not know

A16. In 2006, what percentage of your compensation came from

1. Fixed Salary or contract (not paid on a per case basis) : _____%
2. Fee for service/per case basis : _____%
3. Other (e.g. Administrative supplement, faculty support, etc. Specify _____) : _____%
4. Unknown

A17. For each of the following benefits, enter the percentage paid by your employer or group:

1. Health insurance _____%
2. Disability _____%
3. Dental _____%
4. Vision _____%
5. Retirement _____%
6. Long-term care _____%
7. Other: Specify _____; _____%
8. Unknown

A18. What is the annual allowance your employer or group provides for educational purposes, attending conferences etc.?

A18a. $ _____/Year

A18b. # of Days_____/Year

A19. Who pays your malpractice insurance premium?

1. Self (including your own PC or LLC)
2. Hospital
3. Employer
4. Other. Specify _____
5. Do not know

A20. What is the coverage limit on your malpractice insurance (the choices are given as per incident or claim/per year (e.g., if your policy is 1M/3M, $1M is your per-incident coverage, and $3M your per-year coverage)?

1. 0
2. 1M/3M
3. 2M/5M
4. Other: Specify _____
5. Do not know

A21. What is the annual cost of your malpractice insurance premium (average mature provider premium, exclusive of "tail" coverage)?

1. $_____
2. Don't know

A22. By what percentage have your work hours changed since 2004?

1. No appreciable change
2. Decreased by less than 10%
3. Decreased by more than 10%
4. Increased by less than 10%
5. Increased by more than 10%

A23. What is your attitude toward increased work hours (total hours—clinical, research, and administrative—rather than billable hours)?

1. I will increase my work hours if the compensation is high enough (go to A22a)
2. I will not increase my work hours because
   a. I am satisfied with my current level of income
   b. I do not have any more time available.
   c. Other: Specify _____

A22a. When would you increase your work hours by 10%?

1. If income increased by 5%
2. If income increased by 10%
3. If income increased by 20%
4. If income increased by 25%

A24. Which of the following best describes your primary specialty within Anesthesiology?

1. Generalist
2. Cardiac/Vascular Anesthesia
3. Critical Care
4. Neurosurgical Anesthesia
5. Obstetrical & Gynecologic Anesthesia
6. Pain Medicine
7. Pediatric Anesthesia
8. Trauma anesthesia
9. Ophthalmological Anesthesia
10. GI Anesthesia
11. Plastic Surgery Anesthesia
12. ENT
13. Other: Specify _____

Section B: Time-Use Information

For time-use questions, please use the following interpretation:

- *Week:* a typical seven-day work week (excluding vacation and other paid time off)
- *Clinical time:* total number of hours during which the Anesthesiologist is involved in direct patient care (includes on-call hours spent in actively providing care, and time spent waiting for cases to begin) and providing clinical instruction
- *Administrative hours:* total number of hours spent performing medical director services, attending meetings, scheduling cases, etc.
- *Education and Research hours:* Total number of hours teaching, conducting research, and performing other education duties.

B1. Typically how many hours do you work per week (include clinical, research, administrative, teaching duties, and all call hours)? [0…168]

B1a. Please fill in the following table regarding your typical weekly call hours:

Call Hours	On Site (in a care facility)	Off Site (away from a care facility)
Total	[0 . . 168]	[0 . . 168]
Spent actively providing care	[0 . . 168]	[0 . . 168]

B2. What is your typical clinical workload in hours per week? [0…80]

B2a. What percentage of these hours per week is spent during the weekend? _____ %

B2b. Indicate the % of clinical time you spend each week in each of these practice settings:

1. Hospital or hospital-based (if you cannot split it between inpatient and outpatient give the total percentage) _____ %
   a. Inpatient _____ %
   b. Outpatient _____ %
2. Free-standing ambulatory center _____ %
3. Office-based _____ %
4. Dental office _____ %
5. Other (Specify _____) _____ %

B2c. Enter the percentage of clinical time you typically spend each week on each of the following services:

1. Pre-operative evaluation (including obtaining informed consent) _____ %
2. Intra-operative care _____ %
3. Post-operative and Post-PACU care _____ %
4. Critical Care Medicine _____ %
5. Pain medicine—chronic _____ %
6. Pain medicine—acute and acute pain management _____ %
7. Labor and Delivery _____%
8. Other services (Specify): _____; _____ %

B2d. Enter the percentage of clinical time (and number of procedures) you typically spend each week on each of the following anesthetic techniques:

1. Monitored Anesthesia Care (MAC) _____ %

Number of procedures per week: [0 . . . 100]

2. General Anesthesia _____ %

Number of procedures per week: [0 . . . 100]

3. Regional (excluding epidurals placed for obstetrical cases) _____ %

Number of procedures per week: [0 . . . 100]

4. Labor epidurals _____ %

Number of procedures per week: [0 . . . 100]

B3. What is your typical research workload in hours per week? [1 . . . 100]

B4. What is your typical administrative workload in hours per week? [1 . . . 80]

B5. What is your typical (didactic) teaching workload in hours per week? [1 . . . 80]

B6. In your primary facility, what is the distribution (percentage) of *each* of the following cases where Conscious Sedation is provided by non–Anesthesia providers versus Monitored Anesthesia Care provided by Anesthesia providers?

1. Cataracts
2. Adult Radiology (CTT/MRI)
3. Colonoscopy and UGI endoscopy
4. Pediatric radiology
5. EPS lab
6. Cath lab
7. TEE lab
8. Bronchoscopy suite
9. Other: Specify _____

B7. What percentage of patients that you care for are:

1. ASA I
2. ASA II
3. ASA III
4. ASA IV
5. ASA V
6. Unknown

B8. What percentage of patients that you care for are predominantly:

1. Generalist
2. Cardiac/Vascular Anesthesia
3. Critical Care
4. Neurosurgical Anesthesia
5. Obstetrical & Gynecologic Anesthesia
6. Pain Medicine
7. Pediatric Anesthesia
8. Trauma anesthesia
9. Ophthalmological Anesthesia
10. GI Anesthesia
11. Plastic Surgery Anesthesia
12. ENT
13. Other: Specify _____

B9. What percentage of patients that you care for are (please do not include labor epidurals as emergency, even if administered in the middle of the night).

1. Elective
2. Urgent
3. Emergency
4. Unknown

B10. What percentage of your patients are

1. Pediatric (0–15)
2. Adult (age between 16 and 65)
3. Elderly adults (age greater than 65)

B11. How many hours (excluding call hours) while you are at work during a typical seven-day work week are you not providing professional services because of reasons such as scheduling, staffing, or management delays? [1 . . 80]

B12. In your primary practice setting**,** for Monday–Friday:

1. Is block scheduling for procedures or surgeons done? Yes/No
2. What is the OR utilization between 7 AM and 3 PM? (Total hours used/total hours staffed)
   a. _____ %
   b. Do Not Know
3. How many ORs (as % of total in the facility) are active at 1PM
   a. _____ %
   b. Do Not Know
4. How many ORs (as % of total in the facility) are active at 4PM
   a. _____ %
   b. Do Not Know
5. What percentage of the daily anesthesia case load is added after the OR schedule has been set?
   a. _____ %
   b. Do Not Know

B13. In what percentage of cases do you

1. Supervise residents
2. Medically direct AAs/CRNAs
3. Personally perform anesthesia services

Section C: Usage of Technology

C1. My primary facility adopts new technology (anesthesia machines, patient monitoring equipment, delivery system for anesthesia drugs, respirators, etc.):

1. Too frequently
2. At the right pace
3. Not frequently enough

C2. Adopting new technology is important for (choose any/all that apply):

1. Patient safety
2. Quality of patient care
3. Additional functionality
4. Freeing Anesthesiologists from routine tasks
5. An interesting work environment
6. None of the above

C3. I would prefer access to better technology than what I have available today in (Yes/No):

1. Monitored Anesthesia Care
2. Regional Anesthesia
3. General Anesthesia

C4. I would prefer access to better technology than what I have available today in (Yes/No):

1. Anesthesia machines
2. Patient monitoring equipment
3. Drug delivery systems
4. Respirators
5. IT
6. Other (specify): _____

C5. Professionally, overall I would describe myself as being pro-technology.

1. Yes
2. No
3. Do not know

Section D: Demographic Information

The answers you provide to the demography questions allow us to better estimate the response of labor supply to different external events. Answers to these questions, as to all other questions

in this survey, will be held in the strictest confidence, and no attempt will be made to identify a specific person. However, if you feel uncomfortable answering any of the questions, you may proceed to the next question.

D1. What is your gender?

1. Male
2. Female

D2. In what year were you born? [1900 . . . 1989]

D3. What is your household status?

1. Single with no dependent child(ren) (If so, ask D4)
2. Single with dependent child(ren) (If so, ask D3b)
3. Married or living with a partner with no dependent child(ren) (If so, ask D3a)
4. Married or living with a partner with dependent child(ren) (If so, ask D3a, D3b)

D3a. Are you the sole earner of your household?

1. Yes
2. No

D3b. How many children live in your household? [0 . . 10]

D4. Were you born in the United States?

1. Yes
2. No

In which country? _____

D5. Where did you receive your MD/DO degree?

1. In the US
2. Outside the US

D6. Have you practiced anesthesiology in other countries? Yes/No

If yes, which country? _____

D7. How would you classify yourself? Select all that apply:

1. White or Caucasian
2. Hispanic
3. Black or African American
4. American Indian or Alaskan Native
5. Asian or Pacific Islander
6. Other: Specify _____

Section E: Future Plans

E1. How many hours per week do you expect to work 1 year from now? (Use 0 if you plan to retire within in a year.) [0 . . . 168]

E2. How many hours per week do you expect to work 5 years from now? (Use 0 if you plan to retire within 5 years.) [0 . . . 168]

E3. When do you expect to retire from anesthesia practice?

1. Before the end of this year (2007)
2. 2008 to 2010
3. 2011 to 2015
4. 2016 to 2020
5. After 2020

APPENDIX B

Certified Registered Nurse Anesthetist Survey Questionnaire

Section A: Demographic Information

The answers you provide to the demography questions allow us to better estimate the response of labor supply to different external events. Answers to these questions, as to all other questions in this survey, will be held in the strictest confidence, and no attempt will be made to identify a specific person. However, if you feel uncomfortable answering any of the questions, you can proceed to the next question.

A1. What is your gender?

1. Male
2. Female

A2. When were you born? [1900 . . . 1989]

A3. What is your household status?

