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Review Article

Managed Care, Medical Technology, and Health Care Cost Growth: A Review of the Evidence

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Although managed care plans reduce health care expenditures at any point in time, less is known about whether such plans control health care cost growth. Because use of new medical technology is an important determinant of cost growth, the impact of managed care on utilization of medical technology will largely determine whether managed care can reduce expenditure growth to sustainable levels. This article reviews the literature relating medical technology to cost growth and the literature examining the impact of managed care on either cost growth or on the diffusion of medical technology. Studies that examine plan-level data often reach different conclusions than studies that examine market-level data. The evidence suggests that managed care, as currently practiced, may reduce the rate of cost growth. However, managed care is unlikely to prevent the share of gross domestic product spent on health care from rising unless the cost-increasing nature of new technology changes.

Since the early 1970s, rapidly growing enrollment in managed care health insurance plans has transformed the health insurance market in the United

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States. Virtually nonexistent in most markets three decades ago, by 1994 managed care plans covered 63 percent of the nation's employees.[1] Unlike indemnity fee-for-service (FFS) insurance plans, managed care plans aggressively contract for lower prices from physicians and hospitals and attempt to constrain use of health care services by monitoring providers and changing provider incentives. Health maintenance organizations (HMOs), the strongest form of managed care, effectively reduce health care expenditures (Miller and Luft 1994; Manning et al. 1987; Luft 1981). These cost savings have been achieved, according to most evidence, without significant reductions in the quality of care (Carlisle et al. 1992; Retchin and Brown 1991, 1990; Sloss et al. 1987; Ware et al. 1986; Greenfield et al. 1995; Miller and Luft 1997), suggesting that managed care plans (or at least HMOs) reduce inefficiencies in the health care system.[2]

Largely unrecognized in the rush toward managed care is that the growth in health care expenditures observed since the mid-1960s was largely attributable to factors other than *growing* "inefficiency." It is possible that, although managed care reduces the level of spending at any point in time, it will not alter the historical trajectory of rising medical care expenditures. Health care cost growth will moderate during the transition to managed care plans, but unless the forces underlying health care cost growth are dampened, the "crisis" regarding health care spending will return once the transition period has ended.

Most health economists (81 percent) believe that the increasing development, adoption, and use of new medical technologies account for a major part of the rise in health care expenditures (Fuchs 1996). If this belief is correct, understanding whether managed care is likely to alter permanently the underlying trends in health care cost growth requires an understanding of how managed care influences the process by which medical technologies are developed, adopted, and integrated into the delivery of health care services.

NEW CONTRIBUTION

This study reviews three related literatures. First, we examine the impact of managed care on cost growth. Our review indicates that methodological differences can explain variations in findings. In particular, studies that compare cost growth in HMOs with that in less managed systems tend to find no difference between systems. In contrast, studies that focus on market-level comparisons tend to find slower cost growth in markets with greater managed care penetration. These seemingly contradictory findings can be reconciled if there exist strong market-level spillover effects of managed care penetration.

Yet, even in the studies that report a reduction in cost growth associated with managed care, the magnitude of the estimates suggests that managed care has not succeeded in lowering cost growth to a rate less than the general growth rate of the economy.

One reason why managed care plans may not reduce the rate of cost growth below that of the general economy is that they may not reduce the rate of adoption and diffusion of medical technology. The second body of literature that we review examines the potential plausibility of this explanation by exploring the relationship between health care cost growth and the adoption and use of new medical technology. The evidence confirms that medical innovation is an important determinant of health care cost growth.

Because of the significant influence of medical technology on health care cost growth, the third literature that we review explores the relationship between managed care and adoption and use of new medical technology. Although managed care plans appear more conservative in their use of medical technology at any point in time, several studies suggest that the trajectory of adoption and use of new technologies in HMOs does not differ from that in largely FFS systems of financing and delivering health care.

The next section of this study provides the framework for the analysis. It includes a discussion of our definition of medical technology and an outline of a conceptual model relating managed care, medical technology, and cost growth. The subsequent section provides the review of the three literatures described above, starting with the method for identifying articles to review.

FRAMEWORK

DEFINING TECHNOLOGY

All health care services, from the most simple to the most sophisticated, represent the application of some "technology" to a health care problem. Yet, if we classify all services as technology, we obscure the essence of the relationship between medical technology and cost growth. In particular, changes in utilization driven by advances in medical technology should be considered distinct from those driven by other factors, including underlying changes in the incidence or prevalence of disease, or changes in the incentives and structures surrounding the provision of care.

We therefore distinguish between *medical technology* and *new medical technology*, with the latter term defined as new knowledge regarding the delivery of health care services. This focus is consistent with that of Weisbrod (1991). It is this new technology that has the potential to change physician practice

patterns and influence health care cost growth. In many cases, the new technology is simply knowledge about how to apply existing services in a new way to achieve some clinical objective, such as treating peptic ulcer disease patients with commonly used antibiotics to eradicate *H. pylori* bacteria. In other cases the technology is characterized by new equipment, pharmaceuticals, or procedures.

Application of this definition is complicated by imprecision in identifying the point at which a new technology ceases to be new. Conceptually, technology ceases to be new after it has diffused to a point of equilibrium in the absence of any other shocks to the system. In practice, identification of this point is difficult.

DEFINING MANAGED CARE

Managed care incorporates a range of features that allow the insurer greater influence in the process of care delivery. Tremendous heterogeneity exists in the design of managed care plans. HMOs are generally considered the strongest form of managed care, but there is substantial variation among HMOs. Other types of managed care plans include preferred provider organizations, point of service plans, and managed indemnity plans. Most studies focus on HMOs and do not describe variation in the type of HMO or in the extent of "managedness" in non-HMO plans.

CONCEPTUAL MODEL

Health care costs, by definition, reflect the price and quantity of all services provided. Historically, the FFS system contained incentives for both the price and quantity of services to be greater than optimal. Managed care may reduce costs by obtaining reductions in the prices of health care services through careful shopping and tough negotiation. Managed care may also lower costs by reducing the quantity of services provided, through use of guidelines, incentives, and utilization review. If inefficiencies existed in the FFS-dominated market, the reduction in quantity may be achieved without a reduction in the quality of care.

Largely apart from the activities of managed care plans to reduce prices and control use, medical technology continues to advance. Although managed-care-induced changes in utilization may ultimately affect technological progress, any given technological advance will influence health care costs by altering the quantity, and possibly the price, of services consumed.

