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Technology, Skills, and Health Care Labor Markets

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I. *Introduction*

Over the past twenty years dramatic changes have occurred in the health care industry. Between 1980 and 1993 expenditures increased from about 9 to almost 14 percent of GDP. Since 1993 spending has remained at about 14 percent of GDP, and health care spending in the U.S. has grown at an average rate of 5 percent, substantially below the 12 percent annual growth experienced in earlier years (Health Care Financing Administration, 2000). The emerging consensus is that the rapidly rising costs of the 1980s and early 1990s was driven primarily by technological change (Newhouse, 1992; Fuchs, 1996), and the slowdown in the mid-1990s was a one-time reduction in spending driven primarily by the emergence of managed-care health insurance. Recent reports suggest that health care expenditures are on the rise as technology continues to evolve (Health Insurance Association of America, 2001), and nursing shortages are again a concern (Freudenheim and Villarosa, 2001).

These rising costs and the rapid technological changes have transformed health care. One of the most significant changes was the rise of managed care to finance and deliver health care. In 1988 about 8 percent of individuals with health insurance were covered through a health maintenance organization (HMO), preferred provider organization (PPO), or point of service plan (POS). By 1996 this figure increased to 33 percent (The Lewin Group, 1997). Managed care's share of employer-provided insurance is even greater. Managed-care plans enrolled 85 percent of employees in 1997, up from 77 percent in 1996 and only 48 percent in 1992 (William H. Mercer, 1998). Both small and large firms are now likely to offer their employees at least one managed-care plan (Jensen et al., 1997). Throughout the 1990s, managed-care enrollment increased at a rapid rate of about 11 percent per year for HMOs and about 13 percent per year for PPOs, so that in 1998 HMO enrollment was 78.8 million (InterStudy, 1999). Managed care attempts to control costs through competition and provider cost monitoring, such as mitigating patient and physician moral hazard associated with standard fee-for-service insurance. Thus, one rationale for managed care is to combat the excessive growth in technology and costs due to competition among hospitals (Dranove et al., 1993; Dranove and White, 1994).

Another significant change was in the horizontal structure of health care markets, brought about by mergers, integrations, and collaborations among insurers, hos-

pitals, and physicians (Gaynor and Haas-Wilson, 1999). Between 1994 and 1996 about 41 percent of the 5,200 nonfederal U.S. hospitals were involved in transactions that resulted in changes in asset ownership (Jaspen, 1996). From 1985 to 1995 the number of hospitals fell by 9 percent and the number of beds fell by 13 percent (Gaynor and Haas-Wilson, 1999). By 1995, about a quarter of all practicing physicians remained as solo practitioners, down from over a third in 1991, and the share of physicians employed by hospitals or HMOs increased from 22 percent in 1991 to 30 percent in 1995 (Emmons and Kletke, 1996). In addition, there were over 218 mergers and acquisitions of physician practices in 1996 up from 126 in 1995 (Jaspen, 1997). Independent Practice Associations (IPAs) have become more common in recent years. IPAs are groups of independent practices that collectively contract with managed-care plans to participate in their provider networks. Also, a new form of organization emerged: the physician management firm, which sells both management services to physician practices (which include negotiation and marketing with managed-care plans) and owns physician practices (Gaynor and Hass-Wilson, 1999).

The slowdown in expenditure growth in the mid 1990s and the concomitant changes in insurance markets and hospital and physician markets was accompanied by a slowdown in industry employment and earnings (Engel, 1999). Between 1987 and 1992 job growth in health care averaged 4.6 percent per year while the growth in overall services averaged 3.8 percent per year. Between 1992 and 1997, however, job growth averaged 2.7 percent while growth averaged 4.4 percent in all services industries. The one exception to this trend was the home health industry where employment growth averaged 12.7 percent between 1992 and 1997. Due to changes in federal reimbursement policy in 1998, however, employment in this sector fell by 4.5 percent (Engel, 1999, Table 1).

I explore how the changes in technology have affected workers in the health care industry. Although substantial wage and employment growth occurred, this growth has been concentrated in the higher skilled occupations (registered nurses and health therapists). In addition, substantial increases in the returns to measured skills have occurred. These findings are consistent with previous research demonstrating skill-biased technological change over the last two decades (Bartel and Sicherman, 1999). The movement towards managed care health insurance may have resulted in a one-time reduction in the demand for health care workers, but had a relatively minor effect on the rate of technology adoption. Thus, while we see a slowdown in wage and employment growth in the mid-1990s, as technology continues to rise, wages and employment for higher skilled workers are again rising.

I first review the literature on how health care technology is measured and how this measure has evolved over time. Section III briefly describes the theoretical relationship between technology and the demand for labor. An overview of health care labor markets is presented in Section IV, which examines employment and earnings. I then discuss how the theory applies to the health care industry by first examining the returns to measured skills and then decomposing the relative wage growth in the

industry. Section V discusses the implications of technological change for labor relations in the health care industry. Section VI provides some insight into the future of health care labor markets.