1. Single with no dependent child(ren) (If so, ask A4)
2. Single with dependent child(ren) (If so, ask A3b)
3. Married or living with a partner with no dependent child(ren) (If so, ask A3a)
4. Married or living with a partner with dependent child(ren) (If so, ask A3a, A3b)

A3a. Are you the sole earner of your household?

1. Yes
2. No

A3b. How many children live in your household? [0 . . . 10]

A4. Were you born in the United States?

1. Yes
2. No

In which country? _____

A5. Where did you receive your entry level nursing education?

1. In the US
2. Outside the US

A6. Have you practiced nurse anesthesiology in other countries? Yes/No

If yes, which country? _____

A7. How would you classify yourself? Select all that apply:

1. White or Caucasian
2. Hispanic
3. Black or African American
4. American Indian or Alaskan Native
5. Asian or Pacific Islander
6. Other: Specify _____

Section B: General Employment Information

B1. What year did you start working as a CRNA? [1930 . . . 2007]

For employment questions, please use the following interpretation:

- *Facility:* Includes hospitals (including university hospitals), ambulatory surgical centers, and office suites
- *Groups:* Physician and/or CRNA Group practices
- *Employment arrangement:* Includes employment by a facility or group, contractual arrangement, or self-employment
- *Primary employment arrangement:* The current employment arrangement in which you spend the highest amount of time

B2–B7: Questions about your PRIMARY employment arrangement

B2. How many years have you been in your primary employment arrangement? [0 . . . 50]

B3. Which of the following best describes your primary employment arrangement?

1. One group
2. One facility
3. Multiple groups
4. Multiple facilities
5. Locum tenens
6. Other: Specify _____

B4. How many other CRNAs work in your primary employment arrangement at all facilities (not including locum tenens or other temporary additions to the group)? [0,500]

B5. How many open positions are available in your primary employment arrangement?

1. CRNAs
2. Anesthesiologists
3. Unknown (Go to B7)

B6. To cover our current volume of cases, my primary employment arrangement would prefer to have:

1. More CRNAs (Yes/No/Unknown)
2. More Anesthesiologists (Yes/No/Unknown)

B7. My primary employment arrangement can handle more cases by hiring

1. Additional CRNAs (Yes/No/Unknown)
2. Additional Anesthesiologists (Yes/No/Unknown)

For primary facility questions, please use the following interpretation:

- *Primary facility:* The facility in which you spend a majority of your time

B8–B12: Questions about the primary facility in which you provide services

B8. As part of your primary employment arrangement, in how many facilities do you provide services?

1. One facility
2. Multiple facilities
3. Other: Specify _____

B9. How many of the following professionals practice/work in your primary facility:

1. CRNAs [0,300]
2. Registered Nurse Anesthesia Students [0,300]
3. Anesthesiologists [0,300]
4. Anesthesiology residents [0,300]
5. Surgeons [0, 1,000]

B10. In your primary facility, how many Anesthesiologists do you typically work with on a procedure? [0 . . 20]

B11. What is the financial structure of your primary facility:

1. Non-profit
2. For-profit
3. Governmental (e.g., VA)

B12. Is your primary facility a teaching institution? Yes/No

B13. Is your primary facility a free-standing ambulatory surgical center? Yes/No

The answers you provide to compensation questions allow us to better estimate the response of labor supply to different external events. We do not aim to focus on earnings in this study. Answers to these questions, as to all other questions in this survey, will be held in the strictest confidence, and no attempt will be made to identify a specific person. However, if you feel uncomfortable answering any of the questions, you may proceed to the next question.

Please use the following interpretation for compensation for professional services:

- State the amount reported as direct compensation on a W2, 1099, or K1, plus all voluntary salary reductions (e.g., 401(k), health insurance, etc.) The amount reported should include salary, bonus and/or incentive payments, research stipends, honoraria, and distribution of profits to employees. However, please do not include profits resulting from corporate ownership. Also, do not include benefits paid by the practice, e.g., retirement plan contributions, etc. under compensation. We ask about benefits separately.

B14. This survey and the research based on it will greatly benefit from data on earnings. Would you be willing to provide your earnings?

1. Yes, I will provide a dollar figure (GO TO B14a)
2. Yes, but I will only choose a range (GO TO B14b)
3. No, I prefer not to answer (GO TO B15)

B14a. Annual overall compensation for professional services (clinical, research, teaching, and administrative services, but excluding profits from corporate ownership) before taxes in 2006: $_____

B14b. What was your annual overall compensation for professional services (clinical, research, teaching, and administrative services, but excluding profits from corporate ownership) before taxes in 2006?

1. [<100K]
2. [100K–150K]
3. [150K–200K]
4. [200K–250K]
5. [250K–300K]
6. [>300K]

B15. In 2006, what percentage of your compensation came from

1. Medicare: _____%
2. Managed care (i.e., HMOs): _____%
3. Other: (Specify _____) _____%
4. Do not know

B16. In 2006, regardless of source, what percentage of your compensation for professional services (clinical, research, teaching, and administrative services, but excluding profits from corporate ownership) came from

1. Fixed Salary or contract (not paid on a per case basis) : _____%
2. Fee for service/per case basis : _____%
3. Other (Specify _____) : _____%

B17. For each of the following benefits enter the sum of percentages paid by all your employers (as opposed to you buying them individually). For instance, if one of your employers pays 20% of your health insurance premium and another 30%, you would enter 50%.

1. Health insurance _____%
2. Disability _____%
3. Dental _____%
4. Vision _____%
5. Retirement _____%
6. Long-term care _____%
7. Other (Specify _____) _____%

B18. What is the annual allowance your employer provides for educational purposes, attending conferences etc.?

B18a. $ _____/Year

B18b. # of Days_____/Year

B20. By what percentage has your work hours changed since 2004?

1. No appreciable change
2. Decreased by less than 10%
3. Decreased by more than 10%
4. Increased by less than 10%
5. Increased by more than 10%

B19. What is your attitude toward increased work hours (clinical, research, educational, and administrative)?

1. I will increase my work hours if the compensation is high enough (go to B19a)
2. I will not increase my work hours because
   a. I am satisfied with my current level of income
   b. I do not have any more time available.
   c. Other: Specify _____

B19a. When would you increase your work hours by 10%?

1. If income increased by 5%
2. If income increased by 10%
3. If income increased by 20%
4. If income increased by 25%

B20. Which of the following best describes your primary specialty within Anesthesiology?

1. Anesthesia for all types of surgeries
2. Cardiac/Vascular Anesthesia
3. Critical Care (providing emergency airway, ventilatory, and other support services)
4. Neurosurgical Anesthesia
5. Obstetrical Anesthesia
6. Pain Management
7. Pediatric Anesthesia
8. Trauma Anesthesia
9. Ophthalmological Anesthesia
10. GI Anesthesia
11. Plastic Surgery Anesthesia
12. Other: Specify _____

Section C: Time-Use Information

For time-use questions, please use the following interpretation:

- *Week:* a typical seven-day work week (excluding vacation and other paid time off)
- *Clinical time:* total number of hours during which the nurse anesthetist is involved in direct patient care (includes on-call hours spent in actively providing care, and time spent waiting for cases to begin) and providing clinical instruction
- *Administrative hours:* Performing administrative and clinical management responsibilities
- *Education and Research hours:* Total number of hours teaching, conducting research, and performing other education duties.

C1. Typically how many hours do you work per week (including clinical, research, administrative, teaching duties, and all call hours)? [0 . . . 168]

C1a. Please fill in the following table regarding your typical weekly call hours:

Call Hours	On Site (in a care facility)	Off Site (away from a care facility)
Total	[0 . . 168]	[0 . . 168]
Spent actively providing care	[0 . . 168]	n.a.

C2. What is your typical clinical time in hours per week? [0 . . . 80]

C2a. What percentage of these hours per week is spent during the weekend? _____ %

C2b. Indicate the % of clinical time you spend each week in each of these practice settings:

1. Hospital or hospital-based (if you cannot split it between inpatient and outpatient give the total percentage) _____ %
   a. Inpatient _____ %
   b. Outpatient _____ %
2. Free-standing ambulatory center _____ %
3. Office-based _____ %
4. Physician or dentist's office _____ %
5. Other (Specify _____) _____ %

C2c. Enter the percentage of clinical time you typically spend each week on each of the following services:

1. Pre-operative evaluation (including obtaining informed consent) _____ %
2. Intra-operative care _____ %
3. Post-operative and Post-PACU care _____ %
4. Providing emergency airway, ventilatory, and other support services ("critical care") _____ %
5. Pain management activities _____ %
6. Labor and Delivery coverage, including epidural_____%
7. Other services (Specify): _____ %

C2d. Enter the percentage of clinical time (and number of procedures) you typically spend each week on each of the following anesthetic techniques:

1. Monitored Anesthesia Care (MAC) _____ %

Number of procedures per week: [0…100]

2. General Anesthesia _____ %

Number of procedures per week: [0…100]

3. Regional/Blocks/Spinal Anesthesia _____ %

Number of procedures per week: [0…100]

4. Obstetrical anesthesia _____ %

Number of procedures per week: [0…100]

C2e. For what percentage of your clinical time do you work without the involvement of an Anesthesiologist? [0 . . 100]

C3. What is your typical research workload in hours per week? [0–100]

C4. What is your typical administrative workload in hours per week? [0–100]

C5. What is your typical (didactic) teaching workload in hours per week? [0–100]

C6. In your primary facility, what is the distribution (percentage) of *each* of the following cases where Conscious Sedation is provided by non-Anesthesia (non-AN) providers versus Monitored Anesthesia Care provided by Anesthesia (AN) providers?