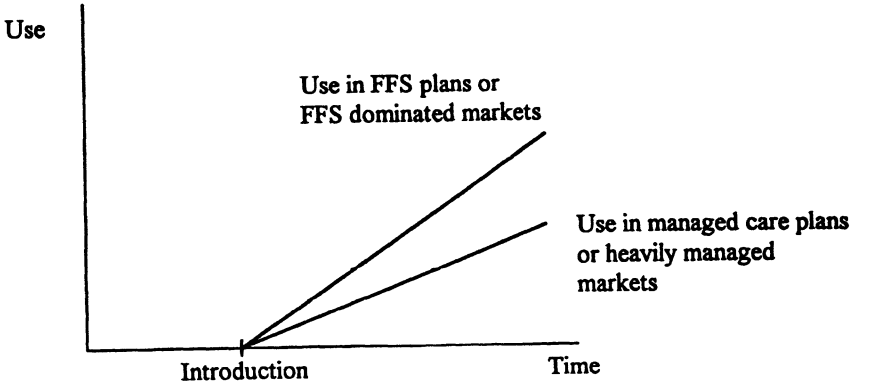

FIGURE 1 Diffusion Curves

Paradoxically, lower utilization of new medical technologies in managed care plans or in managed-care-dominated markets does not necessarily imply lower cost growth associated with managed care. This is because managed care plans (or managed-care-dominated markets) will likely have a lower base level of premiums or expenditures on which growth rates will be computed. Therefore, a flatter diffusion curve associated with managed care does not necessarily imply managed-care-induced reductions in the rate of cost growth. In fact, given that at some point in time there was, by definition, no use of the new technology, lower use of a new technology associated with managed care would imply a flatter diffusion curve associated with managed care if the observation period extended back far enough.

If managed care is to reduce health care cost growth relative to that in an FFS system, the ratio of managed care use of a new technology to FFS use must be less than the comparable ratio for established services. Figure 1 illustrates a case in which use of the new technology is always lower in the managed care plan (or a managed-care-dominated market). Yet, the ratio of managed care to FFS use is constant. If that ratio is higher than the ratio of expenditures for established services, cost growth associated with managed care will exceed that associated with FFS despite the flatter diffusion curve. For example, Manning et al. (1987) report that expenditures in an HMO were

about 70 percent of those in an FFS plan. A managed-care-induced reduction in cost growth would require the ratio of managed care use of new technologies relative to FFS use to be less than 0.70. Similar arguments apply if one is comparing markets that vary in managed care penetration as opposed to plans that vary in managedness.

Of course, the impact of the introduction of new medical technologies on cost growth extends beyond that implied by the price and use of the innovative services. The aggregate impact of a new technology on expenditures also depends on how its introduction influences the use of existing services. New technology may cause the use of some services to rise (complementary services) and the use of others to fall (substitutive services).

Complementary Services

Complementary services are those whose use increases with use of the new technology. For example, consider an improvement in diagnostic imaging that provides higher quality images, allowing for better surgical outcomes. The better outcomes may increase the likelihood that individuals elect to receive surgical treatment. The costs associated with the innovation not only include costs associated with the new imaging procedure, but also the costs associated with the increased likelihood of surgery. In this case, imaging and surgery are complementary technologies. If an innovation leads to greater use of complementary services, expenditures rise more than would be predicted by simply examining the direct expenditures on the innovation. Lee (1992) suggests that the use of complementary services may increase the costs associated with use of new innovations by as much as 50 percent.

In many cases the complementarity with an innovation results because the innovation pulls people into an expensive treatment path when, without the innovation, they would have managed their symptoms inexpensively or even outside of the health care system (Fendrick et al. 1996). For example, in the case of cholecystitis,[3] recent surgical advances that have reduced the mortality and morbidity of cholecystectomy[4] have led to a 60 percent increase in use of this procedure in some delivery systems (Chernew, Fendrick, and Hirth 1997). Prior to the innovation, many asymptomatic or mildly symptomatic individuals may not have been treated because the risk and morbidity associated with treatment exceeded that associated with the disease. Expenditures are increased not only by the increase in cholecystectomy use but also by the increased use of services such as office visits and diagnostic testing associated with the procedure.[5]

A third type of complementarity arises when innovations extend life expectancy. In many cases innovative medical technologies avert or delay death. Survivors often consume greater health care services in the extra years of life. These incremental services, although potentially valuable, and even potentially cost-effective, raise health care expenditures (Meltzer 1997). For example, one study suggests that the rising incidence of end-stage renal disease is, in part, attributable to innovations in treating coronary artery disease (Port 1995).

Substitutive Services

Substitutive services are those that are not provided because of the use of the new technology. The savings associated with avoiding these services offset the costs associated with the innovative technologies and complementary services. In many cases the innovation is intended to replace an established service. For example, one might consider laparoscopic techniques for performing cholecystectomy substitutes for the traditional open procedure. Similarly, in some cases coronary angioplasty may substitute for more invasive coronary artery graft bypass surgery.

If the innovation results in improved health outcomes, substitution away from services that would have been consumed later also may occur. It is hoped that this type of substitution would accompany most preventive services and many other innovations that yield a long-run reduction in morbidity. For example, pharmaceuticals that reduce serum cholesterol may reduce expenditures if they enable sufficient substitution away from treatment for coronary artery disease that would have occurred had cholesterol levels remained high.

Most health care innovation will generate changes in both complementary and substitutive services. What matters is how use patterns change on balance. The pattern of changes in use, termed the *behavioral response*, depends on the elasticities of demand for all services with respect to the characteristics of the innovation (Fendrick et al. 1996).

The evidence summarized below suggests that, on average, innovation has led to higher expenditures on health care services. Hence, if unchecked by managed care, the effect of technological progress will tend to offset any cost savings achieved by managed care through lower prices or lower use of established services. Moreover, if the price and quantity reductions have natural limits, the effect of technological progress on costs may dominate the effects of managed-care-induced cost savings in the long run. However, just as they can influence the use of established services, managed care plans can

influence the rate at which new technologies are adopted and diffuse. The critical question is whether managed care plans successfully exploit this potential.

LITERATURE REVIEW

METHOD

Studies were selected for this review on the basis of several MEDLINE searches. The first set of searches were based on the phrase *health care costs*, which was paired with *growth* and then paired with *diffusion* or *diffusion of technology*. The second set of searches replicated the first set, except that the phrase *medical technology* replaced *health care costs*.