II. *Measuring Technology in Health Care*

It is widely believed that most of the rising costs in the health care industry over the past 50 years can be attributed to technological change (Newhouse, 1992; Fuchs, 1996). Over this period the industry developed not only new types of physical capital, such as magnetic resonance imaging and robotic surgery, but also new procedures, such as coronary artery bypass grafting, renal dialysis, transplantation, artificial joints, and endoscopy. Newhouse argues that this "march of science" played a major role in the rising expenditures in health care and shows that the average length of stay decreased over the last 50 years while the number of admissions remained relatively constant, yet the adjusted cost per day increased dramatically. Thus, what is done to patients once in the hospital drives the cost increases, not the number of patients.[1]

Much of the literature on technological change focuses on how managed care affects the adoption and diffusion of technology (Baker and Spetz, 1999; Baker, 2000; Baker and Phibbs, 2000; Chernew et al., 1998; Cutler and McClellan, 1996; Cutler and Sheiner, 1998). As Chernew et al. (1998) point out, managed care reduces inefficiencies in the health care system by aggressively contracting for lower prices by constraining use of health care services by monitoring providers. If, as is widely believed, the rising costs were largely due to increased technologies and not to growing inefficiency, managed care will reduce the level of spending at one point in time, but will not affect the overall trend in spending.

Because aggregation difficulties make individual technologies a natural unit of analysis, most of the literature on technology analyzes just one technology. Baker and Spetz (1998), however, attempt an aggregate measure of technological change by constructing an index of technology availability. Their index is a weighted sum of the number of technologies and services from a predetermined list available in a hospital, with the weights being the percent of U.S. hospitals without the technology or services. Thus, the weights capture the rareness of the technology or service, so that common technologies receive low weights while technologies that are new, expensive, or difficult to implement have higher weights. Tracking this index by metropolitan statistical area between 1983 and 1993, they show a relatively steady increase in the index reflecting a positive growth in the overall level of technology. They find that managed care modestly affected technology availability in the mid-1980s. Their results suggest that managed care may have helped control the growth rate of new technology availability in the early 1980s, although not in subsequent years.

Focusing on a specific technology, Baker and Phibbs (2000) examine the relationship between managed care and the adoption of neonatal intensive care (NICU). They estimate a hazard model on the decision to enter the neonatal intensive care market and how the changes in HMO activity affected this probability. They find that HMO

activity slowed the diffusion of NICUs during the 1980s and 1990s. Specifically the time to adoption of a NICU was longer in high-managed care relative to lower managed care markets. In a similar vein, Baker (2000) examines how managed care affects the adoption of magnetic resonance imaging (MRI). Also using a hazard model, he finds that increases in market share are associated with slower diffusion of MRI into hospitals between 1983 and 1993 and with substantially lower overall MRI availability in and outside of hospitals in the mid- and later 1990s. These results suggest that technology adoption in health care can respond to changes in financial and other incentives associated with managed care.

Thus, there is evidence of rapid technological change in the health care industry, and more limited evidence that managed care has lowered this growth. After reviewing the literature on the relationship between technology growth, costs, and managed care, Chernew et al. (1998) conclude that while there is some evidence that managed care led to reductions in cost growth, it has been insufficient to stabilize or reduce the percentage of GDP devoted to health care. Managed care may have had a one-time effect on costs by reducing some of the inefficiencies associated with traditional fee-for-service insurance, but if demand-driven technological change is the source of cost increases, the rate of growth in costs should be similar for enrollees in and out of managed-care plans.

III. *Technology Growth and the Demand for Labor*

Given that technological growth has been rapid and is expected to continue to be an important factor in the health care industry, how has this affected labor market outcomes? Technological change affects the demand for labor in two ways. First, shifts in the product demand curves will tend to shift labor demand curves in the same direction, and changes in the elasticity of product demand with respect to product price will tend to cause qualitatively similar changes in the own-wage elasticity of labor demand.

The second aspect of technological change is related to the substitution of capital for labor. Advances in technology can be thought of as reducing the cost of capital. How a lower price of capital affects the demand for a particular type of labor depends on the cross elasticity. If capital and labor are gross complements, an increase in technology will tend to increase the demand for labor. If they are substitutes in production, however, and the scale effect is relatively weak (gross substitutes), technological increases will tend to decrease the demand for labor. The substitution effect will be stronger to the extent that it is relatively easy for firms to make the substitution, and the current share of capital in overall costs is relatively small. The scale effect will be small if there is an inelastic product demand and if capital constitutes a small share of total cost.

Since complementary factors of production must be gross complements, technological change is more likely to increase the demand for skilled than for unskilled labor (Autor et al., 1998; Krueger, 1993; Mincer and Danninger, 2000). First, an industry that has a high rate of technological change requires workers to make frequent changes

in job tasks and operating procedures (Javanovic and Nyarko, 1995). In this environment, firms will increase their demand for better educated and more skilled workers who can more easily learn the new technology and adapt to change. Acemoglu (2000) argues that the twentieth century has been characterized by skill-biased technical change because the rapid increase in the supply of skilled workers has induced the development of skill-complementary technologies. Second, if technological change is defined as capturing the extent some industries are "high-tech" vs. "low-tech," industries that use more sophisticated capital will also employ more skilled workers.