1. Cataracts
2. Adult radiology
3. Colonoscopy and UGI endoscopy
4. Pediatric radiology
5. EPS lab (Electrophysiology Lab)
6. Cath labs
7. TEE (Transesophageal Echocardiogram) lab
8. Bronchoscopy suite
9. Other: Specify _____

C7. What percentage of patients that you care for are:

1. ASA physical status I
2. ASA physical status II
3. ASA physical status III
4. ASA physical status IV
5. ASA physical status V

C8. What percentage of patients that you care for are predominantly

1. Anesthesia for all types of surgeries
2. Cardiac/Vascular Anesthesia
3. Critical Care (providing emergency airway, ventilatory, and other support services)
4. Neurosurgical Anesthesia
5. Obstetrical Anesthesia
6. Pain Management
7. Pediatric Anesthesia
8. Trauma Anesthesia
9. Ophthalmological Anesthesia
10. GI Anesthesia
11. Plastic Surgery Anesthesia
12. Other: Specify _____

C9. What percentage of patients that you care for are (please do not include labor epidurals as emergent, even if administered in the middle of the night)

1. Elective
2. Urgent
3. Emergent

C10. What percentage of your patients are

1. Pediatric (0–15)
2. Adult (age between 16 and 65)
3. Elderly (age greater than 65)

C11. How many hours while you are at work during a typical seven-day work week are you not providing professional services because of reasons such as scheduling, staffing, or management delays? [1 . . 80]

C12. In your primary facility, for Monday–Friday:

1. Is block scheduling for procedures or surgeons done? Yes/No
2. What is the OR utilization between 7 AM and 3 PM? (Total hours used/total hours staffed) _____ %
3. How many ORs (as % of total in the facility) are active at 1PM _____ %
4. How many ORs (as % of total in the facility) are active at 4PM _____ %
5. What percentage of the daily anesthesia case load is added after the OR schedule has been set? _____ %

Section D: Usage of Technology

D1. My primary facility adopts new technology (anesthesia machines, patient monitoring equipment, delivery system for anesthesia drugs, respirators, etc.)

1. Too frequently
2. At the right pace
3. Not frequently enough

D2. Adopting new technology improves (choose any/all that apply)

1. Patient safety
2. Quality of patient care
3. Functions that can be performed
4. Freeing nurse anesthetists from routine tasks
5. An interesting work environment
6. None of the above

D3. I would prefer access to better technology than I currently have available today in (Yes/No)

1. Monitored Anesthesia Care
2. Regional Anesthesia
3. General Anesthesia

D4. I would prefer access to better technology than what I currently have available today with regard to (Yes/No)

1. Anesthesia machines
2. Patient monitoring equipment
3. Drug delivery device
4. Respirators/ventilators
5. IT (Electronic health record, etc.)
6. Other (specify): _____

D5. Professionally, overall I would describe myself as being pro-technology.

1. Yes
2. No
3. Do not know

Section E: Future Plans

E1. How many hours per week do you expect to work 1 year from now? (Use 0 if you plan to retire within a year.) [0 . . . 168]

E2. How many hours per week do you expect to work 5 years from now? (Use 0 if you plan to retire within 5 years.) [0 . . . 168]

E3. When do you expect to retire from anesthesia practice?

1. Before the end of this year (2007)
2. 2008 to 2010
3. 2011 to 2015
4. 2016 to 2020
5. After 2020

APPENDIX C

Director of Anesthesiology Survey Questionnaire

Section A: Facility Information

A1. Which of the following best describes your facility? (Choose all that apply.)

1. A hospital (IF CHOSEN GO TO A2; ELSE GO TO A4)
2. Ambulatory surgery center
3. One or more physicians
4. A managed care organization
5. Another health care provider
6. A healthcare corporation that owns multiple healthcare facilities (e.g., HCA or Health South)
7. Other: _____

A2. What type of ownership is this hospital?

1. Nonprofit
   a. Government
   b. Church related
   c. Other: _____
2. For profit

A3. Is this hospital a teaching hospital?

1. Yes (SKIP TO A4)
2. No
   a. What percentage of your physicians are affiliated with a teaching hospital? _____ %

A4. What percentage of your facility's revenue from patient care comes from

1. Government (Medicare, Medicaid, etc.): _____ %
2. Private insurance (Fee-for-service, HMO, PPO): _____ %
3. Self pay: _____ %
4. Charity, write off, no charge, etc.: _____ %

A5. Enter the total number of physicians *directly employed* by your facility. If you obtain all physician services through independent providers choose zero.

1. 0 (GO TO A6)
2. [1–50]
3. [51–100]
4. [101–150]
5. [151–200]
6. [200–250]
7. >250

A5a. What % of these physicians are

1. Part-time (1 to 20 hours per week)
2. Full-time (21 to 40 hours per week)
3. Per diem, temporary, locum tenens

A6. Enter the total number of RNs *directly employed* by your facility. If you obtain all RN services through independent providers choose zero.

1. 0 (GO TO Section B)
2. [1–50]
3. [51–100]
4. [101–150]
5. [151–200]
6. [200–250]
7. >250

A6a. What % of these RNs are

1. Part-time (1 to 20 hours per week)
2. Full-time (21 to 40 hours per week)
3. Per diem, temporary, locum tenens

Section B: Overall AN/CRNA Employment Information

B1. Does your facility directly employ any Anesthesiologists? If you obtain all Anesthesiologist services through independent providers choose "No."

1. Yes (GO TO B1a)
2. No (GO TO B5)

B1a. On average, what percentage of requests for Anesthesiologists do you meet using

1. In-house Anesthesiologists
2. Anesthesiologists from independent providers

B2. How many job openings for Anesthesiologists did you have open (and filled) for last year (2006), this year (2007; projected), and next year (2008; projected) (IN MATRIX FORM)?

1. Part-time (1 to 20 hours per week)
2. Full-time (21 to 40 hours per week)
3. Per diem, temporary, locum tenens

B3. On average, *how many weeks* did you have to wait for these Anesthesiologist positions to be filled from the time they became available, last year (2006), this year (2007; projected), and next year (2008; projected) (IN MATRIX FORM)?

1. Part-time (1 to 20 hours per week)
2. Full-time (21 to 40 hours per week)
3. Per diem, temporary, locum tenens

B4. During last year (2006), this year (2007; projected), and next year (2008; projected), how many of the *Anesthesiologists* employed by your facility stopped working on account of (IN MATRIX FORM)

1. Termination (layoff, discharge, etc.)
2. Leaving for a different employer
3. Leaving for a different division/department of your facility
4. Retirement
5. Disability, Death, Other reasons

B5. Does your facility directly employ any CRNAs? If you obtain all CRNA services through independent providers choose "No."

1. Yes (GO TO B5a)
2. No (GO TO B9)

B5a. On average, what percentage of requests for CRNAs do you meet using

1. In-house CRNAs
2. CRNAs from independent providers

B6. How many job openings for CRNAs did you have open (and filled) for last year (2006), this year (2007; projected), and next year (2008; projected) (IN MATRIX FORM)?

1. Part-time (1 to 20 hours per week)
2. Full-time (21 to 40 hours per week)
3. Per diem, temporary, locum tenens

B7. On average, *how many weeks* did you have to wait for these CRNA positions to be filled from the time they became available, last year (2006), this year (2007; projected), and next year (2008; projected) (IN MATRIX FORM)?

1. Part-time (1 to 20 hours per week)
2. Full-time (21 to 40 hours per week)
3. Per diem, temporary, locum tenens

B8. During last year (2006), this year (2007; projected), and next year (2008; projected), how many of the *CRNAs* employed by your facility stopped working on account of (IN MATRIX FORM)

1. Termination (layoff, discharge, etc.)
2. Leaving for a different employer
3. Leaving for a different division/department of your facility
4. Retirement
5. Disability, Death, Other reasons

B9. In what form would you be able to provide compensation levels for Anesthesiologists and CRNAs?

1. Hourly pay/fee (GO TO B10)
2. Annual pay/fee (GO TO B11)
3. Neither (GO TO Section C)

B10. What is the average *hourly* pay/fee of

1. Anesthesiologists
    a. Part-time (1 to 20 hours per week)
    b. Full-time (21 to 40 hours per week)
    c. Per diem, temporary, locum tenens
2. CRNAs
    a. Part-time (1 to 20 hours per week)
    b. Full-time (21 to 40 hours per week)
    c. Per diem, temporary, locum tenens

B10a. INTERMEDIATE SCREEN IF RESPONDENT LEAVES ALL OF THE ABOVE BLANK. GIVE RANGES:

1. <$50
2. [$50–$75]
3. [$75–$100]
4. [$100–$125]
5. [$125–$150]
6. [$150–$175]
7. [$175–$200]
8. >$200

B11. What is the average *annual* pay/fee of

1. Anesthesiologists
   a. Part-time (1 to 20 hours per week)
   b. Full-time (21 to 40 hours per week)
   c. Per diem, temporary, locum tenens
2. CRNAs
   a. Part-time (1 to 20 hours per week)
   b. Full-time (21 to 40 hours per week)
   c. Per diem, temporary, locum tenens

B11a. INTERMEDIATE SCREEN IF RESPONDENT LEAVES ALL OF THE ABOVE BLANK. GIVE RANGES:

1. <$75K
2. [$75K–$100K]
3. [$100K–$125K]
4. [$125K–$150K]
5. [$150K–$175K]
6. [$175K–$200K]
7. [$200K–$225K]
8. [$225K–$250K]
9. [$250K–$275K]
10. [$275K–$300K]
11. [> $300K]

Section C: AN/CRNA Assignment Information

C1. On average, the services of how many *Anesthesiologists* are required in your facility per working *day* (independent of whether each performs multiple procedures or works with other Anesthesiologists and/or CRNAs)? [0 . . . 100]

C1a. INTERMEDIATE SCREEN IF RESPONDENT LEAVES THE ABOVE BLANK. GIVE RANGES:

1. [1–5]
2. [6–10]
3. [11–15]
4. [16–20]
5. [21–25]
6. [26–30]
7. [31–35]
8. [36–40]
9. [41–45]
10. [46–50]
11. >50

C2. On average, the services of how many *CRNAs* are required in your facility per working *day* (independent of whether each performs multiple procedures or works with other CRNAs and/or Anesthesiologists)? [0 . . . 100]

C2a. INTERMEDIATE SCREEN IF RESPONDENT LEAVES THE ABOVE BLANK. GIVE RANGES:

1. [1–5]
2. [6–10]
3. [11–15]
4. [16–20]
5. [21–25]
6. [26–30]
7. [31–35]
8. [36–40]
9. [41–45]
10. [46–50]
11. >50

C3. On average, how many anesthesia procedures are performed in your facility (you can choose to provide this for one of the following time durations):

1. Weekly
2. Monthly
3. Annual

C4. What percentage of anesthesia professionals' time utilized by your facility is spent on procedures involving the following types of sedation (IN MATRIX FORM FOR ANESTHESIOLOGISTS, CRNAs)?

1. Monitored anesthesia
2. Regional/Spinal anesthesia
3. General anesthesia

C5. What percentage of anesthesia professionals' time utilized by your facility is spent on procedures involving the following types of services (IN MATRIX FORM FOR ANESTHESIOLOGISTS, CRNAs)?