The inclusion of the terms *growth* or *diffusion* in the searches reflected our desire to limit the review to those studies that examined changes in practice patterns using longitudinal data. A wide body of literature examines the relationship between managed care and the use of various high-technology services at any particular point in time. Yet, as Newhouse et al. (1985) note, even if HMOs are less likely to use medical technology at any point in time, a constant ratio of HMO use of technology to FFS use will imply similar rates of cost growth. Hence, we do not review the literature that compares HMO use of medical technology to FFS use at a point in time. Miller and Luft (1994) review several studies that make such a comparison and conclude that HMOs are less likely to use services that are expensive and/or have less costly alternatives.

We only searched for English-language articles published since 1990.[6] However, we considered for review studies referenced by any of the other work. We also considered for review studies with which the authors were familiar and studies recommended by colleagues.

We excluded abstracts or articles in conference volumes. We also excluded articles published in journals aimed at nonacademic, managerial audiences or articles focused on experiences outside of the United States. We reviewed the articles identified by any of our sources and included those that were relevant.

MANAGED CARE AND COST GROWTH

The methodologies used to assess the impact of managed care on cost growth fall into two broad categories, the "horse race" approach and the "market comparison" approach. The horse race approach typically involves collecting data from managed and unmanaged plans or, more commonly,

TABLE 1 Managed Care and Cost Growth Horse Race Studies

Study	*Observation Period*	*Unit of Observation*	*HMO Cost Growth/FFS Cost Growth (per year)*
Luft (1980)	1962/1963-1970/1971	Delivery system and statewide data	95.8%
Newhouse et al. (1985)	1976-1981	Delivery system and nationwide data	98.9%
Ginsburg and Pickreign (1996)	1991-1995 (Hay Huggins data) 1991-1995 (KPMG data)	Delivery system and nationwide data	96.0% 80.4%

strongly managed plans (typically HMOs) and less strongly managed plans. The analysis compares growth in some aggregate spending measure (such as premiums) between systems. Studies typically adjust for differences in benefit design and demographic changes. The market comparison approach examines similar outcome measures in distinct markets that differ in their HMO penetration. In some cases, the unit of observation is the hospital instead of the market, but managed care penetration is computed at the market level and there is no attempt to attribute costs to one system or another.

Three studies that use the horse race approach are summarized in Table 1. Two of the studies (Newhouse et al. 1985; Luft 1980) rely on data that are now out-of-date. In the early time period, the cost growth in the managed care plan approximates that in the nonmanaged plan. The results from the recent data are mixed. Ginsburg and Pickreign (1996) report that relatively recent data from Hay Huggins support the conclusions drawn from the earlier studies, but similar data from KPMG Peat Marwick reveal somewhat slower growth in HMO premiums.[7] The similarity of cost growth between systems may reflect a pricing strategy among HMOs to peg premiums to those charged in the FFS sector.

The market comparison studies, listed in Table 2, generally indicate that cost growth was inversely related to HMO penetration. Many of these studies focus on hospital expenses or revenues. For example, Robinson (1991, 1996) measures changes in hospital expenses in California, adjusting for input price differences, finding as much as a 44 percent slower rate of hospital care cost growth in markets with high HMO penetration relative to markets with low HMO penetration. Robinson and Luft (1988) compare hospital cost growth

TABLE 2 Managed Care and Cost Growth—Market Comparison Studies

Study	*Study Period*	*Main Unit of Observation*	*Primary Findings*
Robinson (1991)	1982-1988	Hospitals in California	An increase of 10 percentage points in HMO penetration results in a 9.4% reduction in the rate of increase in cost per admission.
Robinson (1996)	1983-1993	Hospitals in California	Cost growth per admission was 44% lower in markets with high HMO penetration compared to markets with low HMO penetration, largely because of reductions in the volume and mix of services.
Robinson and Luft (1988)	1982-1986	Hospitals	All payer rate regulation reduced cost between 6.3% and 16.3%. California's market-oriented strategy reduced costs by 10.1%.
Gaskin and Hadley (1997)	1985-1993	Hospitals	Cost growth in hospitals in areas with high rates of HMO penetration was slower than that in areas with low HMO penetration (8.3% vs. 11.2%).
Melnick Zwanziger, and Verity-Guerra (1989)	1980-1987	Hospitals in California	Hospital revenue growth in competitive markets was similar to that in noncompetitive markets prior to selective contracting, but lower after selective contracting.
Zwanziger, Melnick, and Bamezai (1994)	1982-1988	Hospitals in California	Hospitals in the most competitive markets had a 17% lower increase in inflation-adjusted expenses relative to hospitals in the least competitive markets. These reductions in expense growth were not concentrated in particular cost or revenue centers.
Zwanziger et al. (1994)	1975-1990	Hospitals in California	Prior to selective contracting, costs in highly competitive areas were 17% higher than those in less competitive markets. By 1990, after selective contracting, the gap narrowed to 4%.
Melnick and Zwanziger (1995)	1980-1991	Statewide and national data on	Inflation-adjusted expenditures in California for hospital, physician, and pharmaceuticals grew by 27%, 58%,

TABLE 2 Continued

Study	*Study Period*	*Main Unit of Observation*	*Primary Findings*
		hospital, physician, and pharmaceutical expenditures	and 41%, respectively, over the study period. Comparable national figures were 54%, 82%, and 65%.
Zwanziger and Melnick (1988)	1980-1985	Hospitals in California	The introduction of selective contracting reduced the magnitude of the positive relationship between hospital competition and hospital costs.
Melnick and Zwanziger (1988)	1980-1985	Hospitals in California	Between 1983 and 1985 inflation-adjusted inpatient costs in highly competitive markets decreased by 11.3% compared with a less than 1% increase in less competitive markets.
Melnick, Zwanziger, and Bradley (1989)	1977-1986	Hospitals	Hospital expenses as a percentage of per capita income fell in California between 1982 and 1986. Most of the decline, and most of the divergence in the trend between California and the United States, is attributable to the 1982-1983 period. California and the United States had similar trends from 1984 through 1986.
Wickizer and Feldstein (1995)	1985-1992	Insured employee groups	A 25% increase in market-level HMO penetration would result in a 16% decline in premium growth.
Hill and Wolfe (1997)	1981-1994	Health plans offered to state employees in Madison, Wisconsin	Lower premium growth occurred in the first 2 years following a rapid transition to managed care and then the rate of increase returned to national trends.

rates between 1982 and 1986 in California, a state with high managed care penetration, with those in four regulated states (New York, New Jersey, Maryland, Massachusetts) and with those in all other states. They did not explicitly adjust for managed care penetration. Both regulation and managed

care controlled cost growth, but the results were mixed regarding which approach had the strongest effect.

