

Chapter 2

The Epidemiology and Economics of Cardiothoracic Surgery in the Elderly

David A. Etzioni and Vaughn A. Starnes

Abstract Cardiothoracic surgery is performed primarily in older individuals. Within the United States and globally, the numbers of these older individuals will increase dramatically in the near future, driving enormous changes in the amount, profile, and delivery of health care. In this chapter we analyze recent trends in the patterns of treatment provided by cardiothoracic surgeons. While incidence rates for coronary artery bypass procedures have declined, other procedures have not changed significantly in frequency. With the forecasted increases in the number of older individuals there is good reason to believe that the volumes of cardiothoracic procedures that are performed will rise significantly, even if incidence rates continue to decline. Cardiothoracic surgeons should meet the challenges engendered by these changes through ongoing innovation and a continued focus on quality of care and clinical outcomes.

Keywords Coronary artery bypass • Open heart surgery • Elderly • Health manpower • Appropriateness • Epidemiology • Health care costs • Economics

Introduction

The disease processes which call upon the skill of a cardiothoracic surgeon are predominantly found in older individuals. Atherosclerotic coronary artery disease (CAD), valvular disorders, and neoplastic disorders are all primarily afflictions of the elderly. The primary focus of a cardiothoracic surgeon is to care for these problems in the manner which optimizes patient outcomes, and it is this focus which has earned the field respect and status. In the chapters that follow,

the clinical considerations of treating a patient who is older relative to one who is younger are explored. With this chapter, we take a step away from the clinician-patient relationship and explore the epidemiologic, economic, and pragmatic ramifications of cardiothoracic surgery in a population that is increasingly elderly. In the interest of providing insights which have depth and detail, these analyses will focus primarily on the United States (US) population.

Demographics: The Aging Population

“Demography is destiny”

August Comte

Over the next two decades, the US population is poised to undergo an unprecedented change. The “aging” population – often mentioned but rarely explained – is a demographic shift that results from several distinct demographic phenomena. First, we are living longer. Based on data from the US Centers for Disease Control, an individual born in 2004 has a life expectancy of 77.8 years, compared to less than 50 years one century ago [1]. Second, the baby boomers are entering retirement age. Between 1946 and 1964 the US saw a remarkable rise in the number of births relative to the periods before or following. In 2011, the first of the baby boomers enter retirement age, and the proportion of individuals in the US aged 65 years and older will begin to increase rapidly. Another demographic phenomenon is also important to mention: the US population is increasing rapidly. Between 1990 and 2000 the US population increased by 32.6 million (13%), the largest absolute increase of any decade in the country’s history.

Taken together, these trends have clear importance for the field of cardiothoracic surgery in determining the base population of potential patients. Between 2010 and 2025, the US population is expected to increase by 40.5 million people (13.1%) (Fig. 2.1a). Increases will be disproportionately higher among older individuals – the numbers of individuals

D.A. Etzioni (✉)
Department of Surgery,
Mayo Clinic Arizona,
5777 E. Mayo Blvd, Phoenix, AZ 85054, USA
e-mail: etzioni.david@mayo.edu

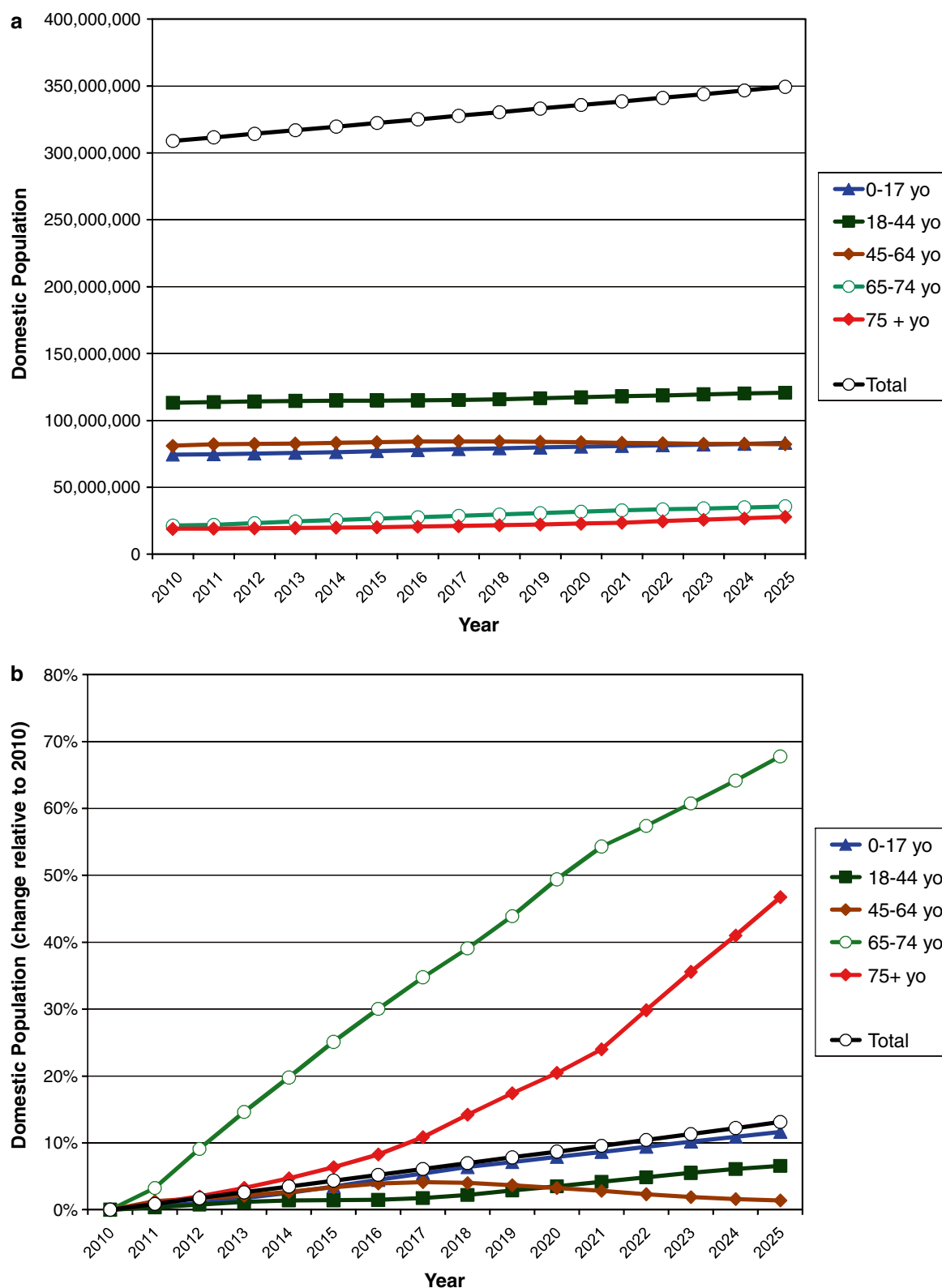


Fig. 2.1 (a) US Population, 2010–2025; (b) US Population, 2010–2025 (% change relative to 2010)

aged 65–74 will increase by 67.8% and those aged 75+ by 46.7% (Fig. 2.1b).

The US is not alone in experiencing dramatic shifts toward an aging population. Figure 2.2 shows global statis-

tics that illustrate similar emerging trends in the global population. These shifts are predicted to be more dramatic in less developed regions relative to more developed regions.

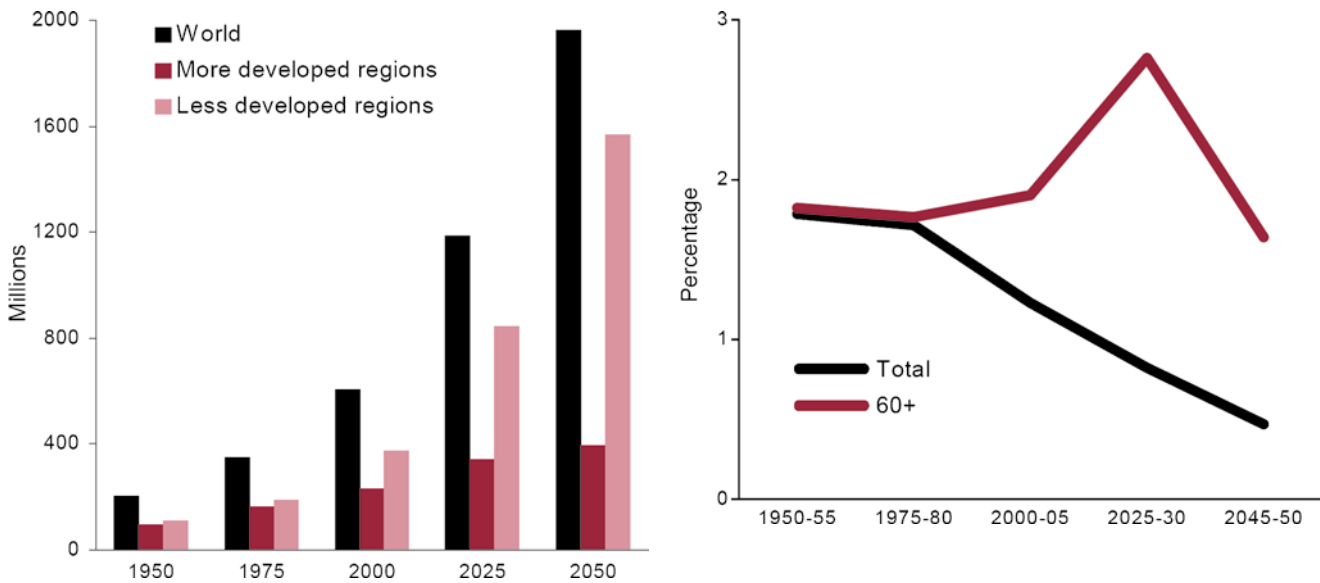


Fig. 2.2 World growth in population aged 60+ years (from the United Nations Department of Economic and Social Affairs Population Division [38])

A Data-Driven Approach

Throughout this chapter, we will use original analyses of existing data in order to provide insight into patterns of cardiothoracic surgical treatment provided within the US. In order to do this, we will rely on two population-based databases of domestic hospital discharges – the National Hospital Discharge Survey (NHDS) and the Nationwide Inpatient Sample (NIS). A brief description of each of these sources of data is therefore important.

The NHDS is managed by the National Center for Health Statistics, and represents an annual sampling of domestic hospital discharges. Each year, 350,000 discharges from approximately 500 hospitals are abstracted based on an approach that is designed to yield information that is representative of all domestic hospitalizations [2]. Within the NHDS, de-identified information about each discharge, including age, sex, race/ethnicity, diagnoses, procedures performed (according to ICD-9 coding scheme), and diagnosis-related grouping (DRG) are reported.

The NIS is published by the Healthcare Cost and Utilization Project through a partnership that is organized by the Agency for Healthcare Research and Quality. Similar to the NHDS, the NIS database contains discharge data including procedure and diagnosis codes (also according to ICD-9 coding scheme). The NIS differs from the NHDS in that it represents much larger sample (approximately eight million records per year), but it does not sample from as broad a range of geographic regions. Also, the regions which contribute discharge data to the NIS have changed significantly over time.

These two datasets are best considered complementary. For analyses of procedures which are performed commonly,

the NHDS data are the most accurate representation of the overall, nationally-representative patterns of treatment. Also, because the NHDS sampling methodology has remained stable over time, it is a better resource for examining temporal trends in procedure rates. The NIS, because of its larger sample size, is a better resource for assessing rates of procedures which occur with lower frequency. We rely on the NIS to yield detailed point estimates for procedural rates which can then be used for the purposes of forecasting, and in situations where a large sample size is required in order to yield more precise estimates. At the time of writing this chapter, the most current data available for each of these datasets was 2006. In Appendix 1 we document the International Classification of Disease, 9th Edition (ICD-9) procedure codes which we used to ascertain procedures for this analysis.

Historical Rates of Treatment

The number of individuals in the US who undergo cardiothoracic surgical procedures is changing. Within this section we will analyze historical rates of specific types of cardiothoracic surgical procedures – coronary artery bypass grafts (CABGs), valve operations, and pneumonectomies (see Appendix 1 for description of corresponding ICD-9 procedure codes). These three classes of procedures clearly do not represent the breadth of the field; by limiting our analyses to these relatively more common procedures we hope to provide a report that is more detailed while still representative of evolving trends in the entire workload of cardiothoracic surgeons.