Bartel and Sicherman (1999) examine the relationship between technological change and wages across manufacturing industries and show that the positive correlation between technological change and the wage structure is due to the sorting of individuals on the basis of their unobserved characteristics into industries with different rates of technological change. If these unobserved characteristics reflect an individual's innate ability, more able individuals are sorted into industries with higher rates of technological change. They first estimate a random effects regression and find a positive correlation between the rate of technological change and wages. This effect is substantially weakened, however, in fixed effects models, which suggests that worker characteristics play an important role in accounting for the correlation between wages and technological change. They then examine the relationship between the return to schooling and technological change and find a positive and significant correlation between technological change and the return to education — but when individual and industry fixed effects are added to the regressions the effect goes to zero. These results imply that the observed education premium in high-tech industries is due to the sorting of highly educated individuals on the basis of their unobserved characteristics into the high-tech industries.

IV. *Health Care Labor Markets and Technology*

An Overview. This section presents an empirical analysis of health care labor markets. I first provide an overview of the labor market and then attempt to relate changes in technology to the trends found in the market. Table 1 provides health care wage and salary employment by year, 1983–1999, compiled from the monthly outgoing rotation group (ORG) earnings files of the Current Population Survey (CPS), which provides a large sample of health care workers over the last two decades. Between 1983 and 1999, employment in hospitals increased from 4.4 to about 5.1 million, while non-hospital employment increased from about 2.9 million in 1983 to 6.5 million in 1999. While the moderate growth in hospital employment occurred early in the period, non-hospital employment grew rapidly throughout, especially in the 1990s. RN employment increased rapidly but has leveled off somewhat since 1993 with 1999 employment of about 2.2 million. Schumacher (2001) shows that about 72 percent of RNs were employed in hospitals in 1988, but that percentage decreased to about 65 percent by 1998. Much of the growth in employment during the 1990s has been in the non-hospital sector, while prior growth occurred in hospitals.

Table 1

Health Care Employment by Year
(thousands)

	Hospitals	Non-Hospitals	RNs	LPNs
1983	4,358.3	2,986.1	1,364.2	455.7
1984	4,249.8	3,086.5	1,379.6	412.1
1985	4,271.9	3,092.2	1,421.3	392.3
1986	4,418.5	3,205.0	1,482.0	410.1
1987	4,430.8	3,488.6	1,577.6	403.3
1988	4,508.3	3,721.5	1,519.6	402.0
1989	4,552.2	3,867.7	1,567.6	402.8
1990	4,709.4	4,122.3	1,656.6	436.7
1991	4,837.8	4,335.0	1,668.8	446.5
1992	4,912.9	4,676.4	1,778.1	448.7
1993	5,038.5	4,840.1	1,839.6	437.4
1994	4,988.3	4,894.5	1,933.3	390.5
1995	4,974.9	5,303.9	1,949.0	394.9
1996	5,033.2	5,502.8	1,966.6	393.1
1997	5,134.5	5,696.6	2,034.2	400.5
1998	5,151.2	5,670.4	1,999.1	377.1
1999	5,128.0	6,554.2	2,150.8	351.0

	Clinical lab	Health Tech	Health Aides	Nursing Aides
1983	254.9	199.4	314.7	1,249.8
1984	280.2	198.8	347.3	1,215.0
1985	295.9	185.9	352.3	1,226.3
1986	289.5	205.1	368.7	1,272.5
1987	248.1	212.6	370.1	1,296.8
1988	271.0	258.1	394.4	1,360.0
1989	301.2	278.7	418.0	1,423.2
1990	301.2	268.7	433.1	1,426.2
1991	314.0	312.0	492.6	1,476.0
1992	299.5	487.0	360.7	1,535.9
1993	317.9	492.2	311.1	1,661.2
1994	332.8	562.8	340.6	1,613.9
1995	370.7	608.1	350.2	1,703.4
1996	363.4	579.1	323.3	1,800.1
1997	391.3	614.7	352.0	1,803.4
1998	351.6	685.6	337.0	1,838.9
1999	351.6	721.3	347.4	1,999.4

Source: Monthly CPS ORG files from 1983–1999. The occupations correspond the Census three-digit occupation codes for registered nurses, licensed practical nurses, clinical laboratory technologists and technicians, health technologists and technicians, health aides other than nursing, and nursing aides.

Real wages by year (in 1999 dollars) are displayed in Table 2 for five groups of workers: RNs, LPNs, health therapists (inhalation, occupational, physical, speech, and therapists, not elsewhere classified), a health-care comparison group, and a non-health-care comparison group. The comparison groups allow relative wage comparisons. The non-health-care comparison group consists of females with at least 16 years of schooling not employed in the health care industry. This group captures economy-wide variations in earnings for females over the period.[2] The health-care comparison group is made up of all wage and salary workers in the health industry other than RNs, LPNs, and therapists,[3] and captures within-industry earnings variations. Note that because the CPS reports earnings only for wage and salary employees and individuals with high earnings are topcoded by the CPS, I do not use these data to analyze the earnings of physicians and other high-income health care workers.[4]

Table 2 shows that RN real wages increased substantially from 1983 to 1993; by 1993 an RN earned on average $20.43 per hour. From 1993 to 1997, however, real wages fell for RNs. Real wages in 1998 and 1999 have risen again to a wage of $19.91 per hour. In results not shown, the real wage growth up to 1993 is most rapid in hospitals and, likewise, the declines since 1993 are more severe in hospitals. The other health care groups show similar, though less steep, increases in real wages over the early period, and they also show relatively flat wages between 1993 and 1999. Note, however, that wages for the non-health-care comparison group increased steadily over the entire period.