1. Pre-operative evaluation and consenting
2. Anesthesia during procedures
3. Post-operative recovery
4. ICU medicine
5. Chronic and acute pain management
6. Advanced life support
7. Other services

C6. What percentage of anesthesia professionals' time utilized by your facility is spent on procedures involving the following specialties (IN MATRIX FORM FOR ANESTHESIOLOGISTS, CRNAs)?

1. Ambulatory Anesthesia
2. Cardiac Anesthesia
3. Critical Care
4. General
5. Neurological Anesthesia
6. Obstetrical Anesthesia
7. Pain Management
8. Pediatric Anesthesia
9. Trauma
10. Other specialties

C7. On average, what percentage of requests for anesthesia services do you have to reschedule or postpone due to lack of availability of Anesthesiologists? [0 . . 100]

C8. On average, what percentage of requests for anesthesia services do you have to reschedule or postpone due to lack of availability of CRNAs? [0 . . 100]

C9. How would you characterize the availability of Anesthesiologists in your facility?

1. Need more to meet current demand
2. Availability sufficient for current demand
3. Need less for existing demand

C10. How would you characterize the availability of CRNAs?

1. Need more to meet current demand
2. Availability sufficient for current demand
3. Need less for existing demand

Section D: Technology Preference & Usage

D1. The medical technology available in Anesthesiology (patient monitoring equipment, delivery system for anesthesia drugs, automated procedures, etc.) causes procedures in our facility to be performed

1. Considerably faster
2. Faster
3. No change in the rate
4. Slower
5. Considerably slower

D2. The medical technology available in Anesthesiology (patient monitoring equipment, delivery system for anesthesia drugs, automated procedures, etc.) causes our facility to provide

1. Considerably higher-quality patient care
2. Higher-quality patient care
3. No change in the quality
4. Lower-quality patient care
5. Considerably lower-quality patient care

D3. For each of the following levels of sedation, choose the availability of technology your facility would prefer (exclude cost considerations for now; we will ask about costs later)

1. Monitored anesthesia care
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
2. Regional/Spinal anesthesia administration
   a. Lower than present level
   b. Same as present level

   c. Higher than present level
3. General anesthesia administration
   a. Lower than present level
   b. Same as present level
   c. Higher than present level

D4. For each of the following types of services choose the availability of technology your facility would prefer (exclude cost considerations for now; we will ask about costs later):

1. Pre-operative evaluation and consenting
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
2. Anesthesia during procedures
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
3. Post-operative recovery
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
4. ICU medicine
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
5. Chronic and acute pain management
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
6. Advanced life support
   a. Lower than present level
   b. Same as present level
   c. Higher than present level
7. Other services
   a. Lower than present level
   b. Same as present level
   c. Higher than present level

D5. Rate the likely effectiveness of the following options on the overall quality of monitored anesthesia care in your facility.

1. Greater availability of CRNAs
   a. Very likely to improve
   b. Likely to improve
   c. Be about the same as it is now
   d. Unlikely to improve
   e. Highly unlikely to improve
2. Greater availability of Anesthesiologists
   a. Very likely to improve
   b. Likely to improve
   c. Be about the same as it is now
   d. Unlikely to improve
   e. Highly unlikely to improve
3. Greater availability of automated monitoring technology
   a. Very likely to improve
   b. Likely to improve
   c. Be about the same as it is now
   d. Unlikely to improve
   e. Highly unlikely to improve

D6. Do you think that greater use of technology in the area of monitored anesthesia care will lead to cost-savings?

1. Yes (GO TO D6a)
2. No (GO TO END)

D6a. Which of the following factors are likely to contribute to this cost reduction? (Select all that apply)

1. Reduced time to perform procedures
2. Reduced use of Anesthesiologists
3. Reduced use of CRNAs
4. Reduced malpractice costs
5. Other cost-savings

APPENDIX D

Relevant Portions of the Survey of Surgeons

Section A: General Information

A1. What is your gender?

1. Male
2. Female

A2. In what year were you born? [1900 . . . 1989]

A3. When did you start practice as a physician? [1930 . . . 2007]

A4. Which of the following best describes your primary specialty?

1. Cardiothoracic surgery
2. General surgery
3. Neurosurgery
4. Ophthalmic surgery
5. Oral and maxillofacial surgery
6. Orthopedic surgery
7. Otorhinolaryngology
8. Plastic surgery
9. Vascular surgery
10. Urology
11. OBGYN
12. Cardiology
13. Gastroenterology
14. Interventional radiology
15. Other: Specify _____

Section B: Practice location

This section asks about the locations where you currently conduct procedures.

B1. Select all the locations where you currently conduct procedures and indicate the percentage of procedures you conduct in each location.

1. Own office _____%
2. One or more hospitals _____%
3. Free standing ambulatory surgery center _____%
4. Other: Specify _____ _____%

= 100%

B2. Provide your best estimate of the locations where you will conduct procedures five years from now.

1. Own office _____%
2. One or more hospitals _____%
3. Free standing ambulatory surgery center _____%
4. Other: Specify _____ _____%

= 100%

B3. Approximately how many of the following professionals work in your primary procedure location? The "primary procedure location" is the location where you perform the largest share of your procedures.

1. Surgeons or interventional physicians [0, 1,000, Do Not Know]
   a. Surgeons practicing the same specialty as you [0, 1,000, Do Not Know]
2. Anesthesiologists [0,300, Do Not Know]
3. Anesthesiology residents [0,300, Do Not Know]
4. Anesthesiology Assistants [0,300, Do Not Know]
5. Certified Registered Nurse Anesthetists [0, 300, Do Not Know]
6. Student Registered Nurse Anesthetists [0,300, Do Not Know]

Section C: Compensation, hours worked, and malpractice coverage

C1. In total, how many hours do you work in a typical week? Please include all of your clinical, research, administrative, and teaching duties in your response. [1 . . . 168]

C2. What percentage of your overall time is spent conducting procedures? _____%

C3. What is your willingness to increase the total hours you work? Please consider all of your clinical, research, administrative, and teaching duties in your response.

1. I would be willing to increase total hours worked, if fairly compensated
2. I would not be willing to increase total hours worked even if fairly compensated
3. Can't say

[IF 1, SKIP TO QUESTION C5]

C4. [C3 = 2] Please indicate why you are unwilling to increase your total work hours. Select one.

1. I am satisfied with my current level of income
2. I do not have any more time available.
3. Other: Specify _____

[GO TO QUESTION C6]

C5. [C3 = 1] How much would your income have to increase in order for you to increase your work hours by 10%?

1. If income increased by 5%
2. If income increased by 10%
3. If income increased by 20%
4. If income increased by 25%
5. If income increased by more than 25%

C6. Who pays your malpractice insurance premium?

1. Self (including your own PC or LLC)
2. Hospital
3. Employer
4. Other. Specify _____
5. Do not know

C7. What are the coverage limits on your malpractice insurance?

1. I don't carry individual malpractice insurance
2. $1,000,000 per incident/$3,000,000 per year
3. $2,000,000 per incident/$5,000,000 per year
4. Other: Specify _____
5. Do not know

C8. What is the annual cost of your malpractice insurance premium (average mature provider premium, exclusive of "tail" coverage)?

1. $_____
2. Do not know

Section E: Opinions about technology

E1. Please complete the following sentence: The facility where I do the majority of procedures adopts new technology. . . . Examples of new technologies include endoscopes, instruments for laparoscopic surgery, and surgical robots.

1. Too frequently
2. At the right pace
3. Not frequently enough
4. No opinion

E2. Adopting new technology:

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
1. Increases patient safety					
2. Improves quality of patient care					
3. Allows for additional functionality					
4. Frees physicians from routine tasks					
5. Provides an interesting work environment					
6. Improves efficiency (better utilization of resources, better scheduling, etc.)					

E3. Generally speaking, do you think you receive an adequate amount of training about how to use new technology?

1. Yes
2. No
3. Do not know

E4. Professionally, would you describe yourself as being pro-technology?

1. Yes
2. No
3. Do not know

APPENDIX E

Technical Details on Demand-Based Assessment

Denote by n_{Ki} the number of workers in occupation $K = AN, CRNA$ in a state i. Denote by q_{Ki} the FTE total employment, where

$$q_{Ki} = n_{Ki} \frac{\overline{t}_{Ki}}{t_K}$$

and $\overline{t}_{Ki}$ is the average number of clinical hours in the state, while t_K is a predefined number of clinical hours considered as full time. Denote by $\overline{t}_{Kij}$ the average time to do a procedure of type j in state i and p_{Kij} the average number of procedures of type j in state i.

We observe q_{Ki}, which can be seen as the minimum of the quantity demanded or supplied. If there is excess demand, $q_{Ki} = q^s_{Ki}$, while, if there is excess supply, we observe $q_{Ki} = q^d_{Ki}$. We can calculate q_{Ki} either using total clinical hours,

$$q_{Ki} = n_{Ki} \frac{\overline{t}_{Ki}}{t_K},$$

or using the "demand" for labor,

$$q_{Ki} = n_{Ki} \frac{\sum_j p_{Kij} \overline{t}_{Kij}}{t_K},$$

since

$$\overline{t}_{Ki} = \sum_j p_{Kij} \overline{t}_{Kij}.$$

In the first assumption, labor supply is similar across states such that there exists a desired number of hours worked that is the same across the country. This assumption takes the form

$$L_0 : t^s_{Ki} = t_K,$$

where we choose t_K for simplicity, but the key point is that desired hours of work are the same across states i. (In practice, this is chosen to be the national average workweek from our surveys.) If this is the case, then shortage is given by

$$s_{Ki} = q^d_{Ki} - q^s_{Ki} = \frac{n_{Ki}}{t_K}\left(\sum\nolimits_j p_{Kij}\bar{t}_{Kij} - t_K\right) = \frac{\bar{t}_{Ki} - t_K}{t_K} q_K .$$

Hence, states where inputs work more (less) than the desired level are in excess demand (supply).

In the second assumption, the same amount of time taken to do a particular procedure is same across states. The assumption takes the form

$$D_0 : \bar{t}^d_{Kij} = \bar{t}_{Kj}.$$

We can use such "chart times" to calculate counterfactual demand and compare with actual supply. The shortage simplifies to

$$s_{Ki} = q^d_{Ki} - q^s_{Ki} = \frac{n_{Ki}}{t_K}\sum\nolimits_j p_{Kij}\left(\bar{t}_{Kj} - \bar{t}_{Kij}\right).$$

Hence, states where procedures are done faster have a larger shortage.