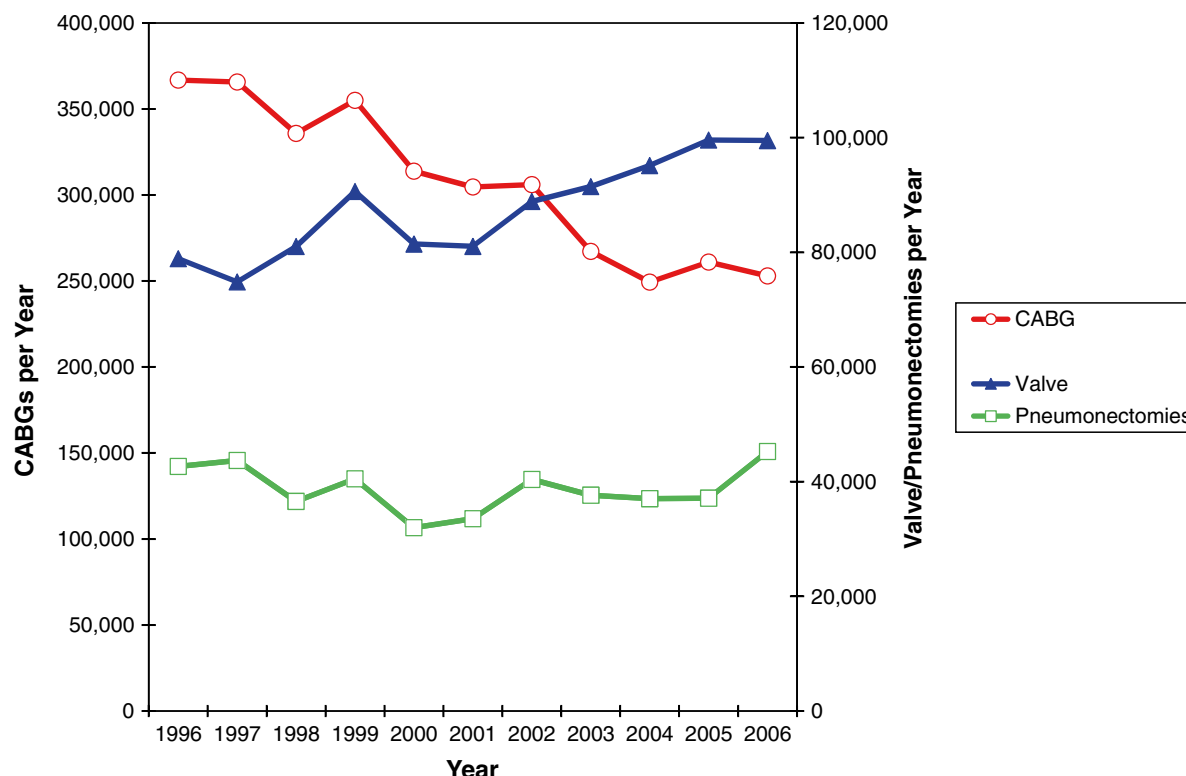


Fig. 2.3 Domestic volume of CABG, cardiac valve replacements, and pneumonectomies; 1996–2006 (from The National Hospital Discharge Survey (NHDS), available at <http://www.cdc.gov/nchs/nhds.htm>)

Between 1996 and 2006 the numbers of CABG operations performed in the US declined, from 366,000 per year in 1996 to 252,000 in 2006 (31% decrease) (Fig. 2.3). Valve operations and pneumonectomies each increased slightly; valve operations increased from 79,000 per year in 1996 to 99,000 in 2006 (26% increase) and pneumonectomies increased from 66,000 per year to 78,000 per year (19% increase). The measurement and tracking of procedural volume is enormously important for policy planning, however, it is important to acknowledge that over the last 10 years, the US population has grown considerably and also aged. To account for these trends, all subsequent figures in this section are “age-adjusted.” This method modifies an overall incidence rate to adjust for changes in the demographic makeup (especially age distribution) of a population over time.

The importance of accounting for differences in procedure rates within age groups is best demonstrated in terms of an incidence rate curve for each procedure. Figure 2.4 demonstrates incidence rate curves for several commonly performed cardiothoracic procedures. These incidence rate curves clearly show that it is the elderly population who are the primary patient population for cardiothoracic surgical procedures. Changes in the population of individuals aged less than 40 years old clearly would have little impact on procedure volumes; quite the opposite for the population aged 65 years or older.

It is also useful to analyze how these incidence rates have changed over time (Fig. 2.5a–c). For CABG procedures, the population-based incidence rate has declined from 13.8 procedures per 10,000 population in 1996 to 8.5 in 2006, a 38% reduction (Fig. 2.5a). Decreases were most rapid in the age groups with the highest rates of operation – those aged 60–79 years. Incidence rates were more stable, however, in the oldest age group (80+ years old). By contrast, the incidence rates for valve procedures and pneumonectomies have remained fairly constant (Fig. 2.5b–c).

Forecasting Rates of Treatment

“It’s tough to make predictions, especially about the future.”

Yogi Berra

What will happen to rates of cardiothoracic surgical procedures in the future? In general, forecasting patterns of treatment is an endeavor which can be labeled better as art than science. The effort needs to be made, however, in order to ensure that the resources available are sufficient to the task at hand. Historically, several methods have been used to project the demand for surgical procedures. While each has

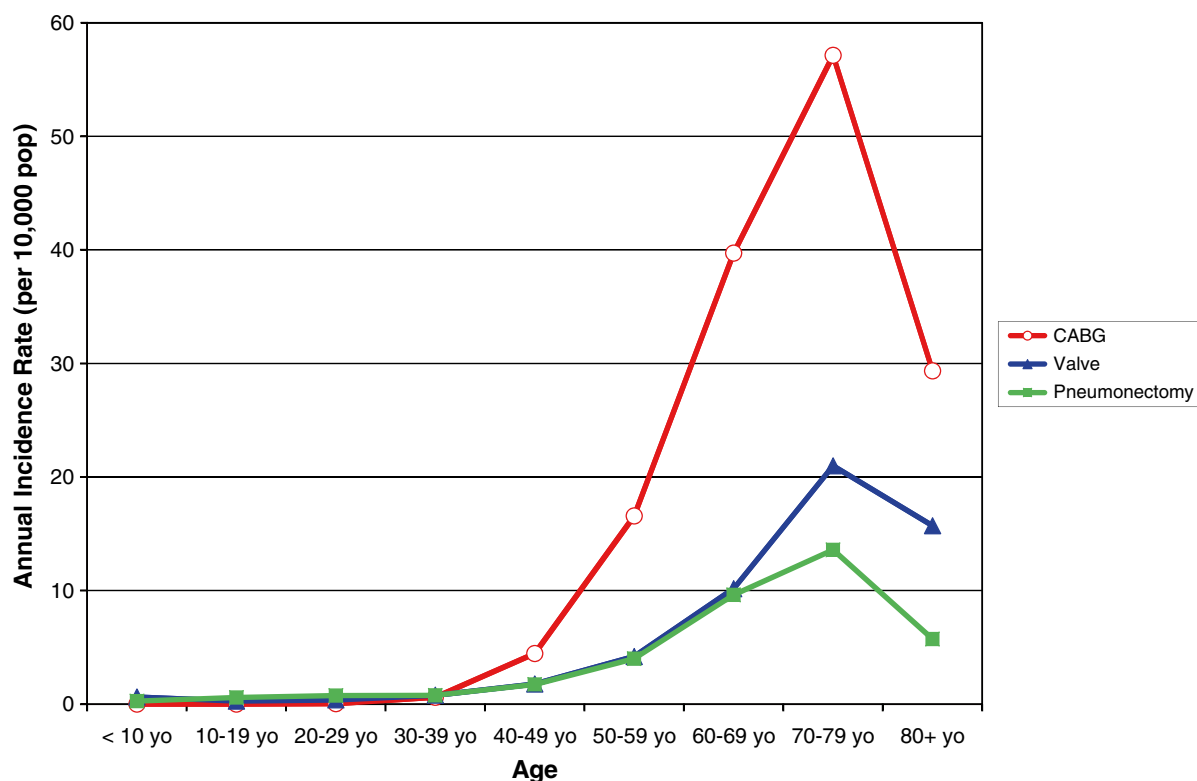


Fig. 2.4 Age-specific incidence rates for CABG, valve operations, and pneumonectomies (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/datahcup.htm>)

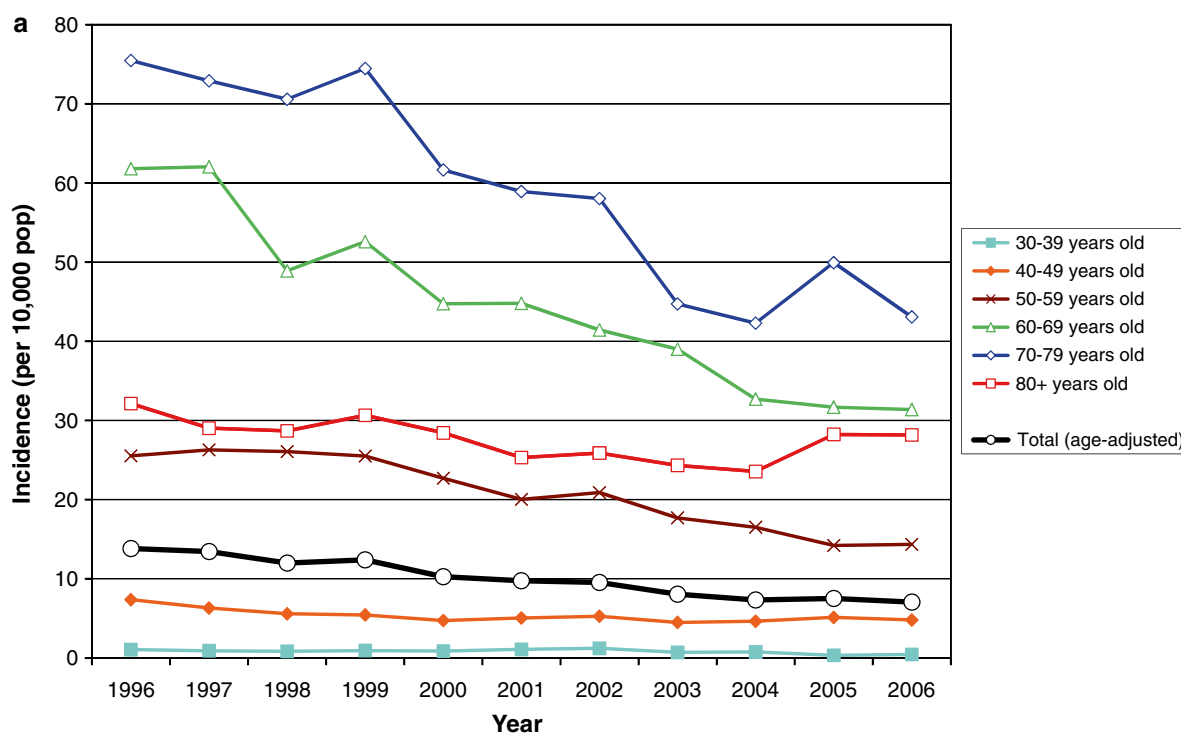


Fig. 2.5 (a) CABG incidence rates: 1996–2006; (b) CABG incidence rates: 1996–2006; (c) pneumonectomy incidence rates: 1996–2006 (from The National Hospital Discharge Survey (NHDS), available at <http://www.cdc.gov/nchs/nhds.htm>)