Gaskin and Hadley (1997) use a national sample to examine changes in hospital costs as a function of marketwide HMO penetration. They find hospital cost growth to be inversely related to HMO penetration, estimating that 1992 to 1993 health care cost growth in a market with 40 percent HMO penetration would be 3.4 percentage points lower than in markets with a 5 percent HMO penetration.

A series of studies by Zwanziger, Melnick, and colleagues examined hospital cost and revenue growth over time in California before and after 1982 (Zwanziger and Melnick 1988; Melnick and Zwanziger 1988; Melnick, Zwanziger, and Bradley 1989; Melnick, Zwanziger, and Verity-Guerra 1989; Zwanziger et al. 1994). Although they did not examine the impact of managed care on cost growth directly, the introduction of selective contracting in 1982 suggests that the observed changes in trends in expenses and revenue growth resulted, in part, from managed care plans shopping for hospitals on the basis of price. The central findings from these studies are that hospital cost and revenue growth slowed markedly following the introduction of selective contracting and that the effects were strongest in the more competitive markets. This latter result supports the interpretation that attributes the changes in trends to managed care. Because selective contracting affected a wide spectrum of managed care plans, the definition of managed care in these studies is broader than that employed by the studies focusing on HMOs.

The studies that focused on the experience of hospitals do not measure expenditures from the health system's perspective for two reasons. First, from the health system's perspective, expenditures by payers are the relevant variable as opposed to costs incurred by the providers. However, if HMOs decrease the margin between price and cost for health care services, as suggested by other studies, the effects on system expenditures would be even greater than those reported. Second, these studies do not capture expenditures on non-hospital-based health care services, which are an important, and growing, component of overall spending.

Several studies use a broader perspective to measure the impact of managed care on costs and reach similar conclusions. Melnick and Zwanziger (1995) compare growth in expenditures on hospitals, physicians, and pharmaceuticals in a state with high managed care penetration, California, with that in the nation as a whole and with that in several states with low managed care penetration that relied on regulation to control health care costs. Their study period was considerably longer than that of Robinson and Luft (1988), extending from 1980 to 1991. They report that the lower growth in hospital expenditures in California was accompanied by lower growth in physician and

pharmaceutical spending categories, but that the reductions in spending growth for these services were less than the reductions in hospital spending growth.

Using data from employment groups between 1985 and 1992, Wickizer and Feldstein (1995) estimated the impact of market-level HMO penetration on premium growth. Employing multivariate regression, they report that a 25 percent increase in HMO market share would reduce inflation-adjusted premium growth by 16 percent.

The one exception to the set of findings from market comparison studies is based on analysis of state employees in Madison, Wisconsin, after the state encouraged enrollment in HMOs (Hill and Wolfe 1997). Despite examining only one employer in the market, the size of this employer relative to the market suggests that this work is best included with the market comparison studies. The results indicate that premium growth rates (for all types of coverage) fell for the first 2 years following the transition to managed care but then returned to a trend similar to the national experience. The findings from Madison are significant because the transition to managed care was very rapid. Prior to the state initiative only 7.6 percent of state employees were enrolled in HMOs. Two years later, the enrollment rate in HMOs was 85 percent, a much greater penetration rate than that observed in the other market comparison studies.

The studies by Robinson (1991) and Ginsburg and Pickreign (1996) bridge the gap between the studies that follow the horse race approach and those that are based on market comparisons. Robinson (1991) related cost growth at the hospital level to both market-level HMO penetration and the share of HMO patients in the hospital. The market-level HMO penetration influenced cost growth, but cost growth was not related to the share of hospital patients in an HMO.

Ginsburg and Pickreign's (1996) work is basically a horse race study and as such, found similar rates of cost growth in different systems (at least using the Hay/Huggins data). However, their work found a general reduction in the rate of cost growth over time as managed care penetration has grown, suggesting a potential market-level effect of HMO penetration.

This finding supports the conclusion that, when analyzed as a horse race, HMO expenditure growth matches that in other systems; yet, at the market level, HMO penetration reduces cost growth. Hence, if HMO penetration does lower cost growth, it appears to do so for non-HMOs as well. Baker (1997) provides some evidence to support the existence of a strong HMO spillover effect.

What might account for this spillover between HMO penetration and costs in less-managed delivery systems? Several possibilities exist. First, physicians

and hospitals may tend to treat all patients similarly.[8] Hence, some HMO-induced changes in practice patterns, such as reductions in length of hospital stay, may spill over into FFS or weakly managed systems. In fact, Robinson (1996) estimates that almost two thirds of the reduction in cost growth attributable to HMO penetration results from reductions in admissions and lengths of stay, things that may be influenced by changes in practice style related to the HMO penetration.

Second, as HMO penetration grows, FFS or weakly managed plans may be able to extract some of the same price concessions that more strongly managed plans realize. Perhaps the mechanism by which this occurs is through cost reductions that affect inputs common to all payers. Yet, realization of substantial reductions in prices will require FFS or weakly managed plans to negotiate strongly with providers, perhaps more strongly than their organizational form will permit. The existence of this type of spillover would imply that price concessions achieved by managed care plans do not result in a shifting of costs to other payers.

Finally, the spillover may exist because managed care plans, particularly HMOs, cause a change in the health care infrastructure (i.e., the resources available to deliver care). Considerable evidence suggests that HMO penetration does influence infrastructure (Chernew 1995; Robinson 1996; Hill and Wolfe 1997). The work of Robinson (1996) suggests that this accounts for a relatively small part of the reduction in cost growth, but work by Cutler and McClellan (1996) (reviewed in more detail below) attributes the HMO effect largely to HMO-induced infrastructure changes.