Combining both assumptions yields the following expression for shortage:

$$s_{Ki} = q^d_{Ki} - q^s_{Ki} = \frac{n_{Ki}}{t_K}\sum\nolimits_j \left(p_{Kij} - p_{Kj}\right)\bar{t}_{Kj}.$$

This implies that the variation in the number of procedures is exploited to distinguish demand from supply.

APPENDIX F

Technical Details on Econometric Analysis

Supply

Denote by $q^s_{C,j}$ the amount of hours supplied by a CRNA in state i and, similarly, $q^s_{A,i}$ the amount of hours supplied by an AN in the same state. Denote the type of labor (AN or CRNA) by the index $K = A,C$.

Workers can work for a wage rate $w_{K,i}$, and $\mu_{K,i}$ represents nonlabor income. We use a log-log specification for labor supply:

$$\log q^s_{K,i} = \mathbf{x}_{K,i}\gamma_{K,s} + \alpha_K \log w_{K,i} + \theta_K \mu_{K,i} + \varepsilon^s_{K,i}, \tag{F.1}$$

where α_K is the Marshallian (uncompensated) wage elasticity. We introduce $\varepsilon^s_{K,i}$, an unobserved preference component, and $\mathbf{x}_{j,k}$ is a vector of observed preference shifters.

We asked questions in the AN and CRNA surveys that would allow us to directly calculate the elasticity of labor supply with respect to the wage rate (the percentage increase in labor supply when the wage rate increases by 1 percent). The resulting distribution of this elasticity by state is shown in Figure 4.3 for ANs and Figure 4.4 for CRNAs (both in Chapter Four).

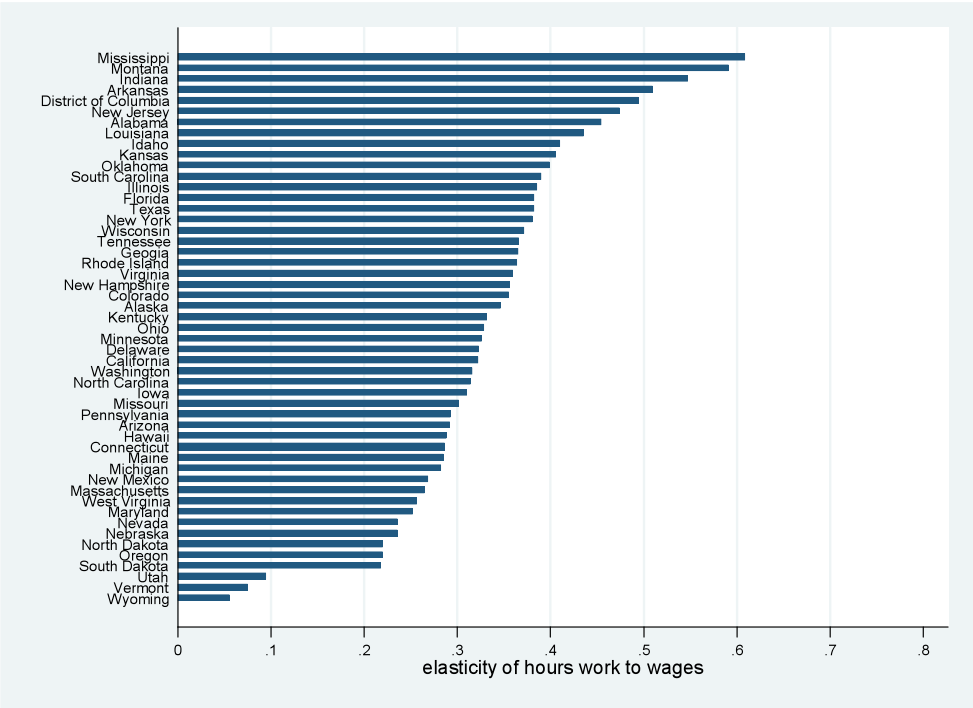
The estimated elasticities vary considerably across states but reveal relatively "inelastic" labor supply. That is, wage increases are likely to produce low increases in the labor supply in response. The average elasticity across states is lower for ANs, at 0.34, than the 0.41 figure for CRNAs (see Figures F.1 and F.2, respectively). The lower estimates for ANs could reflect their higher degree of specialization. The estimates are in the middle of the range estimated in the labor-supply literature for the overall population. Blundell and Macurdy (1999) report estimates in the literature ranging from 0 to 0.9, with most estimates clustered close to the 0.1–0.3 range.

Demand

We assume the existence of a demand function, which is determined at the facility level but is aggregated up to the state level. We proceed from the dual problem and assume the existence of a cost function such that demand functions depend on output (number of procedures). The equation for demand of each input is given by

$$\log q^d_{K,i} = \mathbf{x}_{K,i}\gamma_{d,K} + \Sigma_{K'=C,A}\delta_{KK'} \log w_{K'i} + \delta_{Ky} \log y_i + \varepsilon^d_{k,i}, \tag{F.2}$$

Figure F.1
Estimated Average Elasticity for Anesthesiologists



where y_i is output in state i and $\varepsilon^d_{K,i}$ is an unobserved demand shifter. From this specification, we can define relevant elasticities. First, estimates of δ_{AA}, δ_{CC} give the constant-output elasticity of demand for each input and δ_{AC}, δ_{CA} the constant-output cross-elasticity for the demand for ANs and CRNAs.

Equilibrium

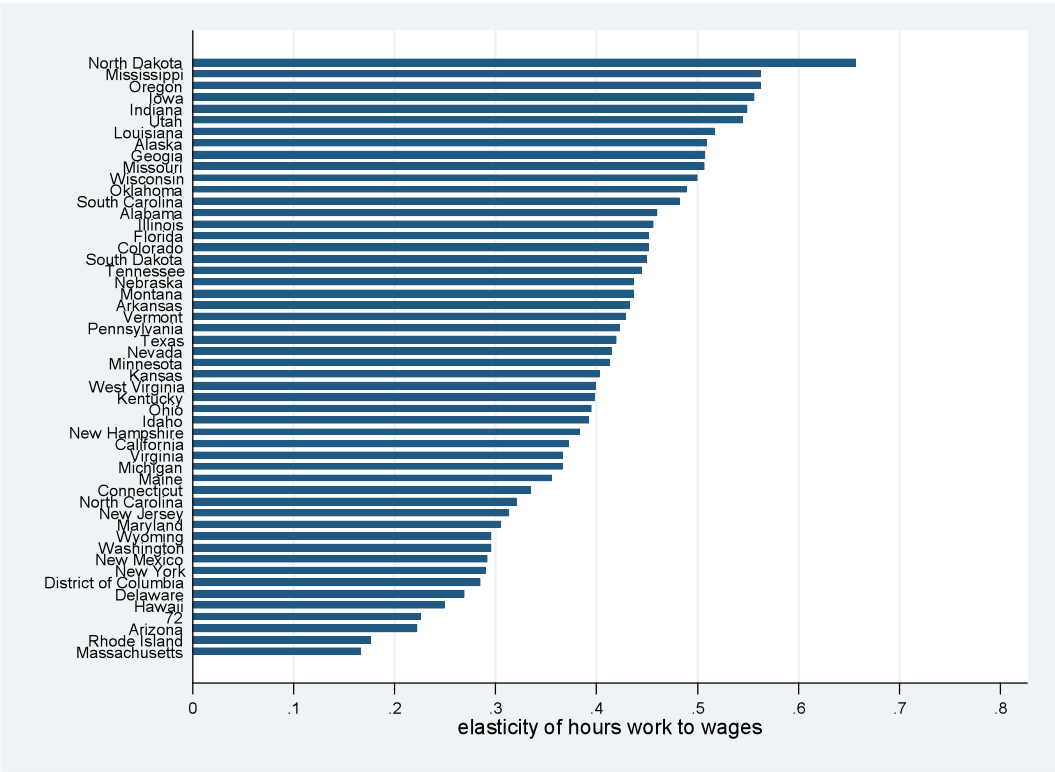
If the data we observe represent an equilibrium, then wages are endogenous and we observe

$$\log q_{K,i} = \log q^d_{K,i} = \log q^s_{K,i}. \tag{F.3}$$

Because the sample is relatively small, identification of correlations between the unobserved preference and demand shifters is tenuous. Hence, we assume that such correlations are 0.

The equilibrium model is estimated by two-stage least squares. In both the disequilibrium and equilibrium models, we weight each observation (state) by the square root of the number of respondents used in computing the aggregate statistics. (This is done for reasons of efficiency and is not to be confused with sampling weights, which are used to aggregate up to the population quantities—the *q*s—used in the analysis.) Under the assumption that each response has the same variance, the sampling variance will be inversely proportional to the square root of each cell's size.

Figure F.2
Estimated Average Elasticity for Certified Registered Nurse Anesthetists



Disequilibrium

Here, wages are exogenous, and the minimum of quantity demanded and supplied is observed:

$$\log q_{K,i} = \min\left(\log q^{s}_{K,i}, \log q^{d}_{K,i}\right). \tag{F.4}$$

In the case where $\log q_{K,i} = \log q^{s}_{K,i}$, we are in a situation of excess demand.

One assumption that might not hold is that output is exogenous. In particular, it is likely correlated with technology or productivity, for which we have poor control. We used as an instrument the number of beds in the state under the assumption that capacity is predetermined while output might not be. When presenting our estimates, we report the partial F-statistic on the instrument. Overall, the number of beds explains roughly 85 percent of the variation in output.

The conditional expectation of demand and supply in the disequilibrium model is not linear in parameters such that we cannot estimate it by linear regression. Following Maddala and Nelson (1974), we estimate the model by maximum likelihood. The derivation of the likelihood function is available from the authors upon request. The model is characterized by two regimes for each input: excess demand and supply. Assuming that the unobserved shifters in Equations F.1 and F.2 are normally distributed, it is straightforward to derive the probabilities characterizing the two regimes. Following Gourieroux (2000), we can estimate how far wages are from equilibrium wage.

Factors Affecting Allocation of Anesthesia Labor

We include a number of state-level variables from sources other than our surveys, in order to characterize the states and associate them with supply or demand.

- Demand Factors
  - First, we use the ARF to get information on the total population and population 65 or older. We also use a measure of population density and median income.
  - Second, we also use the number of beds available in the states as a measure of capacity.
  - Third, as a proxy for competition, we use the HMO penetration rate for 2004.

- Supply Factors
  - We use information on AN residency positions available for the year 2004. ANs need to obtain a license with the state's medical board in order to practice in that state. In the absence of detailed information on the mobility of ANs, we assume that those finishing their residency are likely to stay in the same state.
  - CRNAs are not subject to residency requirements. But the number of education programs in a state may serve as a good proxy of the quantity of trained CRNAs. For CRNAs, we obtained information on the number of accredited nurse-anesthetist education programs in the state.