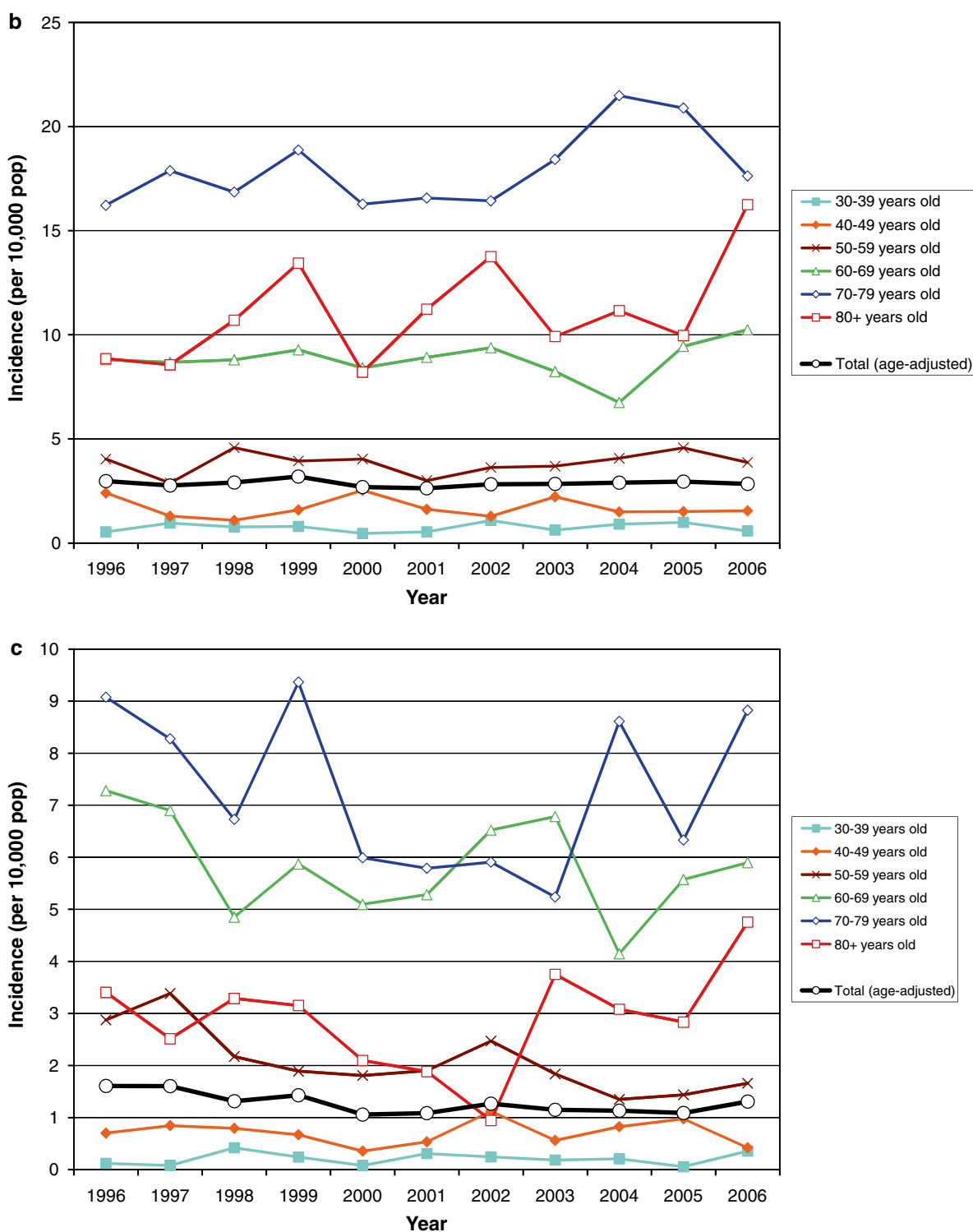


Fig. 2.5 (continued)

its own shortcoming, we will rely on what is best considered a “demands-based model.” In this type of model, rates of surgical treatment (numbers of procedure per unit population) are assumed to be constant, and projections are calculated based on changes in demography. It is important to calculate

these estimates within specified age groups – as we have shown above, cardiothoracic procedures are predominantly performed in older individuals. For the purposes of calculating projected rates of procedures, we will assume that rates of cardiothoracic procedures will be similar to those in 2006,

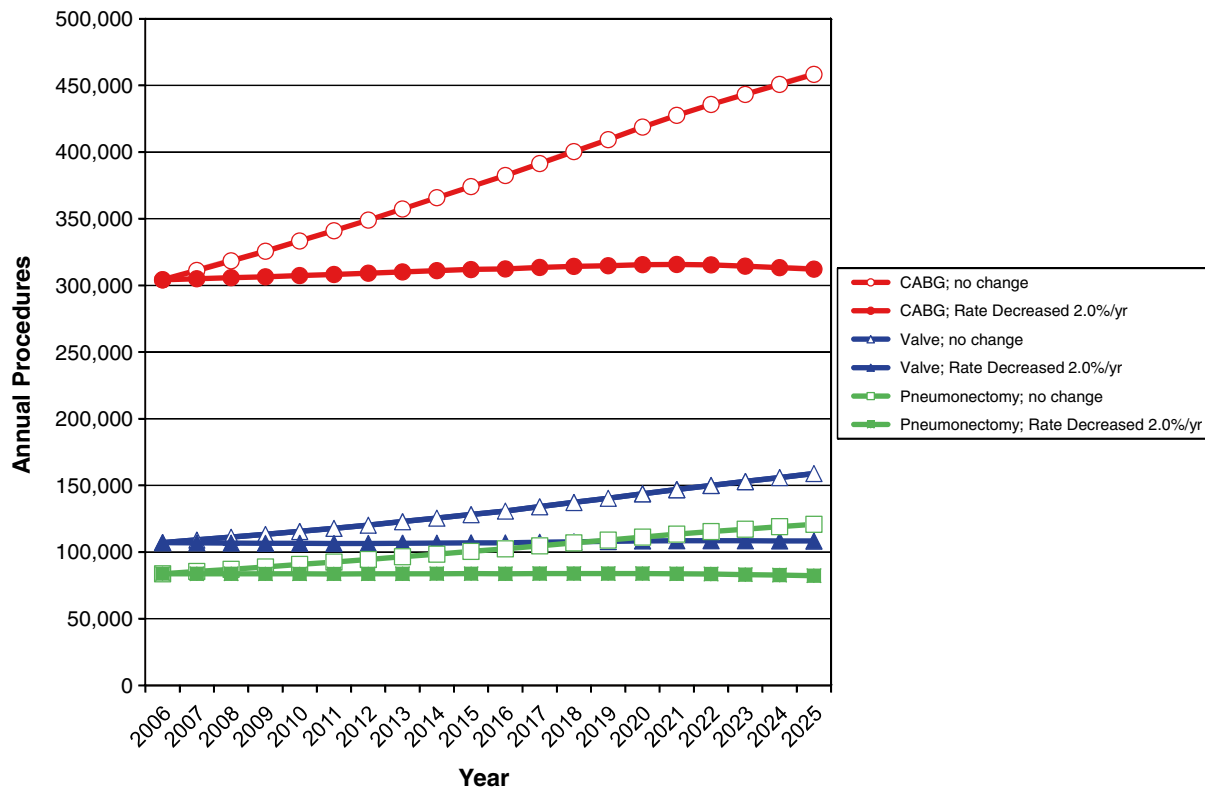


Fig. 2.6 Forecasted volumes of CABGs, valve operations, pneumonectomies; 2006–2025 (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/datahcup.htm>)

and consider the impact of population growth/aging on rates of treatment.

The results of this basic method are shown below in Fig. 2.6. In addition to calculating estimated procedures with a stable incidence rate, we also computed what would happen if the incidence rate for each procedure decreased by 2.0% per year. With the assumption of stable incidence rate, the number of CABGs is forecasted to increase by over 50% between 2006 and 2025. Similar increases are seen for valve operations and pneumonectomies, with increases of 48 and 44%, respectively. It is also worth noting that even with significant decreases in rates of treatments, the numbers of procedures performed per year is still estimated to increase as a result of population growth and aging.

Determinants of Rates of Treatment

In the preceding discussion, we have focused on the obvious relationship between demographics and the utilization of cardiothoracic surgical procedures. Clearly, however, demography is not the only determinant of the numbers of cardiothoracic procedures performed in any region. This point has

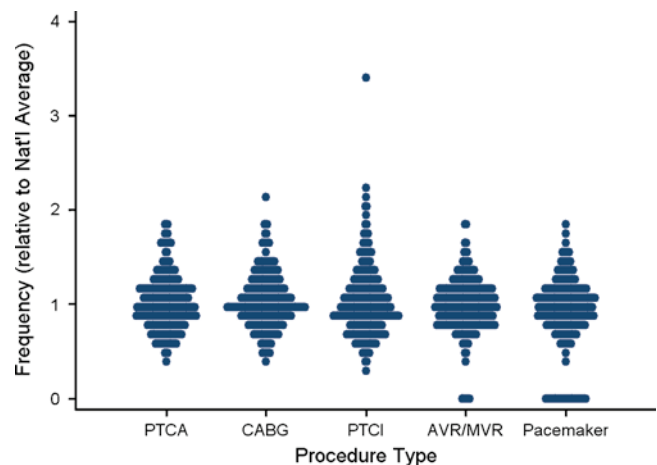


Fig. 2.7 Variation of coronary procedures in hospital referral regions (data from the 2006 Dartmouth health atlas)

been made eloquently and often by health policy researchers from Dartmouth ever since the early 1970s [3]. Their research has demonstrated a significant variation between regions in terms of the rates at which specific procedures are performed. Figure 2.7 shows rates of several types of heart procedures: percutaneous transluminal coronary angiography (PTCA),

CABG, percutaneous transluminal coronary intervention (PTCI), aortic valve replacement/mitral valve replacement (AVR/MVR) within 306 hospital referral regions (HRRs). HRRs are geographic regions which are defined based on patterns of referral for cardiovascular and neurosurgical procedures. Rates of coronary procedures show a significant degree of variation across regions, with many HRRs demonstrating rates that are greater than twice the national average.

What is responsible for these significant variations in rates of procedures? Underlying population-based differences in the prevalence of specific disease processes might explain part of the variation, but this is not believed to be a major explanatory factor. The prevailing explanation is that patterns of treatment and availability of specialists drive the majority of these variations. At some level this is intuitive – an area with few or no cardiologists is likely to have a lower rate of angiography and PTCI. In areas where there is not a shortage of specialists, however, the story becomes much more nuanced and we will devote some time to reviewing current knowledge of the drivers of procedure rates for cardiothoracic surgery. While an exhaustive discussion of these factors is beyond the scope of this chapter, we will focus on several main areas: epidemiologic trends, outcomes in elderly patients, overuse/overuse, payment systems, and the impact of medical technology.

Epidemiologic Trends

In this section we will review recent trends in the epidemiology of atherosclerotic CAD, valvular disease, and lung neoplasms.

Trends in Coronary Artery Disease (CAD)

Patients with atherosclerotic CAD are usually diagnosed on the basis of an acute myocardial infarction (AMI), and we will therefore use data regarding rates of hospitalization for AMI as an estimate of underlying population-based rates of significant CAD. In Fig. 2.8 we show these data. Rates of AMI and CABG are declining at approximately similar rates (AMI decreased by 42.3%, and CABG by 49% between 1996 and 2006). What is driving these significant reductions in rates of hospitalization for AMI? The answer is almost certainly multifactorial, including improved preventive care, early diagnosis of CAD, better cholesterol-lowering medications, and improved medical/surgical interventions.