In most studies, the reduction in health care cost growth was insufficient to bring that growth in line with the general rate of inflation. Melnick and Zwanziger (1995) report a 3 percent, per capita, annual increase in health care spending above the rate of inflation in California (their market with high managed care penetration). Cutler and McClellan (1996) report a similar rise in inflation-adjusted expenditures for treatment of heart attacks. Ginsburg and Pickreign (1996) and Robinson (1996) also report a real increase in health care expenditures in the markets with high HMO penetration.

Moreover, the magnitude of cost growth in the most comprehensive of these studies (those including more than just hospital expenses) suggests that the increases in expenditures not only exceed the inflation rate but have also outpaced gross domestic product (GDP) growth, even in markets with high managed care. For example, the 3 percent per capita annual real expenditure growth reported by Melnick and Zwanziger (1995) compares with a national growth in real, per capita GDP of 1.6 percent.[9] These figures may underestimate the underlying trend in health care cost growth because they incorporate savings from reductions in inefficiencies and movement toward competitive

pricing that may be hard to replicate in the future. The savings reported reflect, in part, the transition to managed care. Preferred Provider Organization (PPO) penetration in the non-Medicare market in California rose from 1 percent in 1983 to 50 percent by 1987 and HMO penetration rose from 17 percent in 1980 to 26 percent in 1987 (Melnick, Zwanziger, and Verity-Guerra 1989).

Wickizer and Feldstein (1995) report an inflation-adjusted growth rate of 5.5 percent per year for premiums in their markets with high HMO penetration.[10] This is well above per capita GDP growth during the study period, but the sample did not permit examination of markets with very high HMO penetration. However, in the Hill and Wolfe (1997) study of state employees in Wisconsin, HMO penetration by 1985 was 85 percent. They report nominal premium growth of 8.2 percent between 1985 and 1989 and 12.6 percent between 1989 and 1993. Nominal growth in per capita Wisconsin state product during the years 1985 to 1992 was less than 5 percent per year. Collectively, the studies suggest that the success of managed care, although an improvement over the traditional indemnity FFS system, may not be enough to stabilize or reduce the share of GDP devoted to health care.

To better understand whether managed care will reduce cost growth further, two issues must be examined. Are the development, adoption, and diffusion of medical technology major drivers of real growth in health care spending? If so, will managed care alter the rate of new technology diffusion?

MEDICAL TECHNOLOGY AND COST GROWTH

Studies that examine the relationship between technology and expenditure change are listed in Table 3. They typically rely on one of two approaches. The *residual method* identifies the component of cost growth attributable to technology by netting out from aggregate cost growth other factors such as general inflation, population aging, the spread of insurance, or rising income. The remaining cost growth, after accounting for these competing explanations, is attributed to diffusion of medical technology. In some such studies, the level of insurance coverage proxies for incentives for technology diffusion and research expenditures proxy for technology development. Yet, in the residual method studies, specific technologies are not identified. Newhouse (1992, 1993) uses this approach and concludes that technology has been the prime determinant of health care cost growth in the postwar period. Schwartz (1987), who controlled for fewer nontechnological factors and examined a shorter time period, comes to a similar conclusion. Peden and Freeland (1995) estimate that about 70 percent of health care cost growth since 1960 is attributable to development and diffusion of new medical technology, much of which is induced by insurance coverage.

TABLE 3 Medical Technology and Cost Growth

Study	*Study Period*	*Method*	*Findings*
Newhouse (1993), Newhouse (1992)	Varied	Residual approach, reviewing non-technology cause of cost growth	"The principal cause of increased costs appears to be the increased capabilities of medicine."
Schwartz (1987)	1977-1984	Residual approach, reviewing non-technology cause of cost growth	Medical innovation and diffusion is the primary, controllable factor contributing to the underlying, upward trend in health care expenditures.
Peden and Freeland (1995)	1960-1993	Regression analysis using the level of insurance coverage and noncommercial research spending as proxies for technology	70% of cost growth is attributable to medical technology (much of which was induced by insurance coverage).
Newhouse (1988)	1949-1985	Regression analysis examining the change in prices as a function of the level of, and changes in, insurance coverage and gross national product (GNP)	The most important explanation of medical price inflation is that high levels of insurance coverage induced high rates of new product development and use.
Scitovsky (1985)	1971-1981	Examined changes in treatment patterns for common illnesses at the Palo Alto Medical Clinic	Big ticket new technologies were responsible for cost growth.
Scitovsky and McCall (1975)	1951-1971	Examined changes in changes in treatment patterns for common illnesses at the Palo Alto Medical Clinic	Little ticket items were responsible for cost growth.

TABLE 3 Continued

Study	*Study Period*	*Method*	*Findings*
Showstack, Schroeder, and Matsumoto (1982)	1972-1977	Examined changes in treatment patterns for patients hospitalized at University of California–San Francisco (UCSF) hospital for 1 of 10 diagnoses	Increased use was largely attributable to use of new technologies.
Cutler and McClellan (1996)	1984-1991	Examined hospital adoption of, and patient receipt of, coronary revascularization technologies	The expansion of invasive cardiac surgeries accounts for almost all of the growth in treatment costs for heart attacks.
Bradley and Kominski (1992)	1984-1987	Decomposed Medicare inpatient costs per case into input price inflation, changes in costs with diagnostic related groups (DRGs), and changes in case mix across DRGs	Technology-related factors accounted for at least 35% of the real increase in costs per case.
Katz, Welch, and Verrilli (1997)	1987-1992	Examined cost growth across different clinical categories	Cost growth was greatest in service categories considered more technologically intensive.
Holahan, Dor, and Zuckerman (1990)	1983-1985	Used two-stage least squares regression analysis to examine changes in Medicare expenditures per enrollee in different specialties	Cost growth was greatest in specialties likely to have experienced the greatest rate of technical innovation.

In related work, Newhouse (1988) estimates a model of medical care price inflation to test among three alternative models of inflation in the health care sector: (1) inflation is caused by an ever increasing demand curve attributable

to rising health insurance coverage, (2) inflation stems from increases in costs due to the development and diffusion of medical technology induced by high levels of insurance coverage, and (3) inflation stems from rising inefficiency in the health care market. Although the evidence cannot clearly reject any of these models, the evidence generally supports the premise that the second model, which emphasizes technical change, is the dominant explanation of rising health care prices.

In contrast to the residual approach, the *affirmative approach* attempts to assess the extent to which specific technologies have contributed to rising expenditures, often focusing on the treatment of specific diseases. By identifying specific diseases or technologies, the affirmative approach provides a more direct, clinically meaningful understanding of the role that technology plays in health care cost growth. The inherent shortcoming of the affirmative approach is that it is difficult to capture all of the potential cost ramifications of new technology.