The mean wages presented above indicate large wage gains by health care workers. These wages are not adjusted, however, for any differences in worker characteristics. An adjusted earnings index is estimated to control for differences in worker and labor market characteristics. For each group of workers, the following equation is estimated:

$$\ln W_{in} = \sum_{j=1}^{J} \beta_j X_{inj} + \sum_{y=1}^{Y} \tau_y YEAR_{iny} + \varepsilon_{in}, \qquad (1)$$

where $\ln W_{in}$ is the log real wage for worker i in occupational group n; X contains observed personal and job-related characteristics that affect the wage, and β their coefficients; and ε is a well-behaved error term. Assuming a common structure of earnings over time (an assumption relaxed below) but allowing the structure to vary across occupational group, the coefficients on year dummies (τ) estimate log earnings differences by year after controlling for worker mix and other characteristics. The year coefficients are converted to a percentage index by the formula $100+(\exp(\tau_y)*100)$.

Figure 1 shows the adjusted earnings index for the five worker groups described above between 1983 and 1999. Dramatic wage gains are apparent for RNs up to 1993 — an RN in 1993 made about 22 percent more than an RN in 1983 with identical characteristics. Health therapists also experienced large wage gains over the period, so that a therapist in 1992 earned almost 18 percent more than in 1983. Wage gains for the other groups of health care workers were more modest, and note that for the health-

care comparison group, *adjusted* wages were relatively flat over the period. The non-health care control group also made gains over the period, consistent with the previous research on female earnings (Blau and Kahn, 2000). But even compared to college educated females, RNs and health therapists made large relative wage gains throughout the 1980s and into the early 1990s.

These wage gains stopped abruptly after 1993, however, for RNs and after 1992 for health therapists. Adjusted wages fell sharply for both groups, so that an RN in 1997 earned only a little more than 10 percent more than in 1983. The adjusted wage index falls for all the groups over this period, but the decline is most severe for RNs and therapists. After 1996 or 1997, wages appear to be again on the rise, as the wage indices rose sharply for all five groups of workers. These relative wage changes are examined more closely below, but overall, there are large wage increases in real wages for workers in health care, and these increases seem largest for higher skilled workers. Schumacher (1997) attributes these wage increases for RNs to an increasing demand for

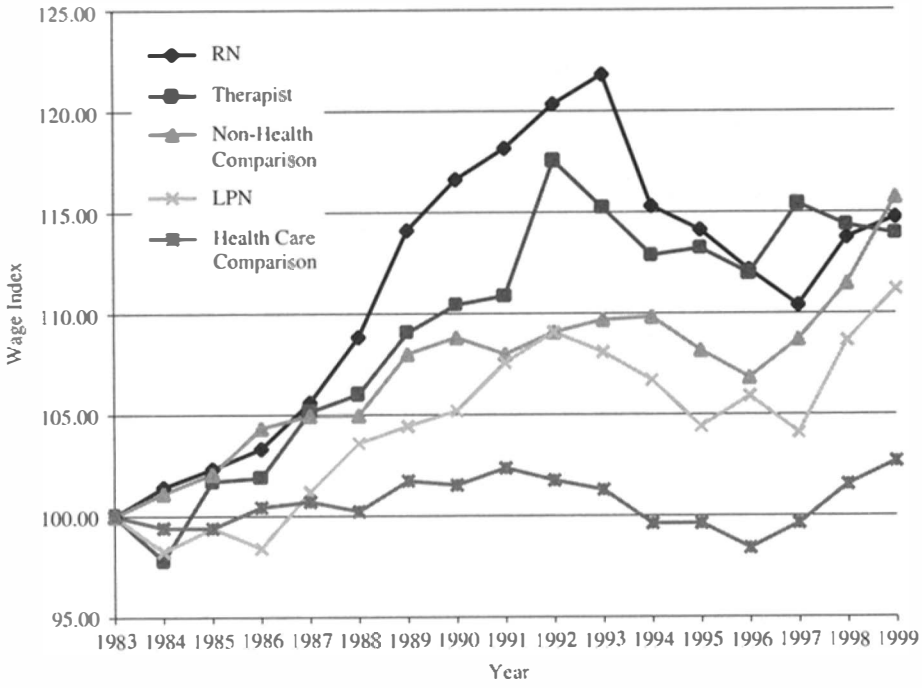
Table 2

Real Wages by Group

Year	RNs	LPNs	Health Therapists	Health Care Comparison	Non-Health Comparison
1983	16.37	11.61	15.38	11.57	14.89
1984	16.48	11.32	15.15	11.58	15.14
1985	16.71	11.57	16.34	11.77	15.42
1986	17.16	11.58	16.16	11.99	15.91
1987	17.49	12.00	16.84	12.23	16.12
1988	18.17	12.21	17.48	12.18	16.06
1989	19.32	12.47	17.84	12.67	16.66
1990	19.80	12.61	18.14	12.77	16.93
1991	20.17	12.79	18.06	12.81	16.85
1992	20.23	13.19	19.77	12.99	17.14
1993	20.43	13.09	19.17	13.05	17.26
1994	19.86	13.23	19.83	13.52	17.89
1995	19.88	12.72	19.99	13.70	17.70
1996	19.30	12.90	19.28	13.57	17.43
1997	19.16	12.55	20.03	13.70	17.77
1998	19.57	12.96	19.89	13.87	18.04
1999	19.91	13.28	20.18	14.24	18.70

Source: Monthly ORG CPS files from 1983–1999. Real Wage is the hourly wage in 1999 dollars. The health care comparison group is comprised of all workers in the health care industry except for RNs and LPNs. The non-health comparison is comprised of all females with at least 16 years of schooling not employed in health care occupations.