These successes are reflected in trends regarding the death rate for heart disease in the US. According to data from the American Heart Association, between 1996 and 2006 the

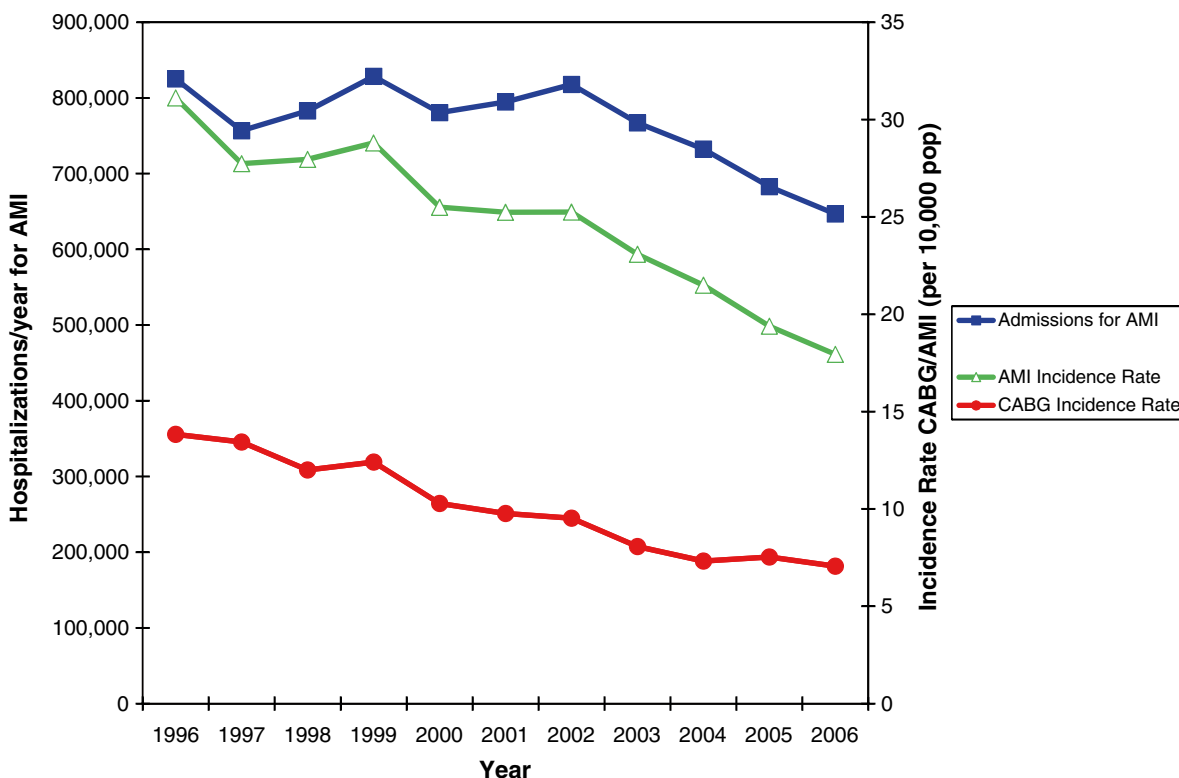


Fig. 2.8 Numbers of hospitalization for AMI; incidence rates of AMI and CABG; 1996–2006 (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/datahcup.htm>; all incidence rates age-adjusted to 1996 population)

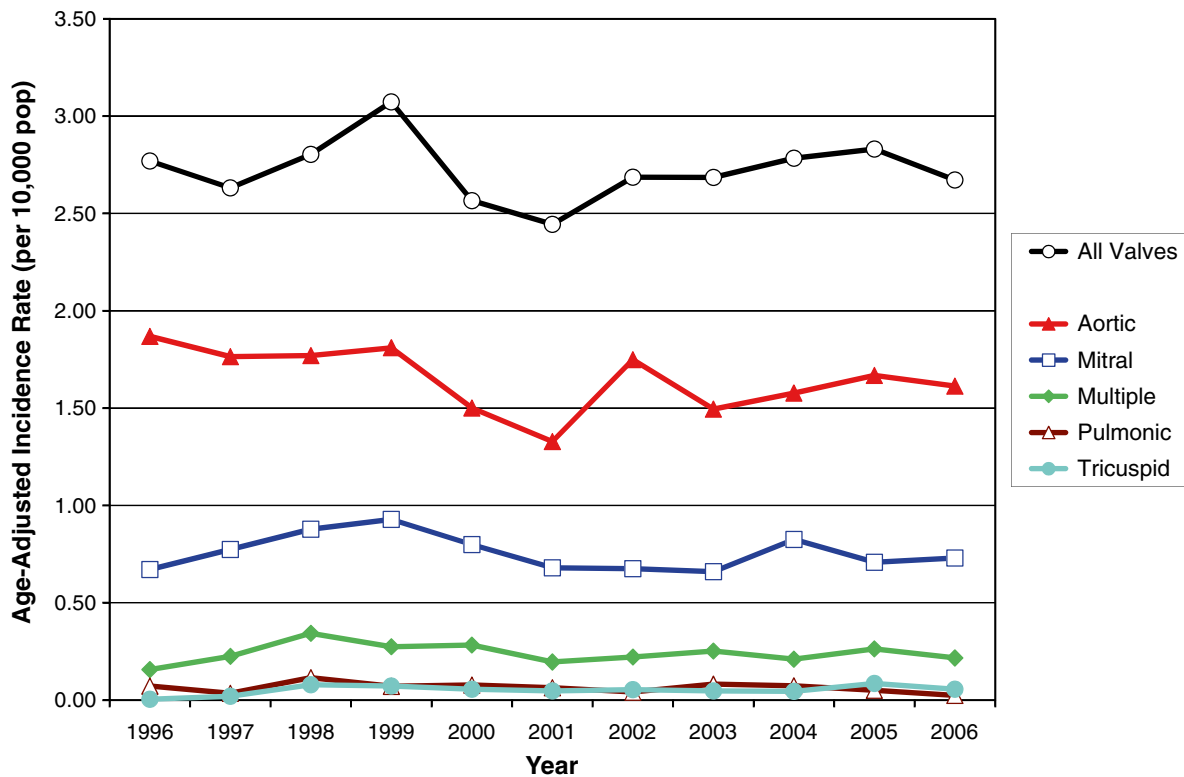


Fig. 2.9 Incidence rates for open heart valve operations (from The National Hospital Discharge Survey (NHDS), available at <http://www.cdc.gov/nchs/nhds.htm>)

death rate from cardiovascular disease decreased by 29.5% [4]. As a cause of death, heart disease clearly encompasses a broad spectrum of disease processes. These analyses are all important, however, in demonstrating the successes achieved in the US in treating CAD.

Trends in Valvular Heart Disease

As with CAD, it is difficult to estimate an underlying population-based incidence of valvular heart disease. While several studies have attempted to calculate such rates based on claims data [5] or prospective cohort studies [6], differences in the definitions of what constitutes disease make comparison difficult. One study pooled data on 11,911 randomly selected adults and found moderate or severe valvular heart disease in 615 [7]. Extrapolated to the entire US population in the year 2000, this study yielded an estimated 2.5% prevalence.

The etiology of valvular heart disease is evolving rapidly. Rheumatic heart disease is increasingly rare in the US, and rates of surgery for rheumatic valvular disease are declining [8]. Other diseases which reflect the effect of senescence on the aortic and mitral valve systems are becoming more common.

Unfortunately, population-based data sources which accurately capture the underlying cause of valvular disease leading to surgical treatment are not available [9]. In Fig. 2.9 we demonstrate that the overall population-based incidence rates for valve operations requiring open heart surgery (valve replacement or valvuloplasty) are approximately stable over the period from 1996 to 2006.

Trends in Lung Cancer

As a disease process, lung cancer is exquisitely sensitive to a singular risk factor – smoking. Over the last century, the incidence rate of lung cancer among individuals living in the US has peaked and is now falling in males, but has reached a plateau in females (Fig. 2.10). These trends are attributable primarily to underlying changes in rates of smoking. Domestic volumes of pneumonectomies remained fairly constant between 1996 and 2006 (Fig. 2.3).

In Fig. 2.11 we show incidence rates for pneumonectomies according to indication. Rates of resection for lung cancer fell sharply between 1996 and 2000, but have been stable between 2000 and 2006. However, in examining age-specific incidence rates an interesting pattern emerges

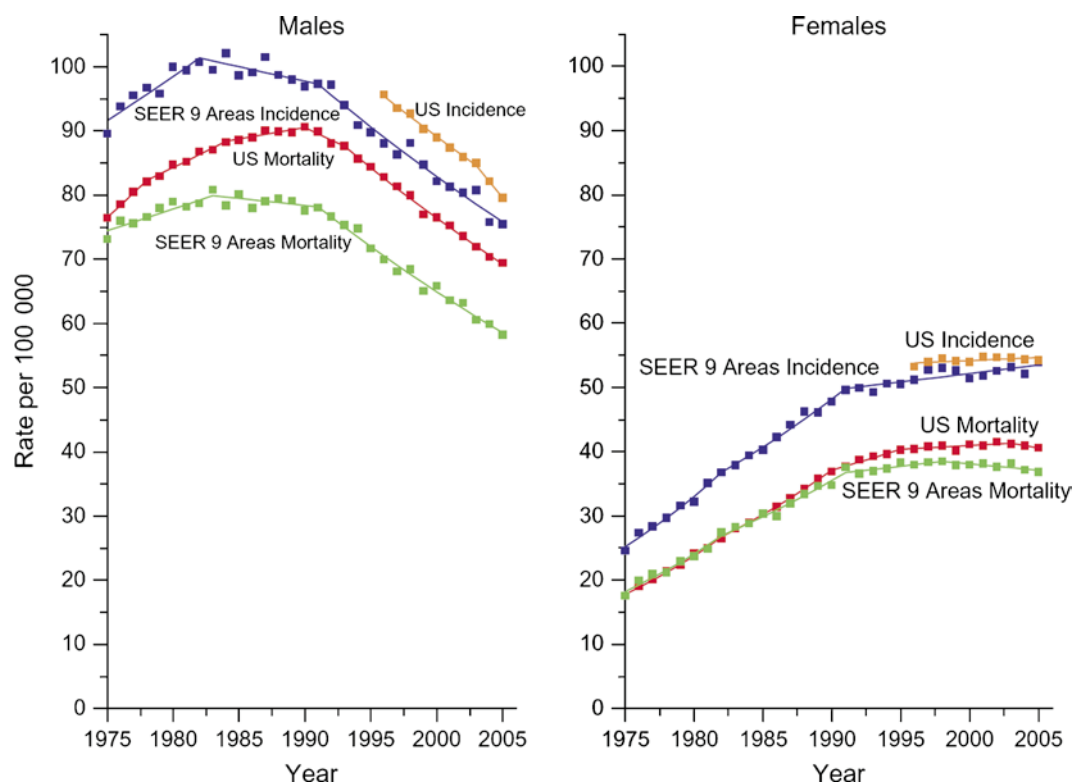


Fig. 2.10 Trends in age-specific incidence and death rates of/from lung cancer by year and gender (from Jemal et al. [39] reprinted with permission)

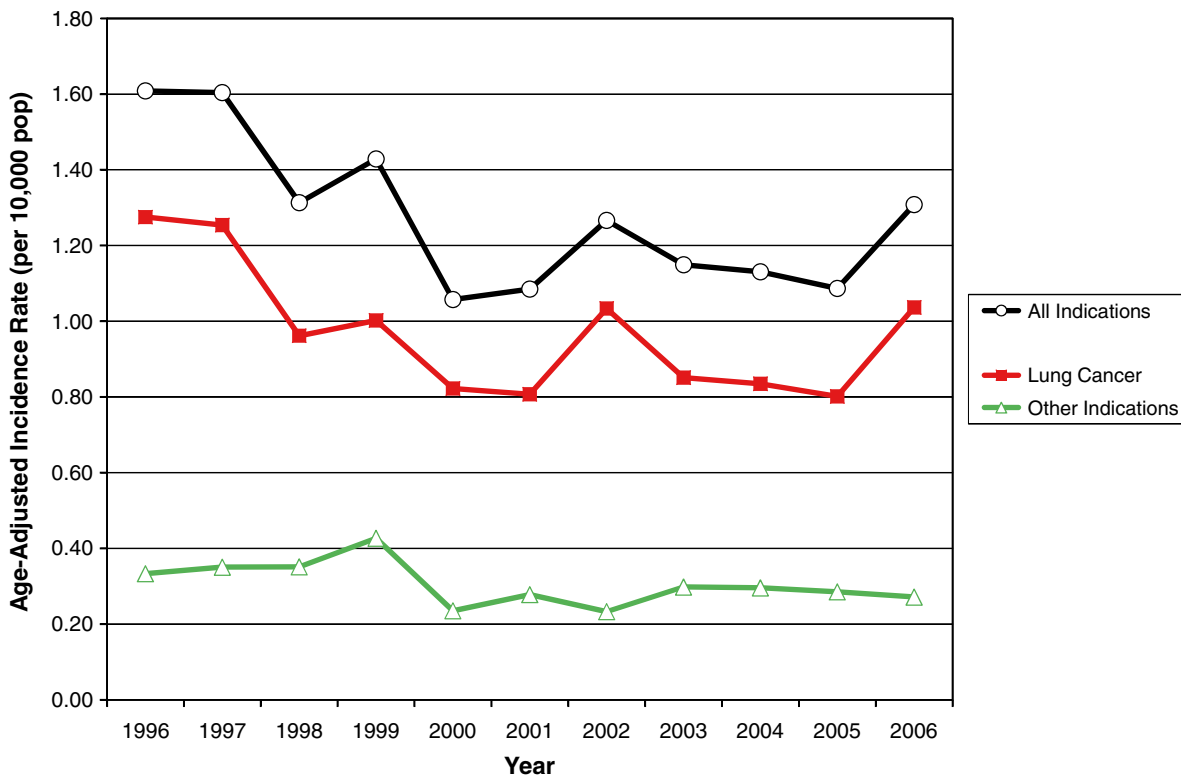


Fig. 2.11 Incidence rates for pneumonectomies in US by indication, 1990–2005 (from The National Hospital Discharge Survey (NHDS), available at <http://www.cdc.gov/nchs/nhds.htm>)