Using the affirmative approach, Scitovsky (1985) and Scitovsky and McCall (1976) analyze the costs of treatment for a selection of illnesses during three different periods to determine the magnitude of, and reasons for, changes in the costs associated with treating these ailments. Holding prices constant, they conclude that between 1951 and 1964, increasing costs for most of the diseases were related to increased use of "little ticket" technologies such as lab tests and X rays. They did not attempt to identify specific changes in knowledge that led to these changes in use patterns.

A similar analysis of experience between 1964 and 1971 revealed that the little ticket technologies continued to account for observed cost increases, with one important exception: the cost of treating acute myocardial infarction rose by 33 percent, largely because of the introduction of intensive care units. These intensive care units clearly represent advances in medical science.

In the last period, from 1971 through 1981, Scitovsky found substantial cost increases for only 7 of 16 diseases, but in most of these cases, the increase arose from specific medical innovations. For example, in childbirth the cost-increasing technology was cesarean sections. In breast cancer, the cost-increasing technologies included the diffusion of radiation therapy in the earlier periods and the introduction of combination therapies including chemotherapy in the later period. In treatment of heart attacks, the prime cost-increasing technologies were the introduction of intracoronary streptokinase infusion and coronary bypass surgery.

Showstack, Schroeder, and Matsumoto (1982) also studied the treatment of specific illnesses to delineate the causes of cost growth. They compared inpatient resource use for 10 diagnoses over a shorter period of time, 1972 to 1977. They reported that technologies that were commonly available in 1972

were used similarly in 1977, but several new technologies, such as ultrasound, nuclear medicine, and fetal monitoring, were used much more often in 1977. This pattern suggests that in aggregate, the new tests were additive rather than substitutive.

Cutler and McClellan (1996), using Medicare claims from 1984 to 1991, report a 4 percent annual increase in the average real reimbursement for treating elderly heart attack patients. They attribute the majority of this increase to the diffusion of new technologies for performing invasive revascularization procedures. Over the study period, cardiac catheterization rates rose from 11 percent to 41 percent of heart attack patients. Bypass rates rose from 5 percent to 13 percent, and angioplasty rates rose from 1 percent to 12 percent.

The affirmative approach employed by Scitovsky (1985); Scitovsky and McCall (1976); and Showstack, Schroeder, and Matsumoto (1982) measure changes in costs per case. They capture use of complementary and substitutive technology only during the episode of care. The common methodology of selecting patients diagnosed with specific diseases may underestimate the fiscal impact of technological change if the new technology expands the number of individuals diagnosed with the specific diseases (or pulls more into the health care system).

Showstack, Schroeder, and Matsumoto (1982) report some evidence consistent with this behavioral response, noting that the changing mix of patients treated over time suggested that indications for treatment had expanded. This point is exemplified further in studies of specific procedures or diseases including cholecystectomy (Legoretta et al. 1993; Steiner et al. 1994), prostate cancer (Lu-Yao et al. 1993), and heart attacks (Cutler and McClellan 1996). As Legoretta et al. (1993) demonstrate, even when a new procedure is less expensive than potential substitute services on a per-case basis, its introduction may increase aggregate expenditures. The cost increase may occur in situations when a diagnostic test or treatment becomes less expensive to the patient or more clinically attractive, leading many people who would not have used the previously existing technology to use the new technology.

Because the affirmative approach focuses on individual technologies or diseases, it suffers from an inability to assess the aggregate impact of technology on cost growth. The body of evidence indicates that the impact of technology varies by disease. Weisbrod (1991) notes that in certain cases, technology clearly lowers costs, particularly when that technology permits complete cure or prevention of a disease. One example of this type of innovation is the Salk-Sabin polio vaccine, which is inexpensive itself and almost completely eliminates the high costs of treating polio.

Several studies provide evidence linking the conclusions from the residual approach (that technology, vaguely defined, is responsible for health care cost growth) to that of the affirmative approach (that in specific clinical areas emerging technologies have been responsible for health care cost growth). Bradley and Kominski (1992) use various criteria based on observed changes in cost and use to identify technology-related changes in expenditures. They do not examine specific technologies. Their findings indicate that technical change was the single largest cause of the increase in the inflation-adjusted cost per inpatient case and much of the remaining increase may also be attributable to medical innovations.

Two studies (Katz, Welch, and Verrilli 1997; Holahan, Dor, and Zuckerman 1990) examine overall growth in physician expenditures during the late 1980s and early 1990s. Although they do not examine any specific diseases or medical technologies, they disaggregate the growth of expenditures by physician type or service type. In both cases, they conclude that cost growth was greatest in areas where technological innovation was high, such as cardiology or orthopedic surgery. Hence, when one combines this evidence with that from the residual approach and affirmative approach, medical technology appears, on balance, to be a prime driver of health care cost growth. For this reason, the long-run impact of managed care on cost growth will depend on the extent to which managed care alters the rate of diffusion of medical technology.

MANAGED CARE AND DIFFUSION OF MEDICAL TECHNOLOGY

Several studies relate managed care to the adoption and diffusion of new medical technology (see Table 4). Langa and Sussman (1993) use a horse race approach to examine the growth in the use of coronary revascularization (coronary artery bypass surgery or coronary angioplasty) in California for patients with a principle diagnosis indicating ischemic heart disease. They report that although the HMOs exhibited a lower rate of revascularization at any point in time, the trend in unadjusted revascularization rates was similar in both systems (see Figure 2). Utilization rates adjusted for demographic, clinical, and hospital characteristics reveal a similar result. Because HMOs typically have lower premiums or costs at any point in time, parallel trends in use of new technology, similar to that observed by Langa and Sussman (1993), imply faster cost growth in HMOs.