APPENDIX G

Summary Statistics of Clinical Hours and Procedures Used in Demand-Based Analysis

Table G.1
Clinical Hours and Procedures: Anesthesiologists

		Weekly Clinical Hours			Weekly Procedures		
State	Total Observations	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation
Alabama	56	53	54.5	9.9	39	97.9	60.2
Alaska	4	3	63.3	5.8	0	—	—
Arizona	113	98	49.4	13.9	77	35.7	20.1
Arkansas	28	23	45.6	11.2	15	50.9	38.9
California	443	383	46.1	15.5	272	31.9	22.5
Colorado	88	79	48.1	11.0	59	43.2	36.1
Connecticut	75	66	52.2	12.3	49	60.8	48.7
Delaware	12	11	53.6	9.5	7	41.6	15.5
D.C.	12	10	43.4	20.3	7	37.1	28.1
Florida	213	191	51.7	14.9	147	72.8	71.1
Georgia	105	89	50.5	12.7	64	62.5	64.8
Hawaii	17	15	51.1	11.7	13	34.0	21.3
Idaho	10	9	43.9	10.1	7	38.4	21.2
Illinois	182	153	51.0	14.5	107	50.9	34.4
Indiana	115	102	47.2	14.9	80	32.2	18.8
Iowa	50	47	46.3	14.3	33	33.8	20.1
Kansas	50	45	43.7	14.5	32	65.3	53.0
Kentucky	59	49	50.4	13.4	39	54.9	51.1
Louisiana	37	33	46.0	11.2	25	78.2	72.5
Maine	31	25	45.6	9.7	16	51.3	33.5
Maryland	126	104	46.8	14.0	75	34.1	22.8
Massachusetts	179	150	43.0	14.8	105	50.4	106.4

Table G.1—Continued

State	Total Observations	Weekly Clinical Hours			Weekly Procedures		
		Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation
Michigan	110	104	50.3	15.3	78	68.9	58.8
Minnesota	117	103	49.4	12.6	68	103.3	242.2
Mississippi	13	10	54.3	7.8	6	60.7	38.8
Missouri	104	95	48.9	13.3	65	53.9	35.6
Montana	21	20	49.2	12.3	14	38.3	15.1
Nebraska	25	23	50.7	15.1	19	47.5	30.9
Nevada	27	22	57.4	16.2	18	31.1	20.0
New Hampshire	28	23	50.5	10.9	16	56.3	38.2
New Jersey	110	92	46.6	16.0	66	53.9	39.8
New Mexico	20	16	49.4	15.4	13	32.9	14.6
New York	262	216	47.5	14.7	160	43.8	62.8
North Carolina	141	121	50.7	12.8	82	77.5	78.1
North Dakota	11	7	49.9	15.4	7	52.9	8.5
Ohio	177	152	49.7	13.2	106	53.8	45.6
Oklahoma	56	46	48.4	13.4	37	59.4	150.6
Oregon	79	71	46.3	17.4	49	42.2	32.1
Pennsylvania	239	209	47.4	14.0	162	58.8	44.2
Rhode Island	15	14	49.4	10.3	9	57.2	57.1
South Carolina	58	53	51.6	12.7	46	65.1	49.2
South Dakota	9	6	59.2	7.4	4	71.8	16.1
Tennessee	84	67	48.1	13.5	47	72.0	78.2
Texas	283	244	49.3	14.2	190	49.1	78.5
Utah	47	44	48.0	16.8	33	42.3	27.1
Vermont	14	14	41.6	10.9	10	39.6	25.2
Virginia	139	108	49.6	12.1	90	52.4	39.6
Washington	172	147	45.9	13.8	102	42.2	50.1
West Virginia	21	19	50.2	12.1	15	57.3	48.9
Wisconsin	97	89	49.0	12.5	68	44.8	31.4
Wyoming	3	3	56.7	15.3	2	33.0	7.1
Total	4,487	3,876	48.5	14.2	2,850	48.4	13.9

Table G.2
Clinical Hours and Procedures: Certified Registered Nurse Anesthetists

		Weekly Clinical Hours			Weekly Procedures		
State	Total Observations	Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation
Alabama	105	95	37.3	10.1	83	32.3	23.5
Alaska	13	13	37.8	10.1	12	31.1	14.9
Arizona	31	29	36.2	12.8	21	29.8	12.1
Arkansas	43	40	42.9	15.3	34	35.5	17.3
California	170	157	36.2	12.9	131	29.6	18.6
Colorado	33	33	34.3	8.7	27	33.0	18.2
Connecticut	44	43	33.6	14.2	37	31.7	18.0
Delaware	29	28	38.0	8.6	21	41.3	21.5
D.C.	6	4	42.0	25.7	3	22.3	11.0
Florida	272	259	37.1	11.0	197	39.2	21.7
Georgia	133	127	36.3	9.7	104	32.9	17.5
Hawaii	15	14	36.9	7.1	12	31.1	18.4
Idaho	44	40	37.8	11.3	36	32.8	15.0
Illinois	140	126	35.4	13.5	101	29.3	15.9
Indiana	48	46	36.3	11.8	30	36.6	22.2
Iowa	47	45	37.5	11.3	32	36.5	18.7
Kansas	84	82	37.2	11.9	69	36.0	21.3
Kentucky	97	93	40.0	9.8	70	34.1	17.1
Louisiana	100	92	40.4	12.3	75	37.0	24.6
Maine	40	36	32.3	11.5	30	28.0	19.4
Maryland	63	57	36.6	8.8	45	32.5	17.7
Massachusetts	67	62	37.1	11.9	50	35.1	24.6
Michigan	231	216	37.1	11.4	179	39.4	26.0
Minnesota	198	184	32.8	12.0	151	28.2	19.2
Mississippi	47	43	34.3	8.3	34	34.8	21.4
Missouri	130	124	39.7	12.2	99	36.3	21.4
Montana	20	19	37.3	11.8	18	39.6	22.6
Nebraska	49	47	37.8	11.6	38	33.8	21.9
Nevada	15	12	37.0	12.0	8	30.4	23.3
New Hampshire	27	24	38.6	6.7	17	38.2	21.8
New Jersey	59	56	34.6	11.0	45	34.1	19.0

Table G.2—Continued

State	Total Observations	Weekly Clinical Hours			Weekly Procedures		
		Obs.	Mean	Standard Deviation	Obs.	Mean	Standard Deviation
New Mexico	25	23	33.3	11.9	17	34.8	23.0
New York	112	104	36.1	13.0	86	34.8	22.4
North Carolina	258	242	35.7	11.9	192	29.9	19.4
North Dakota	31	29	34.0	9.9	24	32.5	18.1
Ohio	242	231	34.9	11.0	187	31.9	20.7
Oklahoma	43	42	40.7	14.0	33	34.3	22.5
Oregon	48	45	41.6	11.4	33	31.8	15.3
Pennsylvania	273	257	37.3	13.0	212	38.4	27.0
Rhode Island	17	16	37.8	7.6	13	37.8	19.5
South Carolina	111	105	37.2	12.2	79	36.1	20.3
South Dakota	42	41	33.9	10.6	31	27.9	15.2
Tennessee	141	134	37.7	12.3	101	34.7	18.6
Texas	320	303	37.8	11.8	245	35.0	24.7
Utah	30	26	37.2	11.7	21	26.5	14.9
Vermont	10	8	28.7	7.4	7	21.7	6.2
Virginia	142	128	36.8	10.4	108	33.2	18.4
Washington	98	89	35.9	11.6	77	29.3	19.7
West Virginia	51	47	39.7	12.0	35	40.8	27.3
Wisconsin	98	94	37.9	10.8	80	31.9	15.6
Wyoming	9	9	41.1	16.8	7	25.1	15.4
Total	4,501	4,219	36.7	12.1	3,397	36.8	11.8

APPENDIX H

Demand-Based Analysis with Alternative Workweek Definitions

In this appendix, we present the noneconomic analysis with a fixed workweek of 40 hours for ANs and CRNAs. The results are presented in Tables H.1 and H.2.

Table H.1
Demand-Based Analysis Results: Anesthesiologists with Full-Time Equivalents of 40 Hours per Week

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
Alabama	153.539	0.268	407.456	0.711	562.669	0.982
Arizona	199.036	0.204	–223.669	–0.229	–26.438	–0.027
Arkansas	28.278	0.097	6.778	0.023	44.232	0.152
California	783.882	0.142	–1,593.376	–0.288	–844.971	–0.153
Colorado	112.756	0.157	–91.374	–0.127	32.956	0.046
Connecticut	143.091	0.224	126.182	0.198	277.276	0.434
Delaware	22.143	0.245	1.429	0.016	23.322	0.258
D.C.	7.397	0.053	–35.402	–0.254	–21.96	–0.157
Florida	727.727	0.228	755.384	0.237	1,490.029	0.467
Georgia	192.988	0.182	137.11	0.129	349.104	0.329
Hawaii	22.164	0.174	–36.456	–0.287	–11.579	–0.091
Idaho	1.104	0.016	10.724	0.152	11.828	0.168
Illinois	452.775	0.205	–66.726	–0.03	412.914	0.187
Indiana	137.723	0.138	–202.04	–0.203	–54.418	–0.055
Iowa	43.605	0.124	–78.969	–0.225	–34.367	–0.098
Kansas	30.9	0.093	114.056	0.344	142.914	0.431
Kentucky	122.868	0.2	–34.756	–0.057	91.361	0.149
Louisiana	74.184	0.133	257.977	0.462	326.891	0.586
Maine	20.783	0.152	19.12	0.14	36.626	0.268
Maryland	133.908	0.119	–167.533	–0.149	–8.043	–0.007
Massachusetts	112.852	0.076	–112.539	–0.076	–7.422	–0.005