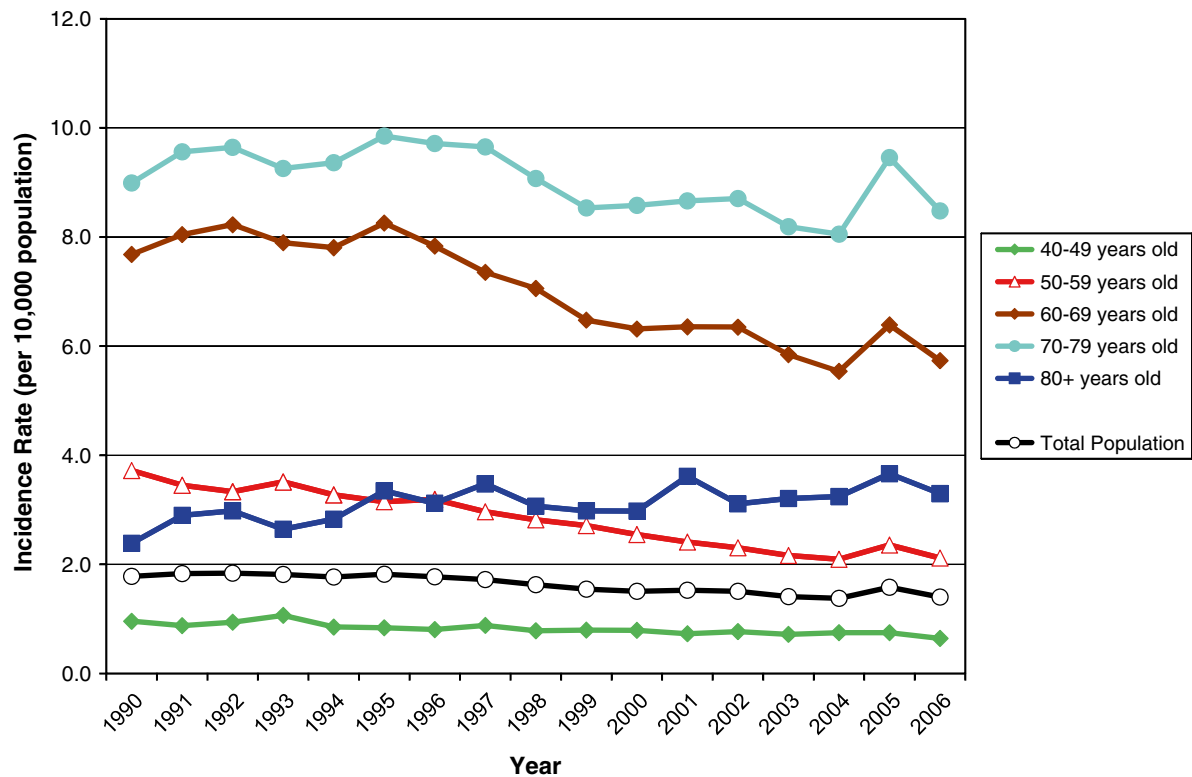


Fig. 2.12 Incidence rates for pneumonectomy for lung cancer in the US, 1990–2005 (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/dataahcup.htm>)

(Fig. 2.12). Incidence rates are declining in younger individuals, but are more constant (if not increasing) in the oldest age groups (70–79 and 80+ years old). These trends are not dramatic, but do raise two related questions which we will explore in the next section. First, what are the outcomes of surgery in very elderly patients? Second – with advances in surgical technique, are these outcomes improving over time?

4.6% for octogenarians and 2.2% for septuagenarians, a rate that was not statistically different from that seen in patients under the age of 70 years (2.4%).

In Fig. 2.13 we analyze trends in hospital mortality for CABG. Overall mortality rates decreased for 4.1% in 1991 to 2.8% in 2006. Improvements were especially dramatic for patients aged 70–79 years, with mortality falling from 5.9 to 3.8%. Unfortunately, this type of analysis is not appropriate for addressing questions regarding which changes in practice are responsible for these improvements.

Outcomes of Cardiothoracic Surgery in Elderly Patients

The ability of cardiothoracic surgical procedures to render a positive clinical outcome is clearly related to the age of the patient in question. Intuitively, the risks and expense of surgery must be weighed against what is known regarding long-term clinical benefits. The safety of major cardiothoracic surgical procedures in elderly patients is increasingly documented in the surgical literature. In a recent review of 2,985 patients who underwent CABG at the Mount Sinai School of Medicine in New York, 28.6% were 70–79 years of age and 9.4% were 80 years or older [10]. Hospital mortality was

Overuse and Underuse

If one assumes that across regions the patterns of treatment provided to patients is *exactly* the same, then inter-region variations in rates of treatment would be attributable entirely to underlying differences in the prevalence of diseases. Few believe this to be the case. In considering how patterns of treatment generate differences in rates of treatment, some nomenclature is useful to organize a review of current knowledge. Toward this goal we will use important terms: underuse and overuse. These terms have been defined elegantly by Chassin et al. and the Institute of Medicine: [11]

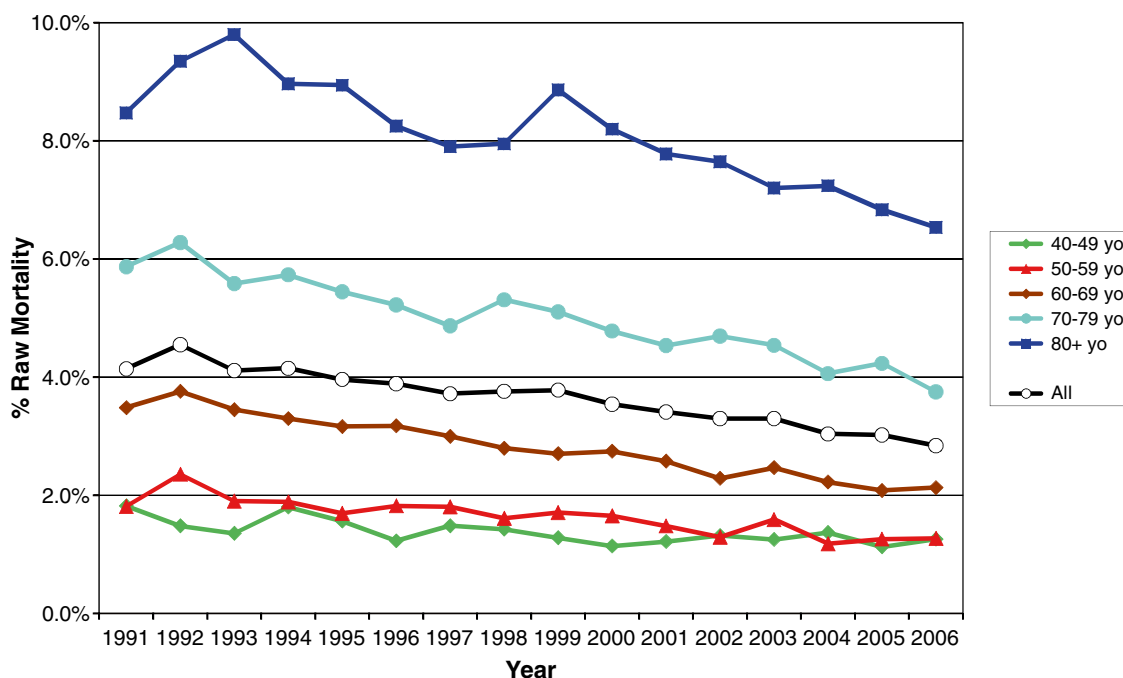


Fig. 2.13 Age-specific and overall hospital mortality rates for CABG; 1991–2006 (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/datahcup.htm>)

Overuse

Overuse occurs when a health care service is provided under circumstances in which its potential for harm exceeds the possible benefit. Prescribing an antibiotic for a viral infection like a cold, for which antibiotics are ineffective, constitutes overuse.

Underuse

Underuse is the failure to provide a health care service when it would have produced a favorable outcome for a patient. Missing a childhood immunization for measles or polio is an example of underuse.

Few areas of medicine have been as closely scrutinized regarding the presence of overuse and underuse as has the treatment of patients with coronary arterial disease (CAD). Any discussion regarding underuse and overuse necessarily begins with an explicit definition of what constitutes an *appropriate* indication for the procedure. Several groups, most notably the group from RAND/UCLA, have developed a method for synthesizing evidence using expert panelists and an iterative approach to attaining consensus. This method has proven to be highly reproducible and valid, albeit more accurate in assessing underuse than overuse [12, 13]. In Table 2.1 we present a summary of studies performed in the

last 10 years which examine underuse and overuse in the use of coronary angiography and revascularization in the treatment of patients with CAD. This brief review shows a rate of overuse of these procedures that is dramatically less than the rate of underuse.

In order to organize the discussion of overuse and underuse of patients with CAD we turn to a simplistic flow chart (Fig. 2.14). The number of patients who receive surgical treatment is, conceptually, a cross product of steps A, B, and C. Most studies examining the diagnosis and treatment of CAD have ascertained cohorts of symptomatic patients on the basis of presentation with AMI. In the remainder of this section, we will describe evidence that examines underuse and overuse of procedures at each of these steps.

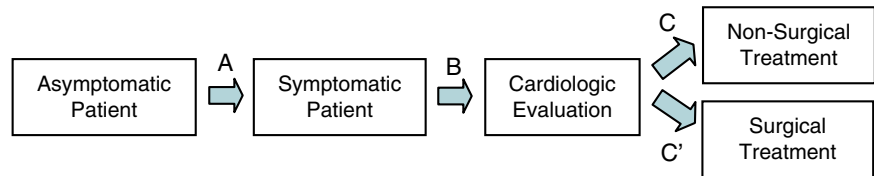
Cardiologic Evaluation

For any one of a number of reasons, the ability of patients to access cardiologic evaluation may be limited. Underinsurance (either no insurance or insured by Medicaid) is an obvious reason. Philbin et al. analyzed a database of New York State hospital discharges where the principal diagnosis was AMI, and found that Medicaid patients were less likely than non-Medicaid patients to undergo coronary angiography, PTCA, and CABG procedures [14]. If under-insurance is a barrier to evaluation, rates of underuse should be lower

Table 2.1 Recent literature examining rates of underuse and overuse of coronary angiography and revascularization

Study	Context	Sample size	Procedure(s) evaluated	Findings
Carlisle et al. [41]	Los Angeles/ multiinstitutional	181 AMI 215 Angiographies	Angiography	22% underuse 3% overuse
Leape et al. [42]	New York/ multiinstitutional	631 Angiographies with CAD	PTCA and CABG after angiography	26% underuse of revascularization
Guadagnoli et al. [16]	HCFA CCP	44,294 AMI	Angiography	39% underuse ^a
Hemingway et al. [20]	London/ multiinstitutional	2,552 Angiographies with CAD	PTCA and CABG after angiography	6% of PTCAs were overuse 2% of CABGs were overuse 34% underuse of PTCA 26% underuse of CABG
Schneider et al. [43]	Medicare	788 PTCAs 709 CABGs	PTCA and CABG after angiography	14% of PTCAs were overuse 10% of CABGs were overuse
Garg et al. [44]	HCFA CCP	9,455 AMI	Angiography	42% underuse
Petersen et al. [15]	VA	1,665 AMI	Angiography	56% underuse
	Medicare	19,305 AMI	Angiography	49% underuse
O'Connor et al. [45]	New England/ multiinstitutional	4,684 CABGS	CABG	1.4% overuse

^aFigure not published; extracted from figure, therefore represents an approximate value

Fig. 2.14 Treatment of patients with CAD (overuse and underuse)

in systems where access to care is more readily available. Petersen et al. examined the treatment provided to patients treated for AMI in the Veterans Health Affairs (VA) and Medicare programs [15]. They found that only 43.9% of VA patients and 51.0% of Medicare patients underwent an angiography that was considered clinically necessary. Even for patients who are insured and/or in integrated health systems there are significant problems with achieving high rates of appropriate evaluation.

The likelihood of coronary angiography is also a function of the degree to which a patient's clinical picture constitutes a mandate for angiography. Guadagnoli et al. analyzed regional variation in rates of angiography using data from the Health Care Financing Administration's Cooperative Cardiovascular Project [16]. They found that regional variations were most affected by differences in the use of angiography for discretionary indications, rather than frank overuse or underuse.