Chernew, Fendrick, and Hirth (1997) compared changes in cholecystectomy rates in HMOs with those in the general population following the introduction of a new surgical method. They report more conservative practice in the HMOs at any point in time but no systematic difference in the

TABLE 4 Managed Care and Diffusion of Medical Technology

Study	*Study Period*	*Unit of Observation*	*Findings*
Langa and Sussman (1993)	1983-1988	Patients discharged from California hospitals with ischemic heart disease	The rate of increase in revascularization rates for HMO patients was parallel to that of fee-for-service patients.
Chernew, Fendrick, and Hirth (1997)	1989-1994	Delivery systems and statewide data	The rate of change in practice patterns following the introduction of a new medical technology was similar in HMOs and the overall health care system.
Hill and Wolfe (1997)	1981-1994	Madison (Wisconsin) and similar cities	Evidence is mixed regarding the impact of HMOs on diffusion of selected medical technologies. Comparisons between several cities suggest a minimal HMO effect.
Cutler and McClellan (1996)	1984-1991	Examined hospital adoption of, and patient receipt of, coronary revascularization technologies	Managed care reduced the rate of adoption of cardiovascular revascularization services.

growth in cholecystectomy rates between the HMOs and the general population over the diffusion period. This finding is consistent with the similar studies using the horse race approach. However, Chernew and colleagues identified a wide variation in the change in use among the HMOs following the innovation studied, and the HMO with the lowest increase in use was that located in the most competitive market. Although this finding is consistent with those from the market comparison studies, they did not observe enough HMOs or markets to generalize the findings. Several of the other HMOs were in markets that had substantial HMO penetration.

Cutler and McClellan (1996) examine the relationship between the state-specific HMO penetration rate and the likelihood that a Medicare patient would receive coronary angioplasty in 1984 and in 1991. They report that in both years, HMO penetration is negatively related to the likelihood that patients would receive angioplasties. Had the share of hospitals that offered

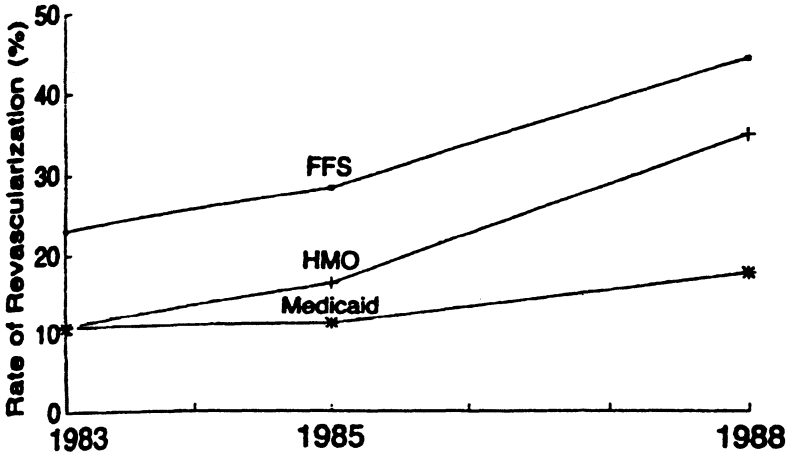

FIGURE 2 Unadjusted Rates of Coronary Revascularization Among Patients Covered by Medicaid, Fee-for-Service Insurance, or an HMO Who Had Principal Diagnoses Indicating Ischemic Heart Disease and Received Care at California Hospitals in 1983, 1985,or 1988.

Source: Langa and Sussman (1993). Copyright 1993 Massachusetts Medical Society. All rights reserved.
Note: Revascularization procedures included both coronary-artery bypass grafting and coronary angioplasty.

the service remained the same in both periods, the magnitude of this relationship would have remained constant over their study period, suggesting parallel trends in use as observed by Langa and Sussman (1993). However, they also report that HMO penetration lowered the rate at which hospitals adopted the technology. The slower adoption rate in areas with high managed care is consistent with, but does not necessarily imply, a slower growth in angioplasty use in areas with high penetration.

The population studied by Cutler and McClellan (1996) was overwhelmingly enrolled in traditional FFS Medicare; hence, any finding must represent a spillover. Moreover, they do not address the likelihood of receiving a related service, coronary bypass surgery, so we have an incomplete picture of how practice patterns changed over this period.

Hill and Wolfe (1997), in their study of the Madison, Wisconsin market following the rapid transition to HMO enrollment, examined technology

adoption by hospitals. After the transition to managed care, and in contrast to earlier behavior regarding ownership of CT scanners, hospitals opted to share a magnetic resonance imaging facility. However, the authors could not attribute this change in behavior to managed care. A variety of other factors, including the need for Certificate of Need approval, may also have been a factor in the decision to have common ownership. Furthermore, the authors report little difference between the diffusion rate of a wide range of technologies in Madison relative to other similar cities with lower managed care penetration during the same time period.

DISCUSSION

It is important to recognize that high, and rising, health care costs may be desirable. Pauly (1993) suggests that the amount of labor devoted to health care in the United States is not excessive by international standards. Moreover, a portion of rising health care costs may simply be a transfer from consumers of health care to suppliers without a net loss in aggregate welfare (Pauly 1993). Finally, health care cost growth is not necessarily undesirable if consumers are willing to pay for the costs associated with new technology. The observed rate of health care cost growth may be optimal even if it exceeds GDP growth.

Nevertheless, prior to the rapid growth of managed care, providers in the health care system had strong incentives to overuse new technologies, and therefore technology developers had strong incentives to introduce expensive innovations. This suggests that at the margin, the costs of health care services exceeded the benefits. The theoretical foundation behind a system of managed care and managed competition is that by changing incentives and markets, resources can be allocated to health care services more efficiently.

Studies that compare cost growth in markets with high managed care penetration with that in markets with low managed care penetration reveal that managed care has reduced the rate of health care cost growth. In contrast, studies that directly compare FFS and managed care plans tend to find similar rates of cost growth. These findings can be reconciled if there exists a spillover effect of managed care on the entire market and some evidence supports this premise. Yet, the magnitude of managed-care-related reductions in cost growth documented by existing studies appears insufficient to stabilize or reduce the percentage of GDP devoted to health care. Not only do most studies report cost growth exceeding the rate of GDP growth, the existing studies are based on the experiences during a period of transition to managed care.

The savings associated with managed care may stem from actions that will not result in a permanent reduction in cost growth. For example, evidence that managed care has resulted in lower physician incomes is consistent with the

hypothesis that the savings associated with managed care plans may reflect price reductions achieved by increased competition (Simon and Born 1996). The recent savings may also reflect efficiency gains (such as reductions in inpatient days) induced by managed care that, despite decreasing the absolute level of expenditures and possibly short-term cost growth, will not result in reductions in the long-term rate of increases in health care spending (Schwartz 1987). As a result, the observed relationship between managed care and cost growth at the market level may reflect the transition to an increasingly strict system of competing health plans.