Table H.1—Continued

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
Michigan	201.719	0.197	279.486	0.273	470.453	0.459
Minnesota	140.901	0.221	245.505	0.385	372.885	0.584
Mississippi	46.988	0.27	–46.289	–0.266	0.795	0.005
Missouri	173.346	0.223	5.604	0.007	150.016	0.193
Montana	28.163	0.267	–36.916	–0.35	–10.116	–0.096
Nebraska	59.563	0.218	–7.409	–0.027	49.11	0.18
Nevada	143.684	0.299	–189.85	–0.395	–45.602	–0.095
New Hampshire	27.664	0.25	28.57	0.258	58.322	0.527
New Jersey	297.239	0.173	94.858	0.055	348.8	0.202
New Mexico	44.033	0.191	–73.421	–0.318	–22.97	–0.1
New York	575.842	0.149	–718.8	–0.186	–96.199	–0.025
North Carolina	185.051	0.188	326.558	0.332	539.168	0.548
North Dakota	8.24	0.155	12.604	0.238	20.845	0.393
Ohio	353.963	0.195	282.31	0.155	648.434	0.356
Oklahoma	60.437	0.175	–47.595	–0.138	10.439	0.03
Oregon	118.753	0.217	–57.387	–0.105	34.335	0.063
Pennsylvania	278.806	0.152	306.991	0.167	587.733	0.32
Rhode Island	21.967	0.157	21.855	0.156	47.56	0.34
South Carolina	114.414	0.21	172.45	0.317	293.549	0.539
South Dakota	21.341	0.33	27.953	0.432	49.294	0.762
Tennessee	127.41	0.147	286.311	0.33	433.577	0.499
Texas	677.519	0.187	–331.639	–0.092	353.044	0.098
Utah	77.66	0.186	–39.563	–0.095	34.967	0.084
Vermont	5.503	0.088	–9.876	–0.158	–3.525	–0.057
Virginia	225.233	0.199	128.794	0.114	345.545	0.306
Washington	143.733	0.139	–142.342	–0.138	–6.702	–0.006
West Virginia	41.381	0.214	8.56	0.044	52.098	0.27
Wisconsin	183.29	0.199	–50.712	–0.055	120.815	0.131

NOTE: Step 1 assumes clinical hours constant across states, 2 assumes a common technology, and 3 combines the two.

Table H.2
Demand-Based Analysis Results: Certified Registered Nurse Anesthetists with Full-Time Equivalents of 40 Hours per Week

	Step 1		Step 2		Step 3	
State	**FTE**	**% FTE**	**FTE**	**% FTE**	**FTE**	**% FTE**
Alabama	–81.591	–0.087	–63.346	–0.067	–123.972	–0.132
Arizona	–4.648	–0.027	–22.507	–0.131	–19.863	–0.116
Arkansas	15.782	0.059	–9.6	–0.036	7.892	0.029
California	–116.331	–0.13	–116.438	–0.13	–224.886	–0.251
Colorado	–22.246	–0.137	–10.091	–0.062	–46.456	–0.286
Connecticut	–82.607	–0.315	–0.518	–0.002	–78.71	–0.3
Delaware	–10.588	–0.070	3.15	0.021	–6.998	–0.046
D.C.	13.696	0.196	–24.206	–0.346	–22.737	–0.325
Florida	–160.251	–0.078	198.47	0.096	46.009	0.022
Georgia	–88.061	–0.131	–25.979	–0.039	–105.436	–0.156
Hawaii	–6.865	–0.077	–1.23	–0.014	–6.733	–0.076
Idaho	–18.482	–0.118	–4.194	–0.027	–22.111	–0.141
Illinois	–117.122	–0.154	–89.983	–0.118	–210.188	–0.276
Indiana	–17.563	–0.099	19.658	0.111	–1.681	–0.009
Iowa	–3.769	–0.025	47.815	0.321	44.387	0.298
Kansas	–48.148	–0.146	3.622	0.011	–44.501	–0.135
Kentucky	–7.733	–0.017	–50.698	–0.112	–58.923	–0.13
Louisiana	–35.563	–0.050	–22.581	–0.032	–55.704	–0.079
Maine	–31.625	–0.202	–17.759	–0.113	–46.597	–0.297
Maryland	–30.417	–0.085	–38.452	–0.108	–72.465	–0.203
Massachusetts	–49.143	–0.092	12.006	0.022	–38.262	–0.072
Michigan	–132.551	–0.096	217.644	0.157	35.419	0.026
Minnesota	–229.858	–0.256	–73.552	–0.082	–315.135	–0.351
Mississippi	–43.479	–0.174	10.301	0.041	–25.507	–0.102
Missouri	–20.167	–0.025	4.928	0.006	–28.135	–0.035
Montana						
Nebraska	–8.812	–0.065	–19.803	–0.145	–32.879	–0.241
Nevada	–0.193	–0.003	–23.223	–0.417	–23.417	–0.42
New Hampshire	–0.058	–0.001	–13.137	–0.231	–12.518	–0.22
New Jersey	–67.460	–0.156	23.594	0.055	–45.967	–0.107

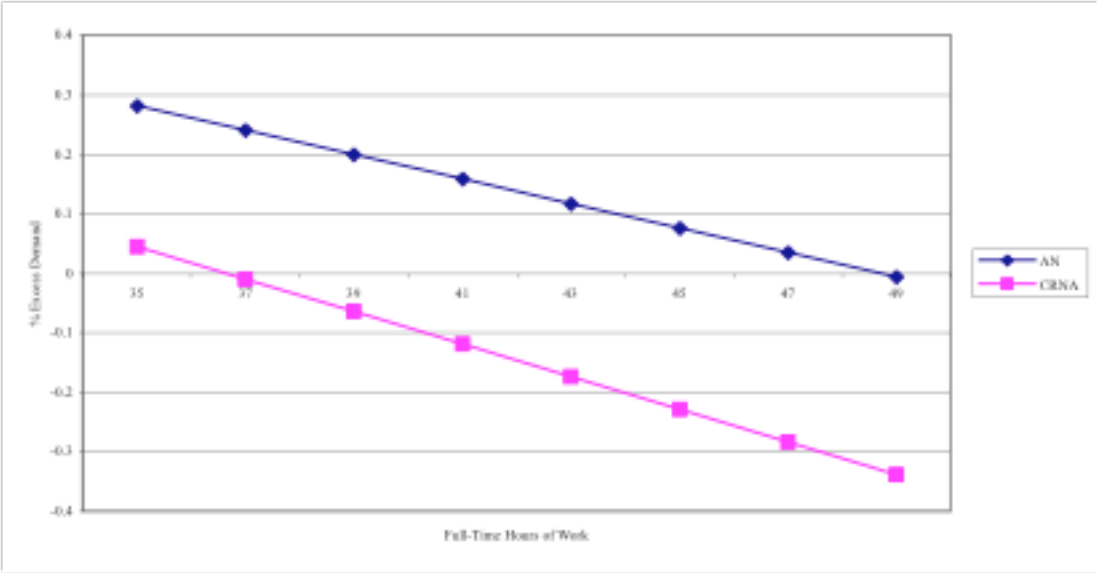
Table H.2—Continued

	Step 1		Step 2		Step 3	
State	FTE	% FTE	FTE	% FTE	FTE	% FTE
New Mexico	–21.776	–0.291	–4.053	–0.054	–23.838	–0.318
New York	–80.832	–0.114	72.61	0.103	–9.106	–0.013
North Carolina	–225.091	–0.163	–49.551	–0.036	–285.851	–0.207
North Dakota	–22.139	–0.146	31.963	0.211	11.996	0.079
Ohio	–158.991	–0.121	11.217	0.009	–123.411	–0.094
Oklahoma	7.943	0.036	–42.1	–0.19	–28.738	–0.13
Oregon	15.384	0.090	–25.163	–0.147	–19.57	–0.114
Pennsylvania	–197.930	–0.093	113.941	0.053	–87.442	–0.041
Rhode Island	–7.219	–0.072	3.72	0.037	–7.47	–0.075
South Carolina	–59.033	–0.097	47.851	0.079	–11.897	–0.02
South Dakota	–42.111	–0.280	–27.185	–0.181	–73.356	–0.487
Tennessee	–68.140	–0.065	–12.083	–0.011	–96.924	–0.092
Texas	–111.984	–0.059	–22.111	–0.012	–159.567	–0.084
Utah	2.328	0.020	–5.465	–0.046	–2.261	–0.019
Vermont						
Virginia	–47.539	–0.057	58.249	0.07	16.315	0.02
Washington	–34.956	–0.112	–40.508	–0.13	–76.115	–0.245
West Virginia	–5.658	–0.020	–34.129	–0.12	–68.612	–0.241
Wisconsin	–19.514	–0.049	–5.091	–0.013	–18.542	–0.047

NOTE: Step 1 assumes clinical hours constant across states, 2 assumes a common technology, and 3 combines the two.

They follow directly from differences in average number of clinical hours worked per week. Since CRNAs spend an average of 37 hours on procedures, using an FTE of 40 hours will cause most states to face an excess supply of CRNAs. Likewise, given that ANs spend an average of 49 hours on procedures, using 40 hours as the benchmark yields a large excess demand. Under step 1, we find that all 49 states we examine face an excess demand of ANs, while only five out of 47 states we examine face an excess demand of CRNAs. At the national level, we obtain that 7,908 more FTE ANs would be required to meet current demand, while there is a surplus of 2,483 FTE CRNAs in the market. Under step 2, the market is roughly in equilibrium at the national level, given the fact that total demand calculated using average time per procedure at the national level, by construction, equals the total number of hours supplied. For ANs, we estimate that 25 of the 49 states examined remain in shortage, and, for CRNAs, the figure is 17 out of 47, a much larger number than in step 1. When we combine the two considerations, 35 out of 49 states face an AN shortage, and six face a CRNA shortage; an overall excess demand of ANs (7,630) and excess supply of CRNAs (2,600) is found.

Figure H.1
Sensitivity of Excess Demand to Definition of Full-Time Work



Since this strategy is strongly dependent on the FTE assumed, we examine the sensitivity of the shortage/surplus estimates to this definition in Figure H.1. We plot the percentage of excess demand at the national level for both ANs and CRNAs for full-time clinical hours of work ranging from 37 to 49. For low values, both CRNA and ANs are in excess demand. There is no estimated shortage when we use as our full-time definition the mean number of hours reported in our surveys. As the workweek increases, CRNAs are in excess supply, though definitions much higher than 40 hours per week would be hard to justify given the average hours reported in the survey. Note that the CRNA market is in equilibrium for 37 hours per week and the AN market for 49 hours, consistent with the data presented in Tables 4.6 and 4.7 in Chapter Four.

Bibliography

AANA—*see* American Association of Nurse Anesthetists.