Figure 1
Adjusted Wage Index 1983–1999



Source: Monthly CPS ORG files from 1983–1999. The adjusted index is calculated by taking the coefficients from a set of year dummy variables from a log wage regression and converting them to a percentage differential ($e^{\beta}*100$, where β is the coefficient estimate).

RNs driven primarily by hospitals' need for higher skilled workers owing to changes in technology and third-party reimbursement policy.

Technology Change and Health Care Labor Markets. I now relate the trends in wages and employment shown above to technological change. The discussion in Section III suggests that skill-biased technological change has been the norm in the U.S. economy as a whole. To the extent that this is true in the health care industry, the demand for higher skilled workers should increase relative to that of their lower skilled counterparts. This is apparent to some extent in Figure 1, which shows that RNs and health therapists made the largest gains in real wages over the last twenty years. The RN/LPN comparison shows that while the lower skilled group of LPNs made modest wage gains between 1983 and 1993, the higher skilled RNs made substantially higher gains. Likewise, the health-care comparison group exhibits a relatively flat adjusted wage profile.

Table 3 presents the mean level of education and potential experience by year for four groups of workers (RNs, health therapists, the health-care comparison group, and the non-health comparison group). These are two measures of skill available in the CPS ORG data. The average level of schooling remained relatively constant at around 15 years for RNs, 16 years for therapists, and almost 17 years for the non-health-care comparison group.[5] There is a slight increase of about .7 years for the health-care comparison group. The average level of potential experience (measured as age–school–6) increased significantly for all four groups. Note that since the ORG files do not contain actual labor market experience, we use potential experience as a proxy. This measure may not accurately reflect true changes in experience, especially for females (O'Neill and Polacheck, 1993).

Table 4 presents annual regression coefficients on schooling and log of experience for each group of workers where the log of real wage is the dependent variable.[6] Other variables included in the model were dummy variables for gender (except for the non-health comparison group, which consists only of females), marital status (2), race and ethnicity (3), part-time status, region (8), industry (8), metropolitan area, union

Table 3

Average Schooling and Potential Experience by Year

	RN		Therapists		Health Comp.		Non-Health Comp.	
	School	Exp	School	Exp	School	Exp	School	Exp
1983	14.9	16.7	15.4	11.8	13.0	18.2	16.6	13.6
1984	14.9	16.7	15.7	11.2	13.0	18.3	16.6	13.8
1985	15.0	16.5	15.8	11.1	13.1	18.3	16.6	13.8
1986	15.1	16.9	15.7	11.5	13.1	18.1	16.6	14.0
1987	15.1	17.1	15.8	11.6	13.2	18.2	16.7	14.2
1988	15.2	17.2	15.8	12.7	13.2	18.5	16.6	14.5
1989	15.3	18.0	15.8	13.3	13.3	18.7	16.7	14.7
1990	15.3	18.4	15.8	13.6	13.3	19.0	16.7	15.1
1991	15.3	18.8	15.7	13.7	13.3	19.1	16.7	15.4
1992	15.0	19.2	15.9	13.8	13.4	19.2	16.7	15.6
1993	14.9	19.5	15.8	13.9	13.5	19.4	16.7	15.9
1994	15.0	20.0	16.0	14.5	13.6	19.6	16.7	16.1
1995	15.0	20.1	16.1	14.1	13.6	19.7	16.7	16.3
1996	15.0	20.3	15.9	14.9	13.7	19.8	16.7	16.5
1997	15.1	20.5	16.0	15.0	13.7	20.0	16.7	16.7
1998	15.1	21.1	15.9	16.0	13.7	20.2	16.7	17.1
1999	15.2	21.1	16.2	16.6	13.7	20.6	16.7	17.4

Source: Monthly ORG CPS files from 1983–1999. Experience is potential experience measured as Age–School–6.

Table 4

The Return to Schooling and Experience by Year

	RN		Therapists	
	School	log Exp.	School	Log Exp
1983	.026	.029	.079	.092
1984	.030	.036	.078	.081
1985	.027	.043	.066	.052
1986	.029	.035	.076	.101
1987	.040	.026	.076	.071
1988	.031	.027	.087	.069
1989	.028	.031	.083	.060
1990	.039	.032	.088	.058
1991	.039	.033	.100	.063
1992	.037	.044	.078	.108
1993	.039	.027	.086	.077
1994	.062	.034	.078	.051
1995	.059	.064	.087	.044
1996	.051	.047	.069	.065
1997	.057	.077	.074	.102
1998	.055	.059	.099	.108
1999	.051	.086	.085	.101
	Health Comparison		Non-Health Comparison	
	School	log Exp.	School	Log Exp.
1983	.077	.083	.104	.043
1984	.077	.092	.110	.064
1985	.082	.093	.104	.053
1986	.086	.112	.107	.056
1987	.086	.101	.105	.053
1988	.087	.102	.096	.049
1989	.098	.092	.112	.056
1990	.098	.095	.106	.053
1991	.097	.093	.110	.057
1992	.099	.099	.094	.076
1993	.100	.104	.101	.076
1994	.108	.109	.111	.075
1995	.107	.111	.096	.071
1996	.107	.106	.099	.071
1997	.107	.107	.096	.079
1998	.103	.106	.091	.071
1999	.114	.100	.093	.070