Recent anecdotal evidence supports the argument that managed-care-induced reductions in health care cost growth have been transitional.[11] Although health care cost inflation slowed in the early 1990s, recent projections suggest that the upward trend is returning. For example, in the first 2 years of operation the Pacific Business Group on Health, a large San Francisco area health care purchasing coalition, reported 9.5 percent and 4.3 percent reductions in premiums, respectively. In its 3rd and 4th years, premium growth was flat; then, in the 5th year, premiums rose by 1 percent. This upward trend in premium growth is supported by a Foster Huggins study that projected rising health care costs in the last years of this decade (Winslow 1997).

The preponderance of evidence suggests that the development, adoption, and diffusion of medical technology are responsible for a large part of the increase in inflation-adjusted health care costs. The evidence that managed care will control technology diffusion is mixed at best. Some evidence from the studies focusing on specific medical technologies support the view that cost growth may diminish in a managed-care-dominated environment relative to that which occurred in the FFS-dominated system. For example, Cutler and McClellan (1996) found evidence that managed care may slow the adoption of new technologies, and Chernew, Fendrick, and Hirth (1997) found one case in which an HMO controlled the rate of increase in use of an attractive innovation.

Yet, in the Chernew, Fendrick, and Hirth (1997) study, the HMO that controlled technology diffusion was the exception rather than the rule. There was no systematic relationship between the type of delivery system and the extent to which use rose following the introduction of a new technology. Langa and Sussman (1993) report that HMO and FFS trends in use of revascularization procedures were roughly parallel. Hill and Wolfe (1997) report little systematic impact of HMO penetration and diffusion of hospital-based technologies.

Nevertheless, it is a mathematical certainty that expenditures on health care services will not rise at a rate faster than GDP indefinitely. If managed care

does not constrain health care cost growth, some other force will do so. Several scenarios are possible (and not mutually exclusive).

1. Managed care plans will increasingly ration care. This may occur, but it would represent a break with the past. Enthoven (1993) suggests that various market characteristics, such as the failure of employers to charge their employees the incremental cost of more expensive health plans, have limited the effectiveness of managed care. Managed care may become more effective in the future if purchasers (employers and employees) are more price sensitive. Nevertheless, if technological progress continues to place upward pressure on costs, constraining cost growth will entail greater restrictions on access to these services.

   Moreover, such restrictions would require the political and legal system to permit stronger rationing. This remains an area of controversy with states responding to public perceptions of rationing by adopting mandatory coverage for certain services and requiring minimum hospital stays following mastectomy or childbirth. It is likely that if this scenario does come to pass, such a system will be characterized by wider differences in access to care, particularly to new technologies, than we have historically accepted. Steiner et al. (1997) report a wide variation in HMO coverage of laser therapies, which is consistent with the hypothesis that some plans are beginning to ration access to new technologies. However, there is little evidence regarding how this disparity in coverage affects access to these therapies (or outcomes). Moreover, it is unclear whether this disparity represents a permanent variation in coverage policies or simply a variation in when plans opt to cover emerging innovations.
2. The decentralized competitive system will be abandoned in favor of a nationalized system. Health care cost growth can be controlled centrally by governmental action. Of course, this will not solve the underlying tension between access to care and cost containment. Some forms of government action, such as premium regulation, would maintain health plan control over issues of technology diffusion. Other more interventionist forms of government action might move the issue of medical technology use from the economic sphere to the political.
3. Technology will develop in such a way as to reverse the traditional relationship between technological progress and cost growth. Reasonable evidence suggests that insurance has been a major factor contributing to the development of new medical technologies. Peden and Freeland (1995) suggest that as much as 70 percent of the impact of cost-increasing technologies on expenditure growth can be indirectly attributed to insurance coverage. Certainly, a system dominated by managed care would increase the incentives to develop cost-reducing technologies and decrease the incentives to develop cost-increasing technologies. Yet, very little evidence exists assessing this phenomenon. Gelijns and Rosenberg (1994) report that preliminary evidence indicates that there has been a shift in the types of technologies developed, but the extent of that shift, and its ultimate impact on expenditures, remains to be established. Several institutional factors, including federal funding of research and the Food and Drug Administration (FDA) policy of approving pharmaceuticals on the basis of improved efficacy as opposed to reduced costs, suggest that the nature of technical change may not dramatically change.

Regardless of which path is taken, evaluation of medical technology is likely to become increasingly important. Technology assessment may be used to inform benefit design. However, because in many cases the key issue is not whether a new technology should be covered but to whom it should be delivered, managed care plans are more likely to use such assessments to develop programs to manage use. Such programs include treatment guidelines and protocols, as well as approaches such as shared decision making that incorporate patient preferences into treatment decisions. If technological progress continues to place upward pressure on health care costs, consumers' willingness to pay at the margin may fall and the pressure for managed care plans to ration new medical technology may grow. Given all of the complex information problems in the health care sector, a better understanding of how managed care plans ration medical technology is imperative and we must work to develop acceptable mechanisms to ration care.

NOTES

1. HCIA/Coopers and Lybrand (1996).
2. Ware et al. (1996) report that, on average, there were no differences in health outcomes for HMO patients relative to fee-for-service patients followed over a 4-year period. However, some subpopulations, such as the elderly and poor, experienced worse health outcomes in HMOs than in other systems.
3. Abdominal pain attributed to gall stones.
4. Removal of the gallbladder.
5. In some cases, the innovative services may be justified, in part, by savings generated outside of the health care system, such as earlier return to work.
6. We limited our search to articles published since 1990 because the searches revealed many citations not appropriate for this review (such as studies on human growth hormone). The more recent citations generally included references to earlier work that were then included.
7. Gabel et al. (1994) measure premium growth in different plans for 1993. The study is not included in Table 1 because the observation period is only 1 year and the data source (KPMG) and results are very similar to those of Ginsburg and Pickreign (1996).
8. There is some evidence that this is not always the case (Arnould, Debrock, and Pollard 1984; Clancy and Hillner 1989; Murray et al. 1992).
9. Growth in California per capita state product and California per capita personal income over this period was about 1.1 percent annually.
10. These markets were assumed to have 20 percent HMO penetration, which was greater than about 70 percent of the observations in their sample.
11. In fact, there is some evidence that the reported reductions in health care cost growth during the early 1990s were overstated (Huskamp and Newhouse 1994).

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