Abenstein, J. P., Kirsten Hall Long, Brian P. McGlinch, and Niki M. Dietz, "Is Physician Anesthesia Cost-Effective?" *Anesthesia and Analgesia*, Vol. 98, 2004, pp. 750–757. As of December 23, 2009: http://www.anesthesia-analgesia.org/cgi/content/full/98/3/750

American Association of Nurse Anesthetists, "AANA Overview," undated Web page. As of June 25, 2008: http://www.aana.com/aboutaana.aspx?id=46

———, *Scope and Standards for Nurse Anesthesia Practice*, Park Ridge, Ill., 2007. As of February 8, 2010: http://www.aana.com/uploadedFiles/Resources/Practice_Documents/scope_stds_nap07_2007.pdf

American Society of Anesthesiologists, "Providers of Anesthesia," undated Web page. As of December 24, 2009:
http://www.asahq.org/providers/aadefinition.htm

———, *Estimation of Physician Work Force Requirements in Anesthesiology*, Bethesda, Md.: Abt Associates, 1994.

———, "Practice Guidelines for Sedation and Analgesia by Non-Anesthesiologists," *Anesthesiology*, Vol. 96, No. 4, April 2002, pp. 1004–1017. As of December 23, 2009:
http://www.asahq.org/publicationsAndServices/sedation1017.pdf

———, "The Scope of Practice of Nurse Anesthetists," Washington, D.C., January 2004. As of December 23, 2009:
http://www.asahq.org/Washington/nurseanesscope.pdf

———, "Distinguishing Monitored Anesthesia Care ('MAC') from Moderate Sedation/Analgesia (Conscious Sedation)," approved by House of Delegates October 27, 2004, last amended October 21, 2009. As of November 2, 2009:
http://www.asahq.org/publicationsAndServices/standards/35.pdf

ASA—*see* American Society of Anesthesiologists.

Bankert, Marianne, *Watchful Care: A History of America's Nurse Anesthetists*, New York: Continuum, 1989.

Blundell, Richard, and Thomas Macurdy, "Labor Supply: A Review of Alternative Approaches," in Orley Ashenfelter and David E Card, eds., *Handbook of Labor Economics*, Vol. 3, Part A, Amsterdam and New York: Elsevier Science, 1999, pp. 1559–1695.

CMS—*see* Centers for Medicare and Medicaid Services.

Centers for Medicare and Medicaid Services, "Physician Supervision of Certified Registered Nurse Anesthetists," fact sheet, January 17, 2001. As of June 25, 2008:
http://www.cms.hhs.gov/apps/media/press/factsheet.asp?Counter=391

Code of Federal Regulations, Title 42, Public Health, Part 482, Conditions of Participation for Hospitals, Subpart D, Optional Hospital Services, Section 482.52, Condition of Participation; Anesthesia Services. As of February 8, 2010:
http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=e95d62d97593cb93146d514417be0105&rgn=div8&view=text&node=42:5.0.1.1.1.4.4.2&idno=42

Cooper, Richard A., Thomas E. Getzen, Heather J. McKee, and Prakash Laud, "Economic and Demographic Trends Signal an Impending Physician Shortage," *Health Affairs*, Vol. 21, No. 1, January–February 2002, pp. 140–154.

Cromwell, Jerry, "Barriers to Achieving a Cost-Effective Workforce Mix: Lessons from Anesthesiology," *Journal of Health Politics, Policy and Law*, Vol. 24, No. 6, December 1999, pp. 1331–1361.

Cromwell, Jerry, Margo L. Rosenbach, Gregory C. Pope, Barbara Butrica, and Jane D. Pitcher, "CRNA Manpower Forecasts: 1990–2010," *Medical Care*, Vol. 29, No. 7, July 1991, pp. 628–644.

Cromwell, Jerry, and K. Snyder, "Alternative Cost-Effective Anesthesia Care Teams," *Nursing Economics*, Vol. 18, No. 4, 2000, pp. 185–193.

Eckhout, Gifford, and Armin Schubert, "Where Have All the Anesthesiologists Gone? Analysis of the National Anesthesia Worker Shortage," *ASA Newsletter*, Vol. 65, No. 4, April 2001. As of December 23, 2009: http://www.asahq.org/Newsletters/2001/04_01/eckhout.htm

Engen, Dale A., Gordon H. Morewood, Nancy J. Ghazar, Ted Ashbury, Elizabeth G. Van Den Kerkhof, and Louie Wang, "A Demand-Based Assessment of the Canadian Anesthesia Workforce—2002 Through 2007," *Canadian Journal of Anesthesia*, Vol. 52, No. 1, January 2005, pp. 18–25.

Fair, Ray C., and Dwight M. Jaffee, "Methods of Estimation for Markets in Disequilibrium," *Econometrica*, Vol. 40, No. 3, May 1972, pp. 497–514.

Fallacaro, M. D., "The Practice and Distribution of Certified Registered Nurse Anesthetists in Federally Designated Nurse Shortage Areas," *CRNA*, Vol. 8, No. 2, May 1997, pp. 55–61.

Gourieroux, Christian, *Econometrics of Qualitative Dependent Variables*, Cambridge University Press, 2000.

Grogono, Alan W., "National Resident Matching Program Results for 2006: Recruitment Shifts to PG-1 Year," *American Society of Anesthesiologists Newsletter*, Vol. 70, No. 5, May 2006. As of February 8, 2010: http://www.asahq.org/Newsletters/2006/05-06/grogono05_06.html

HHS—*see* U.S. Department of Health and Human Services.

Hirsch, Barry T., and Edward J. Schumacher, "Classic Monopsony or New Monopsony? Searching for Evidence in Nursing Labor Markets," *Journal of Health Economics*, Vol. 24, No. 5, September 2005, pp. 969–989.

Lane, Julia, and Stephan Gohmann, "Shortage or Surplus: Economic and Noneconomic Approaches to the Analysis of Nursing Labor Markets," *Southern Economic Journal*, Vol. 61, No. 3, January 1995, pp. 644–653.

Lee, Paul P., Catherine A. Jackson, and Daniel A. Relles, "Demand-Based Assessment of Workforce Requirements for Orthopaedic Services," *Journal of Bone and Joint Surgery*, Vol. 80, No. 3, 1998, pp. 313–326.

Maddala, G. S., and Forrest D. Nelson, "Maximum Likelihood Methods for Models of Markets in Disequilibrium," *Econometrica*, Vol. 42, No. 6, November 1974, pp. 1013–1030.

Mastropietro, C. A., B. J. Horton, S. M. Ouellette, and M. Faut-Callahan, "The National Commission on Nurse Anesthesia Education 10 Years Later, Part 1: The Commission Years (1989–1994)," *AANA Journal*, Vol. 69, No. 6, October 2001, pp. 455–460.

MCCG—*see* Medical Center of Central Georgia and Mercer University School of Medicine.

Medical Center of Central Georgia and Mercer University School of Medicine, "Certified Registered Nurse Anesthetists (CRNAs) at a Glance," undated Web page. As of June 27, 2008: http://www.mccg.org/crna/nurse_anesthesia_profession.asp

Merwin, Elizabeth, Steven Stern, and Lorraine M. Jordan, "Supply, Demand and Equilibrium in the Market for CRNAs," *AANA Journal*, Vol. 74, No. 4, August 2006, pp. 287–293.

Miller, Ronald D., and William L. Lanier, "The Shortage of Anesthesiologists: An Unwelcome Lesson for Other Medical Specialties," *Mayo Clinic Proceedings*, Vol. 76, No. 10, October 2001, pp. 969–970.

Pearson, Linda, "Debate or Deceit? A Look at CRNA Care," *Nurse Practitioner*, Vol. 27, No. 4, April 2002, p. 12.

Pisetsky, M. A., D. A. Lubarsky, B. P. Capehart, C. K. Lineberger, and J. G. Reves, "Valuing the Work Performed by Anesthesiology Residents and the Financial Impact on Teaching Hospitals in the United States of a Reduced Anesthesia Residency Program Size," *Anesthesia and Analgesia*, Vol. 87, No. 2, 1998, pp. 245–254.

Reinier, Kyndaron, Mary Val Palumbo, Barbara McIntosh, Betty Rambur, Jane Kolodinsky, Laurie Hurowitz, Takamaru Ashikaga, "Measuring the Nursing Workforce: Clarifying the Definitions," *Medical Care Research and Review*, Vol. 62, No. 6, 2005, pp. 741–755.

Robinson, James C, "Market Structure, Employment, and Skill Mix in the Hospital Industry," *Southern Economic Journal*, Vol. 55, No. 2, October 1988, pp. 315–325.

Schmitz, Robert, Mary Lantin, and Alan White, *Future Workforce Needs in Pulmonary and Critical Care Medicine*, Cambridge, Mass.: Abt Associates, 1999.

Schubert, Armin, Gifford Eckhout Jr., Todd Cooperider, and Alan Kuhel, "Evidence of a Current and Lasting National Anesthesia Personnel Shortfall: Scope and Implications," *Mayo Clinic Proceedings*, Vol. 76, No. 10, October 2001, pp. 995–1010.

Schubert, Armin, Gifford Eckhout Jr., and Kevin K. Tremper, "An Updated View of the National Anesthesia Personnel Shortfall," *Anesthesia and Analgesia*, Vol. 96, No. 1, January 2003, pp. 207–214.

Seibert, Elizabeth Monti, Judith Alexander, and Alfred E. Lupein, "Rural Nurse Anesthesia Practice: A Pilot Study," *AANA Journal*, Vol. 72, No. 3, June 2004, pp. 181–190.

Staiger, Douglas, Joanne Spetz, and Ciaran Phibbs, *Is There Monopsony in the Labor Market? Evidence from a Natural Experiment*, Cambridge, Mass.: National Bureau of Economic Research, working paper 7258, July 1999. As of December 23, 2009:
http://papers.nber.org/papers/w7258

Sullivan, Daniel, "Monopsony Power in the Market for Nurses," *Journal of Law and Economics*, Vol. 32, No. 2, Part 2, October 1989, pp. S135–S178.

Tremper, Kevin K., Amy Shanks, and Michelle Morris, "Trends in the Financial Status of United States Anesthesiology Training Programs: 2000 to 2004," *Anesthesia and Analgesia*, Vol. 102, 2006, pp. 517–523.

U.S. Department of Health and Human Services, *Physician Supply and Demand: Projections to 2020*, Washington, D.C.: U.S. Department of Health and Human Services, Health Resources and Services Administration, Bureau of Health Professions, October 2006. As of December 23, 2009:
ftp://ftp.hrsa.gov/bhpr/workforce/PhysicianForecastingPaperfinal.pdf

———, *Methods for Identifying Facilities and Communities with Shortages of Nurses: Technical Report*, Washington, D.C., February 2007. As of December 23, 2009:
http://bhpr.hrsa.gov/healthworkforce/nursingshortage/tech_report/default.htm