Note: Coefficients are from separate log wage regressions by year and occupation. Other variables included in the model were dummy variables for gender (except for the non-health comparison group, which consists only of females), marital status (2), race and ethnicity (3), part-time status, region (8), industry (8), metropolitan area, union status, and public employment. Average standard errors on the schooling and log experience variables are .005 and .012 for RNs, .009 and .021 for therapists, .002 and .005 for the health-care comparison group, and .004 and .005 for the non-health group.

status, and public employment. These results reveal a rather large increase in the return to schooling for the health related groups. The return for RNs increased from about 3 percent early in the period to around 6 percent by the end of the 1990s. For the health-care comparison group the return to schooling increases from about 8 to 11 percent. In contrast, the return for the non-health-care comparison group remains relatively constant over the period at around 10 percent.

Likewise, the returns to potential experience increased for all the groups. These results suggest an increasing return to measurable skills in these markets. Registered nurses experienced especially large increase in the returns to experience and schooling. Note that even over the period where real wages were falling for RNs, these returns are increasing, suggesting that as the overall demand for nurses decreased over this period, the returns to skills continued to rise.

In order to examine the relative returns to measured skills in more detail, a set of decompositions for the change in relative wages is provided; one for the years 1983 to 1993 when relative wages were rising, and one for the years 1993 to 1999 when relative wages were declining or relatively flat. The decompositions separate the contributions of changes in relative quantities (the X's) from changes in relative prices (the β's). The procedure of O'Neill and Polachek (1993) is followed by first estimating the following equation separately for each group of workers:

$$\ln W_{in} = \sum_{j=1}^{J} \beta_j X_{inj} + \alpha_n Time + \sum_{j=1}^{J-1} \delta_j X_{inj} * Time_i + \varepsilon_{in}, \qquad (2)$$

where $\ln W_{in}$ is the natural log of the real wage for worker i in occupational group n; X contains individual-specific variables (indexed by j) affecting wages; and β contains the coefficients. *Time* is a linear time trend (1983=1, 84=2, etc.). Interacting *Time* with the other right-hand-side variables allows an estimate of the change in the prices associated with these variables over time for each group (vector δ contains these coefficients). In other words, the interaction terms show how the return to each characteristic has changed over the period. An equation without the time-interaction terms is also estimated to get an estimate of the average return to each characteristic over the period. The mean as well as the average annual change for each characteristic over the period is then calculated. These estimates are used to decompose the change in relative wages over the 1983–1993, and 1993–1999 periods, by separating out the proportion due to changes in the characteristics (quantities) and those due to changes in the coefficients (prices).

Table 5 shows the results of these decompositions comparing RNs and health therapists to the non-health- and health-care comparison groups. The columns labeled ΔX show how much of the total annualized relative wage growth is attributed to changes in the relative characteristics between the groups. This is obtained by taking the average annual change in the variable and multiplying it by the average coefficient over the pooled sample for each group ($\Delta X_i * \beta_i$). The result reported in Table 4 is the difference in this measure between RNs (Therapists) and the comparison group, or $(\Delta X_{RN} * \beta_{RN}) - (\Delta X_c * \beta_c)$. The column labeled $\Delta\beta$ indicates the effect of the change in

Table 5

A Decomposition of Relative Wage Changes for RNs and Therapists

	1983–1993		1993–1999	
	ΔX	$\Delta\beta$	ΔX	$\Delta\beta$
RN/Non-Health				
Schooling	−.001	.032	.002	.053
Experience	−.000	−.005	−.000	.008
Other Variables	−.002	.009	.001	−.023
Residual Trend	−.021		−.055	
Total Annualized Relative Wage Growth	.009		−0.021	
RN/ Health				
Schooling	−.004	−.015	−.002	.002
Experience	−.000	−.005	−.001	.011
Other Variables	−.001	.009	−.001	−.016
Residual Trend	.030		−.007	
Total Annualized Relative Wage Growth	.014		−.015	
Therapist/Non-Health				
Schooling	.003	.027	.005	.059
Experience	.000	−.002	.001	.008
Other Variables	−.001	.004	.002	−.021
Residual Trend	−.021		−.055	
Total Annualized Relative Wage Growth	.010		−0.007	
Therapist/Health				
Schooling	−.001	−.020	.001	.008
Experience	.001	−.002	.000	.011
Other Variables	.000	.004	.000	−.015
Residual Trend	.034		−.006	
Total Annualized Wage Growth	.014		−0.002	