Probably the most important determinant of a patient's likelihood of undergoing coronary angiography during admission for AMI is the availability of the service at the admitting hospital. Theoretically, a patient with a clinical need for angiography would be transferred from a hospital where such services are unavailable to one where the service could be provided. Several investigations have shown,

however, that the hospital capability to perform these procedures has a significant impact on the use of angiography [17]. The timing of arrival at a hospital also appears to have an impact on likelihood of coronary angiography. Kostis et al. examined patients admitted with a first AMI on weekends vs. weekdays and found higher mortality rates and lower use of invasive cardiac procedures for weekend admissions [18].

Surgical vs. Nonsurgical Treatment

The type of treatment (step C, Fig. 2.14) provided to patients after cardiologic evaluation has also been a focus of recent research. Denvir et al. presented standardized patient scenarios to groups of cardiologists and cardiothoracic surgeons in order to better understand their clinical decision-making process [19]. They found that initial agreement between clinicians was quite poor, but improved after open discussion in the context of a multidisciplinary panel. It might be tempting to view these differences in patterns of diagnostic and therapeutic studies as a mere curiosity. The reality is more dramatic, however. Patients who are considered appropriate candidates for CABG have lower rates of mortality when they do undergo CABG compared with patients who do not [20]. Patients who are treated at

hospitals where more aggressive coronary angiography is performed have better survival rates [21].

The decision as to which approach is preferred for a specific patient needs to be considered in the context of evidence regarding the relative efficacy of PTCI and CABG. In 2009, Hlatky et al. published a pooled analysis of randomized trials comparing PTCI vs. CABG for multivessel CAD [22]. Their study analyzed 7,812 patients, and found that rates of death or MI after each type of intervention were not significantly different. Specific subgroups of patients did, however, have better results after CABG compared with PTCI — elderly (age ≥ 65 years) and those with diabetes. A similar analysis performed in 2009 by Naik et al. examined outcomes from trials comparing PTCI and CABG for left main CAD [23]. They found no differences in terms of outcomes (mortality, cerebrovascular/cardiovascular events). Both the Naik and the Hlatky studies found higher rates of re-intervention in the PTCI groups. Since Hlatky's analysis, initial (1 year follow-up) results from the Synergy between PCI with Taxus and Cardiac Surgery (SYNTAX) trial have emerged [24]. The finding from this randomized trial of 1,800 patients was that CABG yielded a lower incidence of a composite endpoint including major cardiovascular/cerebrovascular events. Ongoing results from this trial will surely clarify the discussion regarding the indications for CABG vs. PTCI.

Improving the Appropriateness of Care

The interests of public health are well-served by minimizing the rates of underuse and overuse described above. In this section we discuss what is known regarding barriers to improving the appropriateness of treatment for patients with CAD, and possible mechanisms by which to address them.

Perhaps most importantly, a greater degree of professional consensus regarding which types of patients and types of disease are best served by which type(s) of treatment needs to be achieved. The process that arrives at this higher degree of consensus requires significant advances in clinical research, both observational and experimental, in order to provide sufficient evidence. Improving the evidence basis for treatment is only part of the answer, however. Underuse and overuse of cardiologic evaluation and coronary intervention need to be improved through structural mechanisms within the health care delivery system. The most important of these mechanisms is a multidisciplinary panel which involves the input of both cardiologists and cardiothoracic surgeons. Additionally, health care delivery systems should engage in real-time monitoring and reporting of the appropriateness of treatment provided to patients hospitalized with cardiologic conditions. We are not the first to make these recommendations [25–27].

Professional consensus and monitoring mechanisms are only part of the equation; improving access to care is also part of the equation. Patients treated for acute coronary syndrome in hospitals where intervention facilities are not available are less likely to undergo necessary procedures [17]. While this may not be surprising, it is important to envision a system where every patient receives an *appropriate* evaluation and treatment, regardless of initial portal of entry. Such a system may require greater regionalization, expanded capacity, or other more innovative solutions.

Payment Systems

“There are many mechanisms for paying physicians; some are good and some are bad. The three worst are fee-for-service, capitation, and salary.”

James C. Robinson, 2001 [28]

Total costs of inpatient hospital care for patients with cardiovascular disease are estimated to be \$71.2 billion per year [4]. The average cost for a CABG is over \$30,000 [29]. Who pays these considerable costs?

Demonstrated in Fig. 2.15, Medicare is the most important payment source for the majority of open heart procedures

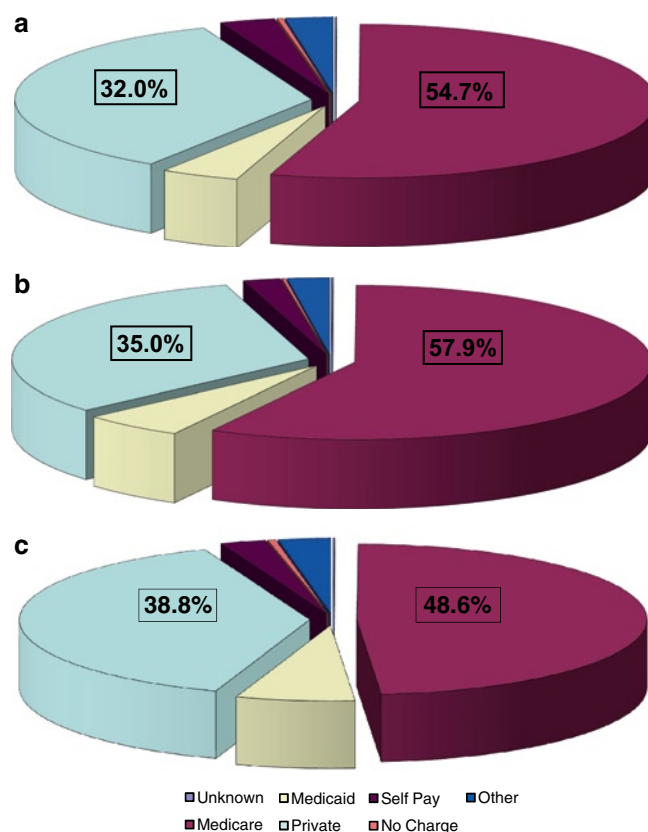


Fig. 2.15 Payment sources for open heart procedures (from The National Institute of Science, available at <http://www.nationalinstituteofscience.org/>). (a) CABG; (b) valve; (c) pneumonectomy

and almost half of pneumonectomies. Medicare is primarily held by individuals aged 65 years and older, and therefore stands to become an even more important payor as the proportion of patients who undergo these procedures are elderly. How quickly is this proportion going to change? In Fig. 2.16, we estimate the proportion of patients undergoing a CABG procedure who will be in specific age groups, using a methodology similar to that used to generate the forecasts discussed earlier. Based on this approach, patients aged 65 years and older will become a more prominent proportion of patients undergoing CABG. In 2006, those aged 65+ years were 56.7% of the CABG patient population, and by 2025 this proportion is forecasted to increase to 67.3%. Over time, Medicare will become an increasingly important mechanism through which cardiothoracic procedures are reimbursed.

The mechanism by which Medicare reimburses facilities and professionals for surgical procedures is primarily based on a fee-for-service model. Facilities are paid through a prospective payment system (PPS) and professionals based on an estimation of the amount of work required – the relative value unit (RVU). In an era of increased focus on cost containment and clinical effectiveness, payers and providers are seeking other mechanisms that more closely link payment

with measurable aspects of quality. We will discuss several of these.

Starting in 2006, Geisinger Health System in central Pennsylvania instituted a PPS within which payments for elective CABG patients encompassed 90 days of follow-up care. This program effectively provided payors with a “guarantee” by covering all expenses resulting from complications incurred during the post-operative period. The effective linkage between efforts to reduce complications and cost savings is intuitive and has the potential to help drive quality improvement. Whether such a system can be expanded to other contexts remains to be seen.

A second, similar system is the Prometheus payment model which works on the payer side of the reimbursement system. Within the Prometheus model, the amount of care required to treat a specific condition is bundled together, along with an estimate of the costs of treating complications – termed “potentially avoidable costs (PACs).” If a health care system can reduce its rate of PACs, then its net reimbursement may be substantially higher. On the other hand, if multiple complications (PACs) occur, an episode of care may engender a lower net income or financial loss.

The same concept is embodied in the “never events” approach taken by the Centers for Medicare and Medicaid

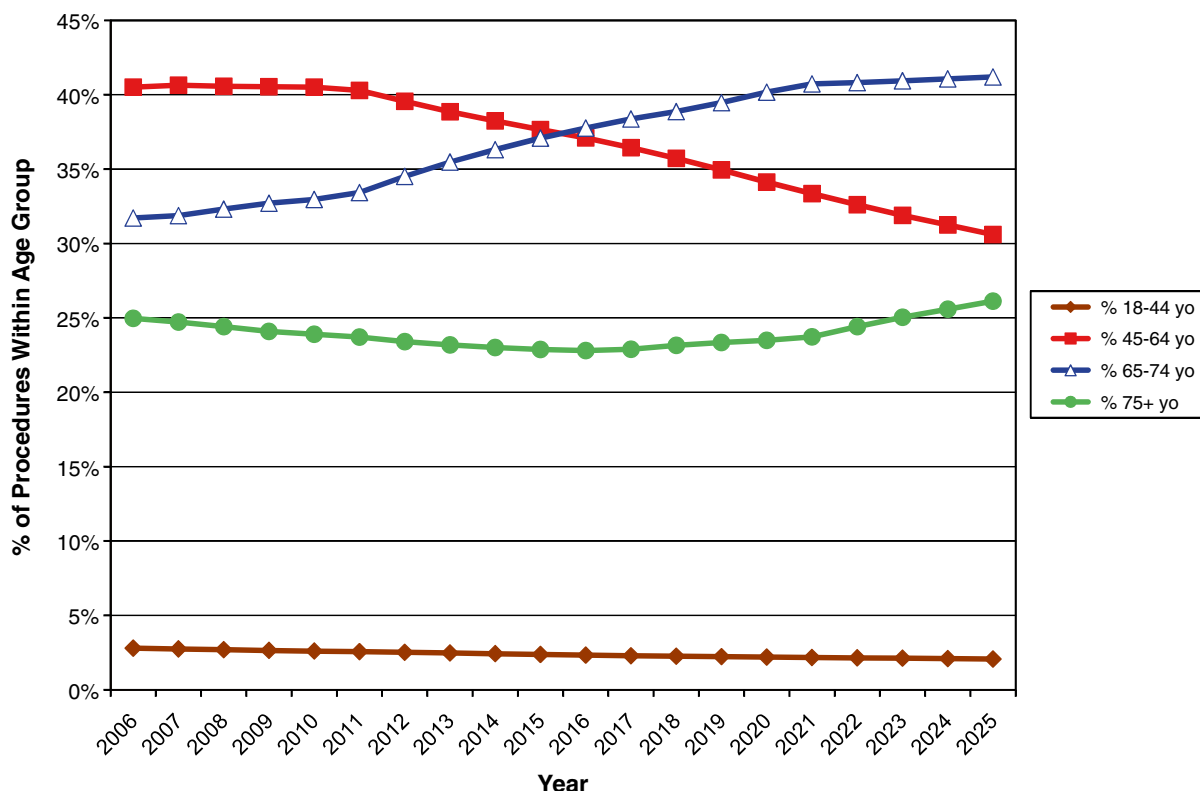


Fig. 2.16 Forecasted changes in payor mix for CABG: 2006–2025 (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/datahcup.htm>)

Services (CMS). Beginning October 1, 2008, CMS no longer reimburses hospitals for additional costs related to the development of any one of the following 8 PACs:

- Pressure ulcer stages III and IV.
- Falls and trauma.
- Surgical site infection after bariatric surgery for obesity, certain orthopedic procedures, and bypass surgery (mediastinitis).
- Vascular-catheter associated infection.
- Catheter-associated urinary tract infection.
- Administration of incompatible blood.
- Air embolism.
- Foreign object unintentionally retained after surgery.

As these systems evolve, new approaches are sure to emerge. At all levels, major participants in the health care delivery system will be asked to link payment to clinical outcomes [30].

Medical Technology

The impact of evolving medical technology on the epidemiology and economics of cardiothoracic surgical procedures is impossible to predict. It may be useful, however, to draw lessons from other fields which have experienced significant technological shifts.

Laparoscopic techniques have dramatically altered the types and rates of surgical procedures performed by abdomi-

nal surgeons. The incidence rate for cholecystectomy increased dramatically as a result of rapid uptake of laparoscopic techniques [31]. This change involved not only an increase in the use of the procedure, but also a change in what was considered an acceptable indication. When the procedure involved a large subcostal incision and a 2–4-day hospital stay, cholecystectomies were primarily performed for acute cholecystitis. With laparoscopic techniques, and lengths of stay often less than 24 h, the procedure is now primarily performed for patients with symptomatic cholelithiasis.

Vascular surgeons have also seen significant changes in the treatment for peripheral arterial disease (PAD). Endovascular procedures are rapidly supplanting open revascularization techniques for the treatment of patients with PAD, in both acute and nonacute contexts [32, 33]. What is most remarkable about this shift, however, is the rapid change in the *types of physicians* who perform endovascular procedures (Fig. 2.17). Vascular surgeons and cardiologists have quickly replaced radiologists as the specialties who are most likely to use endovascular technology for the treatment of PAD.

The lessons for cardiothoracic surgeons are clear. Minimally invasive technologies expand the pool of patients who are appropriate for surgical treatment. With the introduction of techniques for percutaneous valve procedures, there is the potential for a significant increase in the demand for these procedures. Cardiothoracic surgeons should become intimately involved in these technologies, in the same manner that vascular surgeons embraced endovascular approaches.

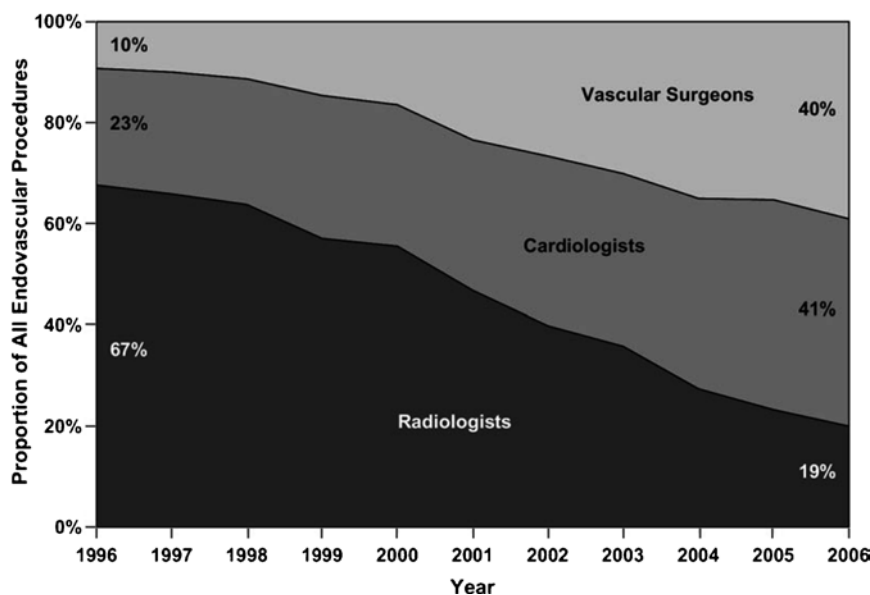


Fig. 2.17 Proportion of endovascular interventions performed by specialty, 1996–2006 (reprinted from Goodney [33] with permission. Copyright 2009, with permission from Elsevier)

Percutaneous valve procedures are only an example – the future will surely present the field of cardiothoracic surgery with many opportunities to be involved in evaluating and applying other new technologies.

The Domestic Supply of Cardiothoracic Surgeons

If the numbers of cardiothoracic procedures performed per year in the US increases, will the workforce be sufficient? In this section, we will consider trends in the numbers of surgeons certified by the American Board of Thoracic Surgeon (ABTS) in order to forecast the numbers of cardiothoracic surgeons in the future. The ABTS was initially formed in 1948, at which time 229 members were certified as founders. In 1949 an additional 15 diplomates were certified, and this number gradually rose, peaking in 1998 with 168 certifications (Fig. 2.18). Since 1998, there has been some decline in the number of certifications per year, with 118 new certifications in 2009.

We estimated the workforce of active ABTS diplomates based on historical data from the ABTS and three basic assumptions: (1) annual certification rate at 2009 levels (118 per year), (2) a 30-year career in practice after certification,

and (3) a 1.0% annual attrition rate. The results of this model are shown in Fig. 2.18. This model shows a decrease from 3,708 to 3,411 surgeons between 2009 and 2025 – a decline of approximately 8%.

The prospect of a workforce of cardiothoracic surgeons which is shrinking and a rising number of procedures raises the possibility of a shortage. If these assumptions hold, how much more work output will be expected per surgeon? We examine the answer to this question in Fig. 2.19. With an assumption of stable incidence rates in the three types of cardiothoracic surgical procedures (CABGs, valve operations, and pneumonectomies), we forecast dramatic increases in the number of procedures per active cardiothoracic surgeon. For CABG, the number would increase 67.5%, and for valve procedures and pneumonectomies, 65.0 and 60.4%, respectively. With an assumption of declining incidence rates, these increases are still significant – 14.1, 12.4, and 9.3% (for CABG, valve procedures, and pneumonectomies). The results we achieve with this simple model parallel those demonstrated by Grover et al who used a methodology similar to ours [34].

Our model's simplicity may underestimate the magnitude of growth in demand relative to supply, especially in its estimation of the effective size of the cardiothoracic surgical workforce. The current workforce of cardiothoracic surgeons

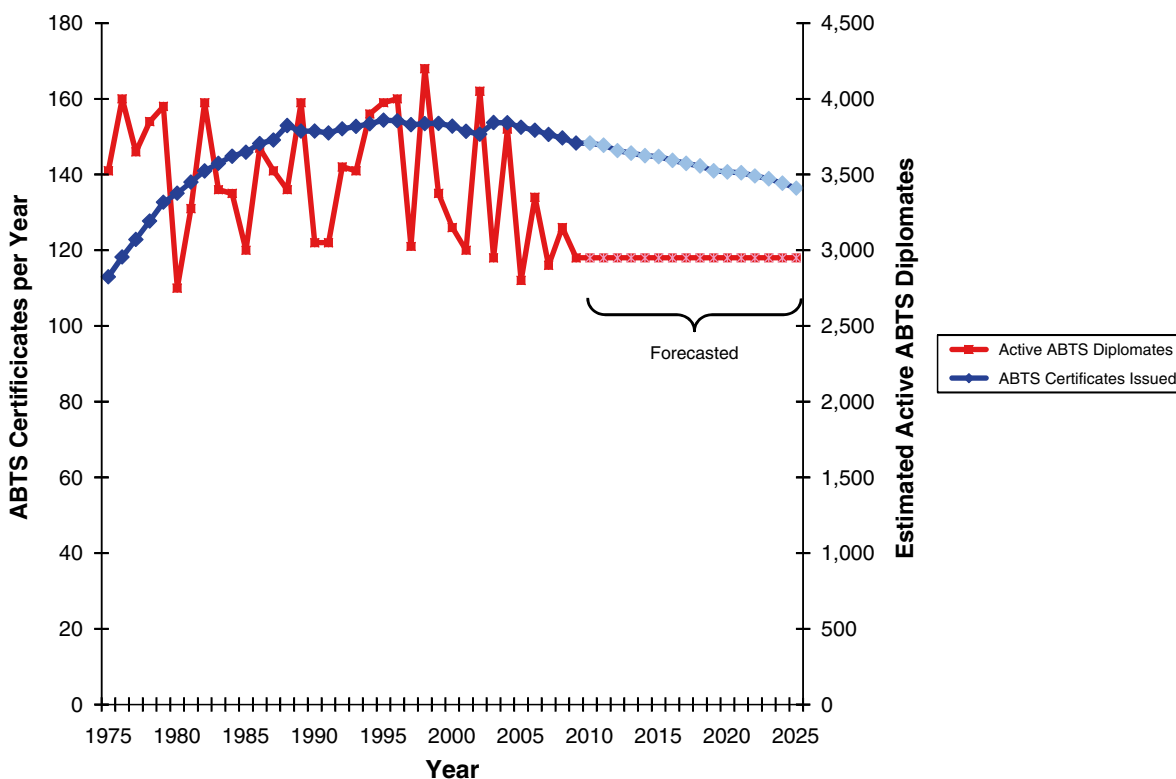


Fig. 2.18 Workforce of ABTS diplomates in the United States with forecast to 2025 (from The American Board of Thoracic Surgery (ABTS))

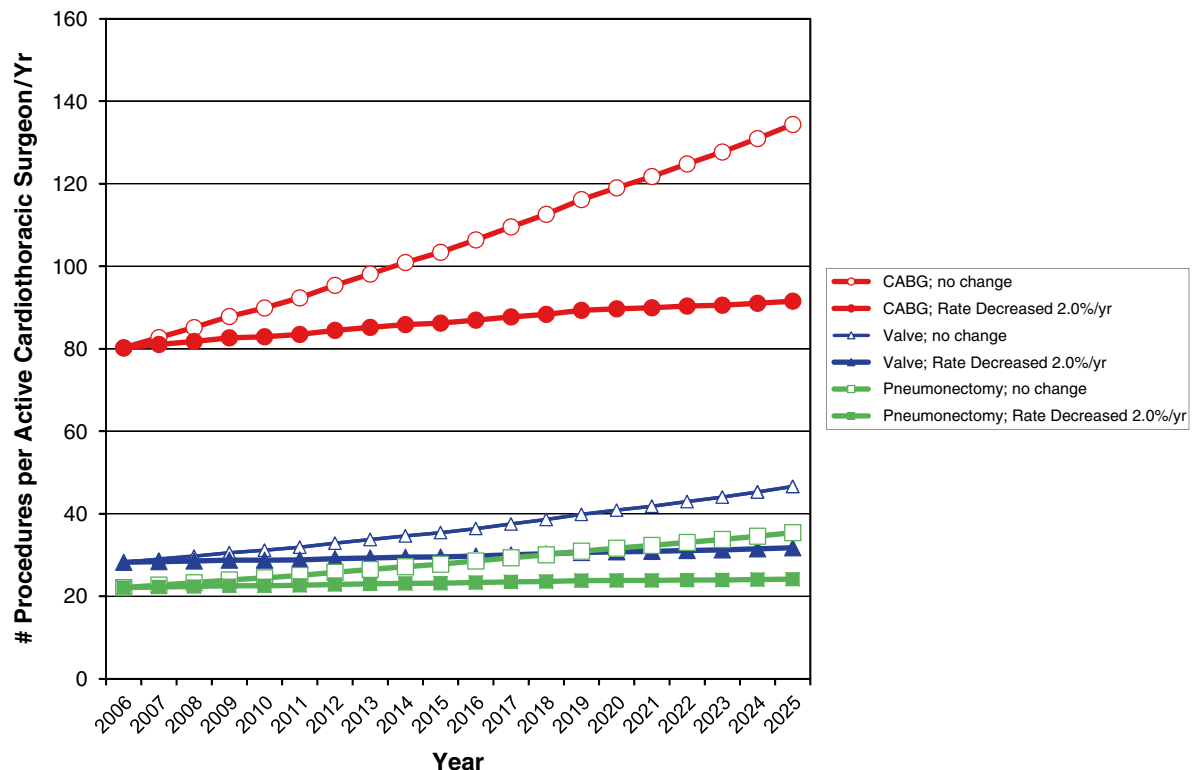


Fig. 2.19 Forecasted changes in numbers of procedures per active cardiothoracic surgeon (from The Healthcare Cost and Utilization Project (HCUP), available at <http://www.ahrq.gov/data/hcup/datahcup.htm>)

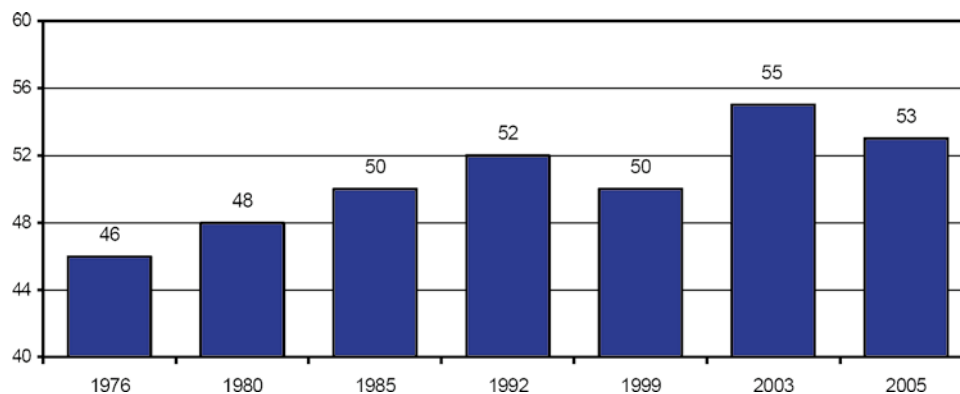


Fig. 2.20 Average age of thoracic surgeons in the US (this graph is reprinted from the 2005 STS/AATS practice survey final results (<http://www.sts.org/documents/pdf/2005practsurvFinalResults.pdf>) and shows the mean age trend of cardiothoracic surgeons based on longitudinal data from survey respondents. © The Society of Thoracic Surgeons. Used with permission. All rights reserved.) [40]

is increasingly older (Fig. 2.20) may be retiring earlier than in previous generations [35].