Note: The table provides a decomposition for the annual change in relative earnings for RNs and Health Therapists between 1983 and 1999 as compared to the non-health and health care comparison groups. The first two columns decompose the relative wage gains over the 1983–1993 period, and the second two columns decompose the relative wage declines over the 1993–1999 period. For each decomposition, the first column multiplies the average annual change in the variable by the average coefficient on that variable over the entire period. The numbers shown are the differences: the RN (or Therapist) effect less the comparison group effect. The second column takes the average annual change in the coefficient (calculated by interacting the variable with a linear time trend) and multiples it by the average for the variable over the period. The other variables category includes the effects of union status, hospital employment, employment in a large metropolitan area, race and ethnicity, public employment, marital status, gender, part-time status, and region. The residual trend is the effects of the time variable not interacted with the other right-hand-side variables.

the return to each characteristic on the relative wage change. It takes the average annual change in the coefficient (the time trend interactions from equation 2) and multiplies it by the average level of the variable over the period ($\Delta\beta_i * X_i$). The number reported in the table is the difference between groups for this product and indicates the effect of changes in the prices associated with this variable on relative earnings, or $(\Delta\beta_{RN} * X_{RN}) - (\Delta\beta_c * X_c)$.

According to Table 5, there has been a large increase in the skill premium in the health care industry. Between the years 1983 and 1993, RNs experienced a .009 percent per year increase in relative wages when compared to the non-health-care comparison group. Changes in relative characteristics suggest that relative wages for RNs would have fallen slightly over the period if this were the only change. Note, however, that the changes in the relative return to schooling increased relative wages dramatically for RNs. The number in the second column of Table 5 suggests that relative wages for RNs would have increased by 3.2 percent *per year* if the change in the return to schooling was the only change, a much larger growth than the approximately one percent per year that actually occurred. The residual trend is the relative difference in the coefficients on the time trend by themselves ($\alpha_{RN} - \alpha_c$), which suggests that there was a downward shift in relative wages for RNs. Thus, changes in the returns to schooling can account for more than all of the relative wage growth for RNs over this period. Similar results are found when comparing health therapists to the non-health control group. The change in the relative return to schooling suggests therapists would experience a 2.7 percent per year increase in relative wages. Again, this is the only sizeable factor in explaining the 1.0 percent per year actual increase in relative wages.

When compared to the health-care comparison group, most of the action appears in the residual trend category. In the 1983 to 1993 period RNs and health therapists experienced a 1.4 percent per year increase in relative wages. The decompositions suggest that neither changes in the characteristics nor changes in the returns to characteristics can explain a sizeable portion of this increase. In fact, the results for schooling suggest that the rate of return to schooling increased even faster for the health-care comparison group than it did for RNs and health therapists. This is consistent with the overall increase in the return to schooling for health care workers shown in Table 4.

Over the 1993 to 1999 period, RNs experienced a relative decline in earnings of 2.1 percent per year when compared to the non-health comparison group and 1.5 percent when compared to the health-care comparison group. Wage declines for therapists were more modest at .7 percent and .2 percent per year compared to the non-health and health comparison groups. Decomposition results over this period show that the relative return to schooling increased even more rapidly in the health industry than in the earlier period. When compared to the non-health-care comparison group, RNs experienced annual wage losses of about 2.1 percent, yet the change in relative returns to schooling suggests that wages would have *risen* for RNs at an annual rate of 5.3 percent. Also, the changes in the relative returns to experience suggest that RNs would have made modest wage *gains* of 0.8 percent per year over the period. The results for health therapists are quite similar.

When comparing RNs and therapists to the health-care comparison group, the returns to school increased relatively faster for RNs and therapists than the control group. Likewise the returns to experience increased for these higher skilled workers relative to the comparison group.

Together, these results for the 1993–1999 period indicate that even though relative wages were declining, the returns to skills for RNs and health therapists rose substantially over the period. Overall there appears to have been a decrease in demand, possibly due to the rise of managed care and other cost containment measures (Schumacher, 2001), yet technology continued to increase so that the returns to school and experience continued to rise. This is consistent with skill-biased technological change in the health care sector. As the technology in the industry evolved over the period, there was an increasing premium placed on measurable skills in our data. The increasing skill premium continued throughout the 1990s despite declining relative wages, due in part to the rise of managed care over the period (Schumacher, 2001; Spetz, 1999). This implies that the demand decrease over the period was most severe for the lower skilled workers in the industry.

V. *Technology and Labor Relations in Health Care*

Given the skill-biased technological change in health care, how might this affect labor relations in the industry? First, the elasticity of labor demand will be affected. As described above, skill-biased technological change in the industry increases the demand for high-skilled workers relative to lower skilled workers. The elasticity of demand for higher skilled labor would also decrease. If technological advances reduce the cost of capital, and skilled labor and capital are gross complements whereas unskilled labor and capital are gross substitutes, technological advances make it more and more difficult to substitute between skilled and unskilled labor.

While not pertaining to technology directly, many health care occupations have licensing requirements, and many are considering, or have recently adopted, additional requirements. A recurring issue among registered nurses, for example, is requiring the baccalaureate degree for licensure. Recently California adopted minimum staffing requirements (Spetz, forthcoming). Finally, nursing shortages are again a growing concern. These factors will make substitution among employees of different skills more difficult and will also tend to decrease the elasticity of demand for these workers.

Second, these changes in technology may affect the distribution of skills across firms, industries, and occupations. If technological advancement occurs disproportionately in certain sectors of the industry (e.g., hospitals, free-standing clinics), workers in those sectors are likely to have a higher and more homogeneous level of skills as technology advances. Likewise, skills within occupations are likely to become more homogeneous. For example, as the demand for RNs increases due to increasing demands for skills, the skill level among RNs should become more standardized over time.