Other health policy researchers have forecasted reductions in the amount of work per physician, resulting from an increasing proportion of women in the medical workforce as well as generational changes in work hours [36]. The actual impact of these trends is difficult to estimate.

Conclusion

The field of cardiothoracic surgery is at an inflection point in its trajectory. With the advent of minimally invasive techniques to treat CAD, rates of cardiac procedures have fallen. These changes had an immediate and dramatic impact on the field, demonstrated in the reduced rates of surgical

training [37]. Over the next 10–20 years, as a result of profound changes in the US population, the field of cardiothoracic surgery will see a significant increase in its patient base. Even with continued decreases in the population-based incidence rates of heart disease and lung cancer, the numbers of open heart procedures and pneumonectomies that will be performed will increase steadily. Percutaneous techniques for valve repair/replacement also have the potential to significantly expand the demand for heart procedures. Cardiothoracic surgeons need to take a leadership role in developing, testing, and diffusing these technologies. Given the declining numbers of cardiothoracic surgeons trained per year and this new demand, we agree with other health policy researchers in forecasting an increase in the workloads of cardiothoracic surgeons [34].

Demography is not the only driver of destiny, however. The appropriateness and quality of care delivered to patients needs to be examined closely and on an ongoing basis. Many view CABG procedures as discretionary procedures which are over-applied to the population as large, a view which is not grounded in truth. Cardiothoracic surgeons need to be a part of the evolution toward a system which considers the care provided to *all* patients after cardiologic evaluations, not only those deemed appropriate for surgical intervention. The field of cardiothoracic surgery must have a seat at the table where these reforms are generated in order to ensure the best health for the population.

Appendix 1: Cardiothoracic Surgical Procedures

Procedure description	ICD-9 Code(s)
Pneumonectomy	32.xx
<i>Local excision or destruction of lesion or tissue of lung/bronchus</i>	32.0x, 32.2x
Other excision of bronchus	32.1x
Segmental resection of lung	32.3x
Lobectomy of lung	32.4x
Complete pneumonectomy	32.5x
Radical dissection of thoracic structures	32.6x
Other excision of lung	32.9x
Valve repair/replacement	35.xx
<i>Closed heart valvotomy</i>	35.0x
Open heart valvuloplasty without replacement	35.1x
Replacement of heart valve	35.2x
Coronary artery bypass graft	36.xx
<i>Removal of coronary artery obstruction and insertion of stent(s)</i>	36.0x
Bypass anastomosis for heart revascularization; w/o arterial implant	36.1x, 36.2x
Other heart revascularization	36.3x
Other operations on vessels of heart	36.4x

Italicized procedures considered nonsurgical, excluded from analysis.

References

1. Arias E. United States Life Tables, 2004. National Vital Statistics Reports 2007;56.
2. Dennison C, Pokras R. Design and operation of the National Hospital Discharge Survey: 1988 redesign. Vital Health Stat. 2000;1:1–42.
3. Wennberg J, Gittelsohn A. Small area variations in health care delivery. Science. 1973;182:1102–8.
4. Lloyd-Jones D, Adams RJ, Brown TM, et al. Heart disease and stroke statistics – 2010 update. A report from The American Heart Association. Circulation. 2009;117:17.
5. Bach DS, Radeva JI, Birnbaum HG, Fournier AA, Tuttle EG. Prevalence, referral patterns, testing, and surgery in aortic valve disease: leaving women and elderly patients behind? J Heart Valve Dis. 2007;16:362–9.
6. Singh JP, Evans JC, Levy D, et al. Prevalence and clinical determinants of mitral, tricuspid, and aortic regurgitation (the Framingham Heart Study). Am J Cardiol. 1999;83:897–902.
7. Nkomo VT, Gardin JM, Skelton TN, Gottdiener JS, Scott CG, Enriquez-Sarano M. Burden of valvular heart diseases: a population-based study. Lancet. 2006;368:1005–11.
8. Cosgrove D. View from North America's cardiac surgeons. Eur J Cardiothorac Surg. 2004;26 Suppl 1:S27–30; discussion S-1.
9. Gammie JS, Sheng S, Griffith BP, et al. Trends in mitral valve surgery in the United States: results from the Society of Thoracic Surgeons Adult Cardiac Surgery Database. Ann Thorac Surg. 2009;87:1431–7; discussion 7–9.
10. Filsoofi F, Rahmanian PB, Castillo JG, Chikwe J, Silvay G, Adams DH. Results and predictors of early and late outcomes of coronary artery bypass graft surgery in octogenarians. J Cardiothorac Vasc Anesth. 2007;21:784–92.
11. Chassin MR, Galvin RW. The urgent need to improve health care quality. Institute of Medicine National Roundtable on Health Care Quality. JAMA. 1998;280:1000–5.
12. Shekelle PG, Kahan JP, Bernstein SJ, Leape LL, Kamberg CJ, Park RE. The reproducibility of a method to identify the overuse and underuse of medical procedures. N Engl J Med. 1998;338:1888–95.
13. Shekelle PG, Park RE, Kahan JP, Leape LL, Kamberg CJ, Bernstein SJ. Sensitivity and specificity of the RAND/UCLA Appropriateness Method to identify the overuse and underuse of coronary revascularization and hysterectomy. J Clin Epidemiol. 2001;54:1004–10.
14. Philbin EF, McCullough PA, DiSalvo TG, Dec GW, Jenkins PL, Weaver WD. Underuse of invasive procedures among Medicaid patients with acute myocardial infarction. Am J Public Health. 2001;91:1082–8.
15. Petersen LA, Normand SL, Leape LL, McNeil BJ. Regionalization and the underuse of angiography in the Veterans Affairs Health Care System as compared with a fee-for-service system. N Engl J Med. 2003;348:2209–17.
16. Guadagnoli E, Landrum MB, Normand SL, et al. Impact of underuse, overuse, and discretionary use on geographic variation in the use of coronary angiography after acute myocardial infarction. Med Care. 2001;39:446–58.
17. Ellis C, Devlin G, Matsis P, et al. Acute Coronary Syndrome patients in New Zealand receive less invasive management when admitted to hospitals without invasive facilities. N Z Med J. 2004;117:U954.
18. Kostis WJ, Demissie K, Marcella SW, Shao YH, Wilson AC, Moreyra AE. Weekend versus weekday admission and mortality from myocardial infarction. N Engl J Med. 2007;356:1099–109.
19. Denvir MA, Pell JP, Lee AJ, et al. Variations in clinical decision-making between cardiologists and cardiac surgeons; a case for management by multidisciplinary teams? J Cardiothorac Surg. 2006;1:2.

20. Hemingway H, Crook AM, Feder G, et al. Underuse of coronary revascularization procedures in patients considered appropriate candidates for revascularization. *N Engl J Med.* 2001;344:645–54.
21. Selby JV, Fireman BH, Lundstrom RJ, et al. Variation among hospitals in coronary-angiography practices and outcomes after myocardial infarction in a large health maintenance organization. *N Engl J Med.* 1996;335:1888–96.
22. Hlatky MA, Boothroyd DB, Bravata DM, et al. Coronary artery bypass surgery compared with percutaneous coronary interventions for multivessel disease: a collaborative analysis of individual patient data from ten randomised trials. *Lancet.* 2009;373:1190–7.
23. Naik H, White AJ, Chakravarty T, et al. A meta-analysis of 3, 773 patients treated with percutaneous coronary intervention or surgery for unprotected left main coronary artery stenosis. *JACC Cardiovasc Interv.* 2009;2:739–47.
24. Serruys PW, Morice MC, Kappetein AP, et al. Percutaneous coronary intervention versus coronary-artery bypass grafting for severe coronary artery disease. *N Engl J Med.* 2009;360:961–72.
25. Pell JP, Denvir MA. Angioplasty, bypass surgery or medical treatment: how should we decide? *Heart.* 2002;88:451–2.
26. Kravitz RL, Laouri M. Measuring and averting underuse of necessary cardiac procedures: a summary of results and future directions. *Jt Comm J Qual Improv.* 1997;23:268–76.
27. Taggart DP. PCI or CABG in coronary artery disease? *Lancet.* 2009;373:1150–2.
28. Robinson JC. Theory and practice in the design of physician payment incentives. *Milbank Q.* 2001;79:149–77; III.
29. Mark DB, Hlatky MA. Medical economics and the assessment of value in cardiovascular medicine: part II. *Circulation.* 2002;106:626–30.
30. Lee PV, Berenson RA, Tooker J. Payment reform – the need to harmonize approaches in Medicare and the private sector. *N Engl J Med.* 2010;362:3–5.
31. Escarce JJ, Chen W, Schwartz JS. Falling cholecystectomy thresholds since the introduction of laparoscopic cholecystectomy. *JAMA.* 1995;273:1581–5.
32. Rowe VL, Lee W, Weaver FA, Etzioni D. Patterns of treatment for peripheral arterial disease in the United States: 1996–2005. *J Vasc Surg.* 2009;49:910–7.
33. Goodney PP, Beck AW, Nagle J, Welch HG, Zwolak RM. National trends in lower extremity bypass surgery, endovascular interventions, and major amputations. *J Vasc Surg.* 2009;50:54–60.
34. Grover A, Gorman K, Dall TM, et al. Shortage of cardiothoracic surgeons is likely by 2020. *Circulation.* 2009;120:488–94.
35. Shemin RJ, Dziuban SW, Kaiser LR, et al. Thoracic surgery workforce: snapshot at the end of the twentieth century and implications for the new millennium. *Ann Thorac Surg.* 2002;73:2014–32.
36. Cooper RA, Getzen TE, McKee HJ, Laud P. Economic and demographic trends signal an impending physician shortage. *Health Aff (Millwood).* 2002;21:140–54.
37. Salazar JD, Lee R, Wheatley 3rd GH, Doty JR. Are there enough jobs in cardiothoracic surgery? The thoracic surgery residents association job placement survey for finishing residents. *Ann Thorac Surg.* 2004;78:1523–7.
38. <http://www.un.org/esa/population/publications/worldage-ing19502050/>. Accessed 01 Apr 2010.
39. Jemal A, Thun MJ, Ries LA, et al. Annual report to the nation on the status of cancer, 1975–2005, featuring trends in lung cancer, tobacco use, and tobacco control. *J Natl Cancer Inst.* 2008;100:1672–94.
40. www.sts.org/documents/pdf/2005practsurvFinalResults.pdf. Accessed 01 June 2010.
41. Carlisle DM, Leape LL, Bickel S, et al. Underuse and overuse of diagnostic testing for coronary artery disease in patients presenting with new-onset chest pain. *Am J Med.* 1999;106:391–8.
42. Leape LL, Hilborne LH, Bell R, Kamberg C, Brook RH. Underuse of cardiac procedures: do women, ethnic minorities, and the uninsured fail to receive needed revascularization? *Ann Intern Med.* 1999;130:183–92.
43. Schneider EC, Leape LL, Weissman JS, Piana RN, Gatsonis C, Epstein AM. Racial differences in cardiac revascularization rates: does “overuse” explain higher rates among white patients? *Ann Intern Med.* 2001;135:328–37.
44. Garg PP, Landrum MB, Normand SL, et al. Understanding individual and small area variation in the underuse of coronary angiography following acute myocardial infarction. *Med Care.* 2002;40:614–26.
45. O’Connor GT, Olmstead EM, Nugent WC, et al. Appropriateness of coronary artery bypass graft surgery performed in northern New England. *J Am Coll Cardiol.* 2008;51:2323–8.



<http://www.springer.com/978-1-4419-0891-9>

Cardiothoracic Surgery in the Elderly

Katlic, M.R. (Ed.)

2011, XXVI, 654 p., Hardcover

ISBN: 978-1-4419-0891-9