The above discussion suggests that the employees' relative bargaining position will strengthen as technology advances. A lower elasticity of demand, more homoge-

neous work force, and increased legal difficulty in substitution suggest that workers will have a relative advantage over firms in negotiations. Given these factors, the rising wages of higher skilled workers observed over the past 20 years should continue in the future.

While the effect of unions has thus far been rather small in the health care industry (Hirsch and Schumacher, 1998), the lower elasticity of demand and more homogeneous work force will make union organizing efforts more attractive. A lower elasticity of demand implies that union bargaining will result in a more attractive contract for union members. Likewise, a more homogeneous work force implies that workers will be more like-minded. Unions are more likely to organize and maintain political support in establishments where workers' performance and skills are relatively homogeneous (Farber and Saks, 1980; Hirsch, 1982; Demsetz, 1993). Given that the effects of unions in the industry have been relatively small, it is not likely that these changes will result in a major growth in unionization. For example, while the rate of unionization among RNs has remained fairly constant at around 20 percent over the past twenty years, the wage differential between union and nonunion RNs is only around 3 percent (Hirsch and Schumacher, 1998). However, union activity will likely increase in the industry. This is evinced by the AFL-CIO's recent focus on organizing health care workers and by the recent decision of the United American Nurses, the labor arm of the American Nurses Association, to join the AFL-CIO (American Nurses Association, 2001). A potential counter to this, however, is that as the skill levels of nurses increase, the distinction between managers and health care professionals may become increasingly blurred, and this may reduce the demand for unions in the sector.

VI. *Conclusions*

I examine the role of technological change in health care labor markets. One of the biggest issues in the U.S. economy over the recent past has been rapidly rising health care costs. Conventional wisdom holds the main factor driving these costs increases has been technological change. These changes in technology have lead to a direct transformation in the delivery of health care and have also lead to indirect transformations through the reshaping of the private and public insurance industry. My findings are consistent with the idea that technological change has resulted in an increase in demand for higher skilled workers in the industry, while being labor-saving among low-skill workers. The earnings of RNs and health therapists rose rapidly over the 1983 to 1993 period, declined between 1993 and 1996, but then began to rise again after 1996. It is generally believed that managed care has had a one-time cost reducing effect in the industry by eliminating some of the inefficiencies associated with fee-for-service health insurance (Newhouse, 1992). The results here suggest a similar finding in the labor market.

Over the period, the return to schooling and potential experience rose rather substantially for health care workers in general, and especially for RNs. Decomposition analysis of relative wage changes over the period indicates that the returns to school-

ing and, to a lesser extent, the returns to experience, increased relatively rapidly for health care workers. This suggests that there has been skill-biased technological change in the industry, so that, even over the 1993 to 1997 period of declining relative wages, the returns to education continued to climb.

In the future we are likely to see continued advances in medical technology. To the extent that these advances continue to be skill-biased we should see a continued movement toward higher skilled labor in the health care field. Recent trends suggest there is a growing demand for high-skilled workers such as registered nurses (Freudenheim and Villarosa, 2001). Especially in today's managed-care-dominated environment, health care providers are constantly searching for more efficient ways to deliver health care. This appears to have translated and will likely continue to translate into hospitals and other health care providers placing a greater emphasis on the skills that workers bring to the job. An additional complication to these labor markets, especially that for RNs, is the supply response to the rising demand. There again appear to be shortages for RNs driven by rapidly expanding demand (Spetz, forthcoming; Zachary, 2001). At the same time proposed minimum staffing and educational requirements in nursing markets are likely to place additional constraints on the market (Spetz, forthcoming). Thus, these effects should make it likely that the wage growth for RNs will be strong throughout the next few years.

NOTES

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[1]For a review of the literature on the relationship between medical technology and cost growth, see Chernew et al. (1998).

[2]About 95 percent of RNs are female, and 75 percent of therapists are females.

[3]The following Census industry categories were included: offices of physicians, office of dentists, offices of chiropractors, offices of optometrists, offices of health practitioners, n.e.c., hospitals, nursing and personal care facilities, and health services, n.e.c. Omitted from this group were medical scientists, physicians, dentists, optometrists, and podiatrists who are likely to have a higher proportion of individuals with earnings topcoded by the CPS.

[4]Earnings are topcoded in the CPS, so that individuals with "high" earnings do not have their actual earnings reported and instead a maximum cap is reported. Between the years 1973–1988 individuals in the CPS with weekly earnings more than $999 are capped, between 1989 through 1997 the cap is set at $1,923 per week, and beginning in 1998 it is increased to $2,885. I apply the correction developed by Hirsch and Macpherson (1999) to adjust for topcoded earners, which estimates the gender- and year-specific mean above the cap assuming the upper tail of the earnings distribution follows a Pareto distribution.

[5]A nurse can attain training through three educational routes: a two-year associate degree generally awarded through a community college or technical school, a three-year hospital-based diploma program, or a four-year baccalaureate degree. For an examination of differences between these degree types see Schumacher (1997) or Spetz (forthcoming).

[6]The log of experience is used instead of the more typical experience and its square to simplify the presentation.

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